

**TWENTY-FIRST PROGRESS REPORT
OF THE
TEXAS A&M UNIVERSITY
NUCLEAR SCIENCE CENTER**

**JANUARY 1, 1984-DECEMBER 31, 1984
CONTRACT DE-AC05-76ER04207**



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

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T W E N T Y - F I R S T 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

January 1, 1984 - December 31, 1984

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and
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By

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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 System	6
C. Utilization by Other Educational Institutions	9
D. Utilization by Non-University Institutions	10
III. Facility Operations	13
A. Facility Safety and Operational Improvements	13
New Emergency Lighting	13
Loading Dock Modification	13
Guardrail for West End of Pool	13
B. Improvements to Reactor Systems and Experimental Facilities	13
Facility Air Monitor System Improvements	13
CTC and Shell Labs Pneumatic Controller	15
Rod Drive Magnet Coil Replacement	15
Fume Hood Installed in Lab 4	15
Console Rod Drop Timer (MA-30)	15
Long Tube Rotisserie Storage Rack Enlargement	15
Area Radiation Monitor Improvements (MA-29)	16
Pulse Instrumentation Update (MA-31)	16
Reflector and Water Shutter Changes to Beam Port 4	16
Shim Safety "Rod Down" Indication	16

	<u>Page</u>
Secondary Treatment System Improvements	16
Thermocouple Lead Repair on I.F. #7526	19
C. Operational Problems	19
Reportable Occurrences	19
Reportable Occurrence No. 84-1 Failure to Perform Ventillation and Security Systems Surveillance Requirements	19
Reportable Occurrence No. 84-2 Loss of Linear Channel Indication at Power	19
Reportable Occurrence No. 84-3 Reactor Safety System Malfunction (Safety Channel #2)	20
Reportable Occurrence No. 84-4 Reactor Safety System Malfunction (Fuel Element Temperature Channel)	20
Secondary Pump Failure	20
D. Changes in Operating Procedures	21
E. Unscheduled Shutdowns	22
F. Reactor Maintenance and Surveillance	22
IV. Facility Administration	25
A. Organization	25
B. Personnel	25
C. Reactor Safety Board	28
Appendix I	
Description of Projects Utilizing the NSCR	
Appendix II	
Publications, Theses, and Papers Which Involved Use of NSC Facilities From 1976 to Date	

Appendix III

Environmental Survey Program and Effluent
Release Summary and Personnel Exposure
Summary

Appendix IV

Universities, Colleges, Industrial Organi-
zations, Government and State Agencies
Served by the NSC During Twenty-Two Years
of Operation

Appendix V

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

List of Tables and Figures

		<u>Page</u>
Table I	Reactor Utilization Summary	4
Table II	Academic Use of the Reactor	8
<u>Figure</u>		
1	Yearly Reactor Operation	5
2	Overall View of Facility Air Monitoring System	14
3	Pulse Instrumentation	17
4	Water Shutter and Reflector Layout	18
5	Nuclear Science Center Reactor Operations Organizational Chart	26

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, governmental agencies, and private organizations and individuals. The facility operating license 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 USDOE Contract Number DE-AC05-76ER04207 (formerly EY-76-C-05-4207) and of 10CFR50.59. The report covers the period from January 1, 1984 through December 31, 1984.

Reactor utilization decreased from 1983 as indicated by a slightly smaller number of samples irradiated and of total irradiations. In addition there was a decrease in megawatt-days of reactor operation and the number of hours at steady state. There was, however, a slight increase in the total number of experiment hours. The observed trend in reactor utilization appears to be a result of the reduced operating schedule begun in September, 1983 and the economic slowdown of 1984.

Core VIII, established in December 1982, was used throughout 1984. Pulse operations were reinitiated in February 1983 for the first time since 1976, and a total of 64 pulses (\$96.44 total pulse reactivity) were executed in 1984.

Several major facility projects modifications, and improvements were completed during the past year. The main loading dock for shield transfers to and from experimenters was modified, and the Facility Air Monitoring system was upgraded to a state-of-the art system. The Area Radiation Monitoring system also received an electronics update for better calibration and response. In an effort to reduce maintenance time, a console rod drop timer was installed, and improved "rod down" switches/indicators were developed for use on reactor control rods.

Experimentally the Beam Port #4 reflector and shutter was improved, the pulsing instrumentation is being expanded, and the pneumatic system controller developed for Lab #4 is now in use in the Center for Trace Characterization (CTC) and Shell Development labs.

Several operational problems occurred in 1984 but did not result in a significant loss of reactor operating time. The secondary cooling pump motor had to be repaired, and instrumentation age also was a factor in some repair down-time.

During this reporting period there were no changes made to the site area; however, there has been made a proposal to extend the runway at nearby Easterwood Airport such that larger aircraft can be accommodated. This extension should occur in 1985 and should have no affect on the air traffic patterns relative to the NSC.

Administratively during 1984 efforts have been made to stabilize the reactor operations staff following the mid year resignations of both a Reactor Supervisor and Manager of Reactor Operations. A long term replacement has been hired to fill the vacated Reactor Supervisor position; however, the manager position has not yet been filled and those duties have been assumed by the Assistant Director.

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 1972 through December 1984. During the present reporting period the NSCR was used by approximately 1500 students (includes 1475 involved in tours or lab work and 26 student researchers) and 39 faculty and staff members representing 16 departments at Texas A&M University. In addition, more than 300 faculty and students from 11 other educational institutions used the facilities, and 4278 visitors were registered during 1984, including several public and private school groups. A total of 15 non-university organizations had programs that were dependent upon the NSCR.

On numerous occasions throughout the year the NSCR was toured by a total of 183 visiting military officers from virtually every free world country. These officers have been receiving training and indoctrination at Lackland Air Force Base, San Antonio, Texas.

Fifteen potential power plant reactor operators from Gulf States Utilities were trained in 1984. Each candidate performed 10 reactor startups, and attended lectures and labs in Reactor Theory, Reactor Design, Console Manipulations, Power Calibrations, and Health Physics procedures.

During twenty two years of operation, the NSC has provided services to 41 departments at Texas A&M University, 107 other colleges and universities, 81 industrial organizations, and 20 federal and state agencies. (See Appendix IV and V for listings).

TABLE I
REACTOR UTILIZATION SUMMARY

	<u>1984 Annual Total</u>
*Number of Days Reactor Operated	238
Reactor Operation (MW-Days)	80.099
Number of Hours at Steady State	2103.98
Average Number of Operating Hours Per Week	42.08
Total Number of Pulses	64
Total Pulse Reactivity Insertion	\$96.44
Number of Irradiations	716
Number of Samples Irradiated	11378
Sample Irradiation Hours	64304.817
Average Number of Irradiations per Operating Day	3.008
Irradiation Experiment-Hours	14979.24
Beam Port Experiment-Hours	71.369
Irradiation Cell Experiment Hours	10.0
Total Experiment Hours	15050.609
Fraction of Utilization Attributable to Commercial Work	.43
Number of Visitors	4278

*Note: 50 Weeks of Operation Available

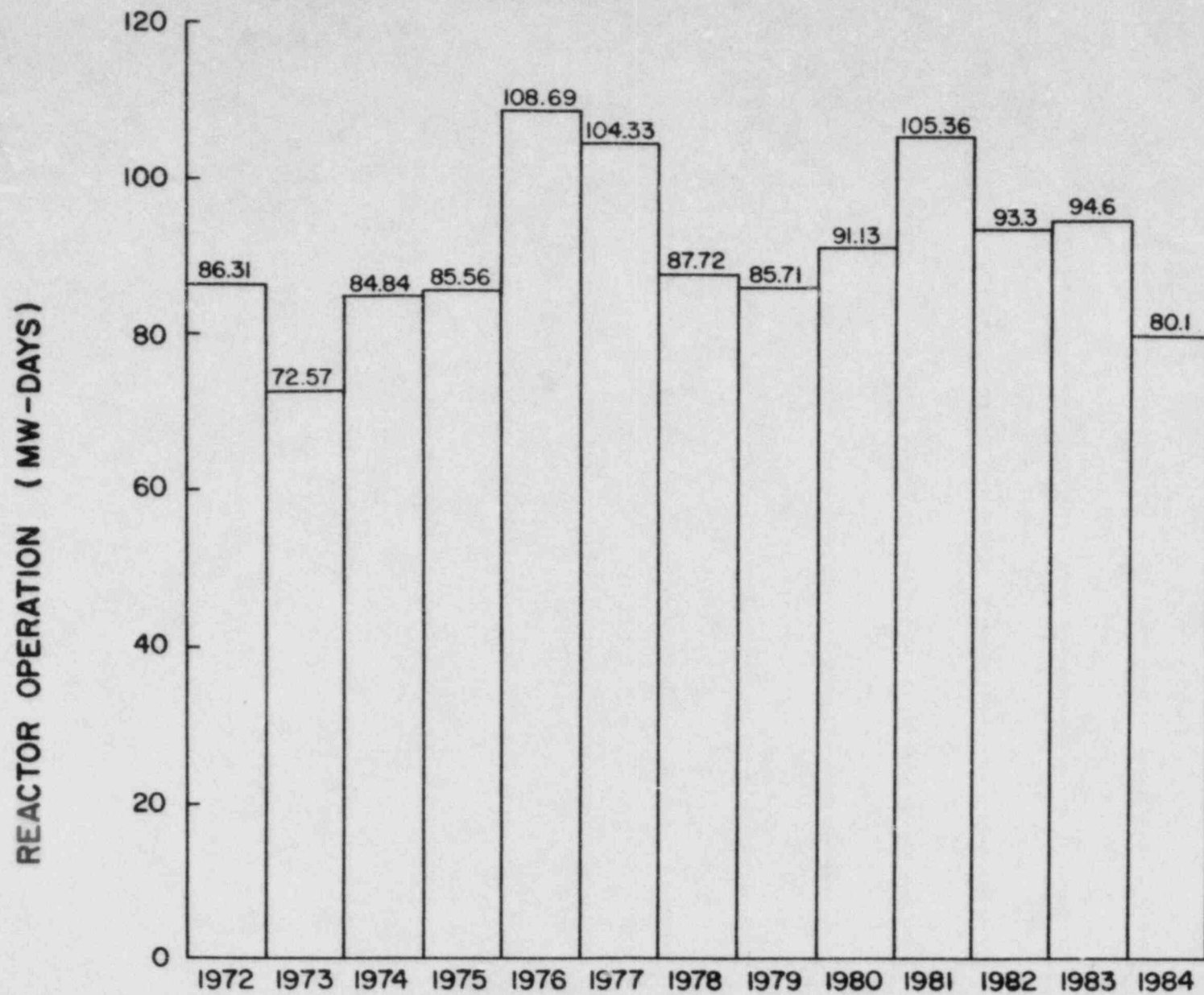


Figure I. Yearly Reactor Operation

B. Utilization by the Texas A&M University System

During 1984 the following personnel from various departments at Texas A&M University used the NSCR for research. Appendix I describes some of the projects completed.

Chemistry Department

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

Students:	M. Tobey	D. Ilger
	L. Divis	J. Jaganathan

Biochemistry/Biophysics

Faculty and Staff: Dr. J. Nagyvary, Professor
Dr. K. Aufterheide, Assistant Professor

Center for Trace Characterization

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

Nuclear Engineering Department

Faculty: Dr. C. A. Erdman, Professor and Head
Dr. R. R. Hart, Professor
Dr. T. A. Parish, Associate Professor
Dr. G. A. Schlapper, Assistant Professor
Dr. R. D. Neff, Professor

Students:	M. Schuller	H. Giap	S. Vrana
	J. Pina	D. Goodman	S. Lee
	E. Parma	D. Rhodes	
	D. Carpenter	A. Morillon	
	M. Whiteacre		

Department of Horticulture

Faculty and Staff: Dr. E. L. McWilliams, Professor

Student: F. Bennett

Department of Oceanography

Faculty and Staff: Dr. J. S. Schofield, Research Associate
Dr. P. Boothe, Asst. Research Scientist
Dr. J. M. Brooks, Lecturer

Nuclear Science Center

Staff: R. D. Rogers, Assistant Director
Y. Contreras, Health Physicist
J. Head, Manager of Technical Services
K. Head, Research Associate
N. Khalil, Student Technician
J. Krohn, Engineering Research Associate
J. Petesch, Reactor Supervisor

Animal Science Department

Faculty and Staff: Dr. W. C. Ellis, Professor

Students: D. Delaney A. Lastovica
R. Worley
L. Roth

Radiological Safety Office

Staff: Dr. R. D. Neff, Radiological Safety
Officer
J. Simek, Assistant Radiological Safety
Officer
P. Sandel, Senior Health Physicist

Small Animal Medicine and Surgery

Faculty: Dr. R. Green, Assistant Professor

Veterinary Physiology and Pharmacology

Faculty: Dr. R. Green, Assistant Professor
Dr. D. Hightower, Professor

In addition to the research performed by the above personnel, the NSCR was used as an educational aid in numerous academic courses offered by the University. Table II indicates the academic courses and the number of students using the facility.

TABLE II
Academic Use of the Reactor

<u>Department</u>	<u>Course No.</u>	<u>Instructor</u>	<u>No. of Students and Purpose</u>
Animal Science	-	Ellis	4-Lab
Chemistry	116	Kolar	1,323-Tour
Chemistry	-	Rowe	1-Dissertation
Horticulture Science	-	McWilliams	1-Thesis
Industrial Education	144	Marshall	24-Tour
Nuclear Engineering	408	Buchanan	15-Lab/Class
	405	Hart	78-Lab/Class
	402	James	19-Lab/Class
	606	Schlapper	15-Lab
	479	Schlapper	25-Tour
Oceanography	-	Presley	11-Tour
Physics	350	Ham	11-Tour
Recreation and Parks	375	Kaiser	38-Tour
Petroleum Engineering	-	Rozgonyi	1-Thesis
Wildlife and Fisheries	485	Grant	1-Undergraduate Project
EDCI	406	Frank	21-Tour

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 Eenergy Reactor Sharing Program. A description of some of the projects utilizing the reactor is presented in Appendix I.

McNeese State University -- Lake Charles, Louisiana

Experimenter: Dr. Jim Beck -- Physics Department

Students: C. Webre

McLennan Community College -- Waco, Texas

Faculty: Mr. Don Tatum -- Physics Department

Students: Physics Classes

Sam Houston State University -- Huntsville, Texas

Faculty: Dr. Charles Manka -- Physics Department
Dr. B. Covington
Dr. C. Fitzpatrick
Dr. Grun

Students: Physics Classes
J. Minton
J. Kainer

Baylor University -- Waco, Texas

Faculty: Dr. Robert McLaurin
Dr. Wang

Students: Physics Classes

Texas State Technical Institute -- Waco, Texas

Faculty: Mr. Carl Kee -- Chairman
Nuclear Technology

Students: Nuclear Technology Classes

Texas State Technical Institute -- Harlingen, Texas

Faculty: Mr. Pedro Jimenez -- Chairman
Nuclear Technology

Students: Nuclear Technology Classes

Louisiana State University -- Baton Rouge, Louisiana

Faculty: Dr. R. Knaus

Sul Ross University -- Alpine, Texas

Faculty: Dr. D. Nelson
 Dr. G. D. Mattison
 Dr. D. Rohs

Texas Tech University -- Lubbock, Texas

Faculty: Dr. C. R. Richardson -- Animal Science

Student: Mike Conner, Ph.D. Dissertation

<u>Public and Private School Tours</u>	<u>No. of Students</u>
University Medical School--San Antonio, TX	14
Texas Women's University--Denton, TX	7
Breckenridge High School--Breckenridge, TX	36
McAllen High School--McAllen, TX	13
Allen Academy--Bryan, TX	11
Jets Chapter--Houston, TX	11
A&M Consolidated--College Station, TX	571
Terry High School--Rosenberg, TX	31
Montgomery High School--Montgomery, TX	21
St. Joseph School--Bryan, TX	60
Caldwell High School--Caldwell, TX	31
Beaumont High School--Beaumont, TX	34
Iola High School--Iola, TX	11
Lamar Jr. High--Bryan, TX	35
All Saints School--Lubbock, TX	14
Sweetwater High School--Sweetwater, TX	8
Royal Middle School--Brookshire, TX	44
Others: Career Day, Various	150
SFA Energy Workshop, Nacogdoches, TX	20
High School Computer Camp, Various	18
Pre-College PE Students, Various	22
Math Scholars, Various	6

D. Utilization by Non-University InstitutionsNational Aeronautics and Space Administration -- Houston, Texas

Experimenters: J. Wagstaff
 Dr. D. Blanchard

Shell Development Company -- Houston, Texas

Experimenters: L. H. Griffin
L. Papajohn
E. L. Woody

Texas Instruments -- Dallas, Texas

Experimenters: S. Halfacre
B. Gnade

Gulf Nuclear -- Houston, Texas

Experimenters: A. Payne
R. Sallee

Teledyne Isotopes -- Westwood, New Jersey

Experimenter: D. Schutz

Catalytic, Inc. -- Wilsonville, Alabama

Experimenter: M. Turgeon

Gulf States Utilities -- St. Francisville, Louisiana

Experimenter: D. Grimes

Halliburton Services -- Laurel, Mississippi

Experimenters: R. Leonardi
G. Cormier

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

Experimenter: Dr. J. Cundiff

Hughes Research Labs -- Malibu, California

Experimenters: Mr. E. Wesel
Dr. R. Hart

Hughes Aircraft -- Carlsbad, California

Experimenter: Mr. D. Bell

Tracerco -- Houston, Texas

Experimenters: W. Ramage
Dr. Ferguson
J. Landry
R. Gilman

White Sands (U.S. Army) -- White Sands Missile Range, New Mexico

Experimenter: Capt. J. Bliss

Jim Beck, Consultant -- Lake Charles, Louisiana

Experimenter: Dr. J. Beck

Exxon Production Research Company -- Dallas, Texas

Experimenter: W. Lowry

Radian Corporation -- Austin, Texas

Experimenter: B. Mann

Andrychuck Gemstones -- Richardson, Texas

Experimenter: J. Head

American Hoechst Corporation -- Baton Rouge, Louisiana

Experimenter: K. Head

Gulf Science and Technology Company -- Pittsburg, Pennsylvania

Experimenter: E. G. Miller

III. FACILITY OPERATIONS

A. Facility Safety and Operational Improvements

New Emergency Lighting

Replacement emergency lighting units with low maintenance gel-cell batteries were installed throughout the facility. The increased reliability of the new units will result in greater safety in the event a power failure requires building evacuation.

Loading Dock Modification

The outside loading dock adjacent to the Material Handling Area was modified to include a hydraulic adjustable lift platform. This feature allows for greater ease in the transfer of shipping shields to and from transport vehicles.

Guardrail for West-End of Pool

For increased safety during tours and facility operations, a guardrail spanning the entire west end of the main pool was installed. A handrail adjacent to the steps leading to the area above the irradiation cell was also installed.

B. Improvements to Reactor Systems and Experimental Facilities

Facility Air Monitoring Systems Improvements

The facility air monitoring equipment was replaced with new electronics and detectors as part of an upgrade to a state-of-the-art system. The changes include new analyzers, amplifiers, and power supplies, along with a TRS-80 computer for collection and storage of data. The detectors for all channels are now located in the tunnel, with all electronic systems housed in a separate room within the mechanical equipment room (see Figure 2). These locations will allow access to all monitoring equipment regardless of confinement building condition. These changes will result in greatly increased reliability and performance with decreased maintenance. An increase in detector efficiency with a decrease in maintenance was achieved by installing a cover over the detectors for FAM channels 1, 2, and 4. This cover will provide a better environment for the collection paper drives and the particulate detectors.

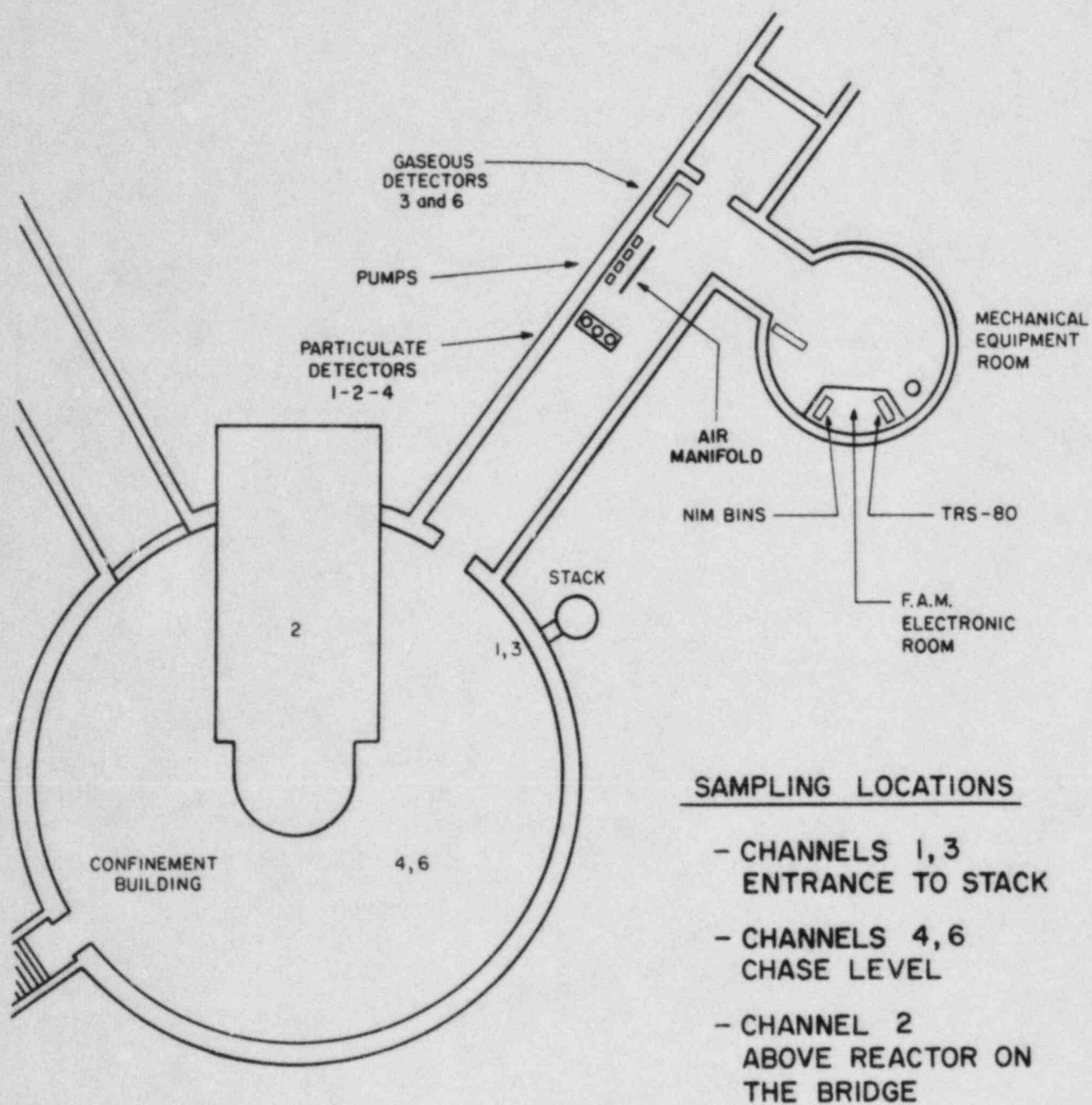


Figure 2. Overall View of Facility
Air Monitoring System

Center for Trace Characterization (CTC) and Shell Labs Pneumatic Controller

The compact pneumatic system controller first used in Lab 4 has been duplicated and is now in use in CTC and Shell Development labs. Permit for operation is still controlled through switches in the control room.

Rod Drive Magnet Coil Replacement

Due to a lack of replacement magnet coils from the manufacturer of the shim safety drive units, a magnet coil replacement was designed by electronics personnel. Values for impedance and current matched original specifications and the holding power was increased over the original units. Approval by the Reactor Safety Board for these units was granted after extensive testing showed complete compatibility with other existing components.

Fume Hood Installed in Lab 4

The ability to handle certain samples in Lab 4 was hampered by the lack of a fume hood surrounding the pneumatic receiver. This was alleviated in November by the relocation of the pneumatic receiver into an enclosed fume hood. Equipped with its own exhaust fan, the hood allows for the safe handling of certain hazardous materials during pneumatic irradiations. A transparent access door is used to allow sample handling in such a way as to contain any gases released from the sample.

Console Rod Drop Timer (MA-30)

In September a console-installed rod drop timer was tested and approved for measuring the elapsed time between the activation of a high fuel temperature scram and the activation of the rod bottom light when the control rod is dropped from its "full out" position. The new timer will replace the previous method of using an oscilloscope for the measurement. The oscilloscope will still be used periodically to verify the accuracy and reliability of the console timer.

Long Tube Rotisserie Storage Rack Enlargement

Due to increased usage of long tube thermal rotisseries for irradiations, an enlarged storage rack and four additional rotisseries were built. The underwater storage table along the north edge of the main pool was moved westward to make room for the eight rotisserie storage rack. These changes will allow for the required decay time necessary for certain samples, while providing the sufficient number of rotisseries for overall volume of irradiations of this type.

Area Radiation Monitor Improvements (MA-29)

Due to partial obsolescence of the detector circuitry in the ARM system, a modification of the amplifier circuit was necessary to make it compatible with modern replacement detectors. With these changes an amplifier gain adjustment method of calibration has replaced the previous method of varying the detector high voltage. These changes have provided a more accurate and reliable system.

Pulse Instrumentation Update (MA-31)

The pulse instrumentation currently in use at the NSC provides linear and integrated outputs in a reading of megawatt-seconds. Currently in testing is a replacement pulse integrator (see Figure 3) having the same outputs, with an additional logic signal at the point of maximum reactor power. A shielded pair input cable will serve to further reduce electronic noise in the system. The new design incorporates an enable/disable timer serving to turn the integrator on and off. The improvements in the new unit will increase the information and accuracy required by future experimenters.

Reflector and Water Shutter Changes to Beam Port 4

The reflector and water shutter previously used in Beam Port 4 were replaced with a new reflector and water shutter system (see Figure 4). The new reflector allows for a more intense neutron beam, while the new water shutter provides for reduced radiation levels and improved operation during filling and evacuation.

Shim Safety "Rod Down" Indication

The reed switch that actuates when the control rod is in its full down position is mounted below the normal water level in the reactor pool. To allow for easier maintenance the previous one-piece switch and bracket was replaced with a stationary switch positioner and a slip-in replacement switch. This will enable maintenance or replacement to be done quickly without the need for working underwater.

Secondary Treatment System Improvements

An improvement to the secondary cooling treatment system was accomplished through the construction of a new amplifier system for the pH controller and the installation of a single electrode probe with an internal reference. These changes will increase the accuracy of the system with a decrease in required maintenance.

TIMER FUNCTIONS:

- ① TR SCRAM < 15 SECONDS AFTER PULSE.
- ② DORIC THERMOCOUPLE INDICATOR SWITCHED TO PEAK RETENTION ≤ 2.5 SECONDS AFTER PULSE BY INTERNAL TIMER.
- ③ INTEGRATION START AT PULSE INITIATION; STOP BY TIMER.
- ④ TIMED PERMIT ≤ 5 MINUTES.

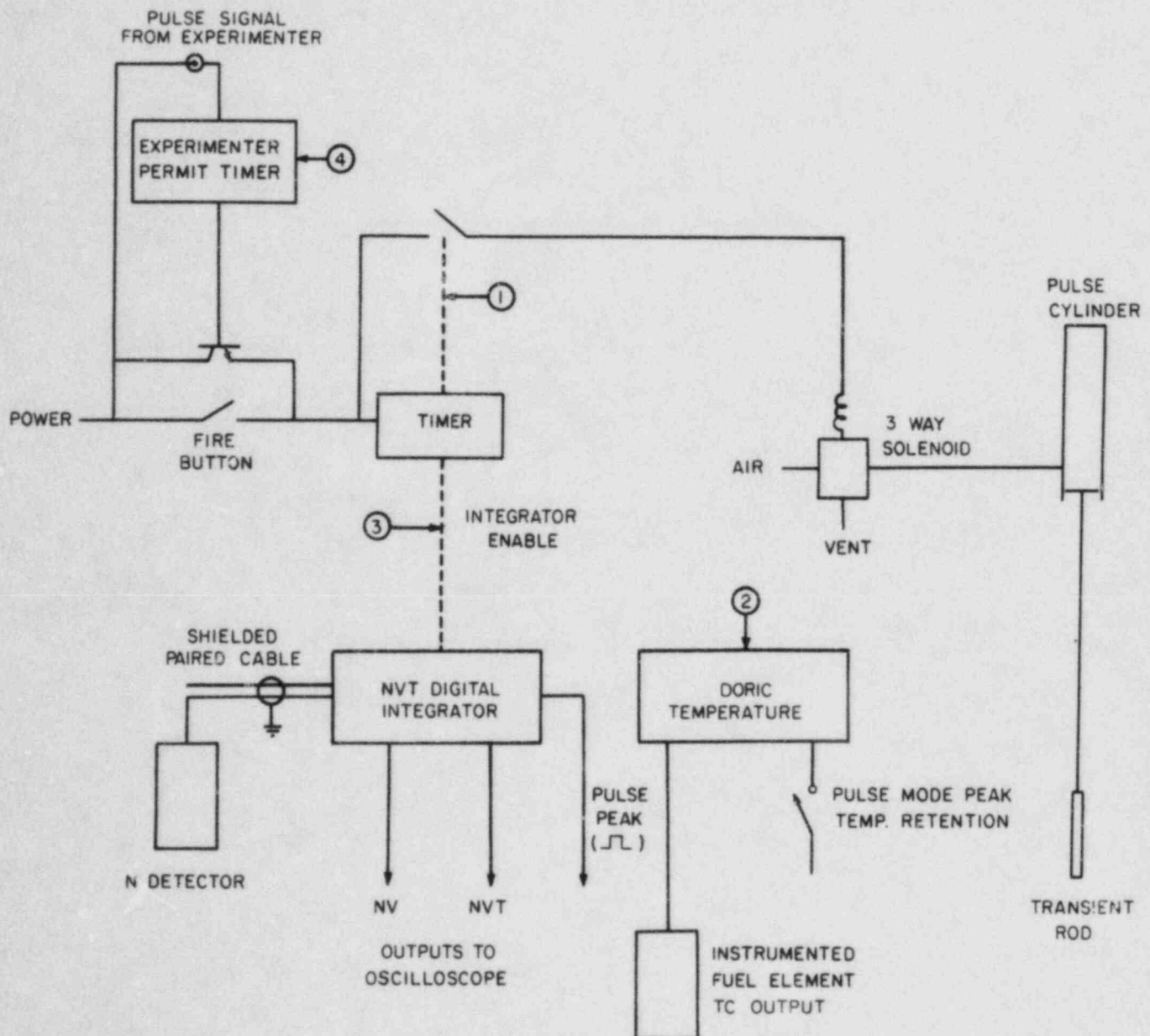


Figure 3. Pulse Instrumentation

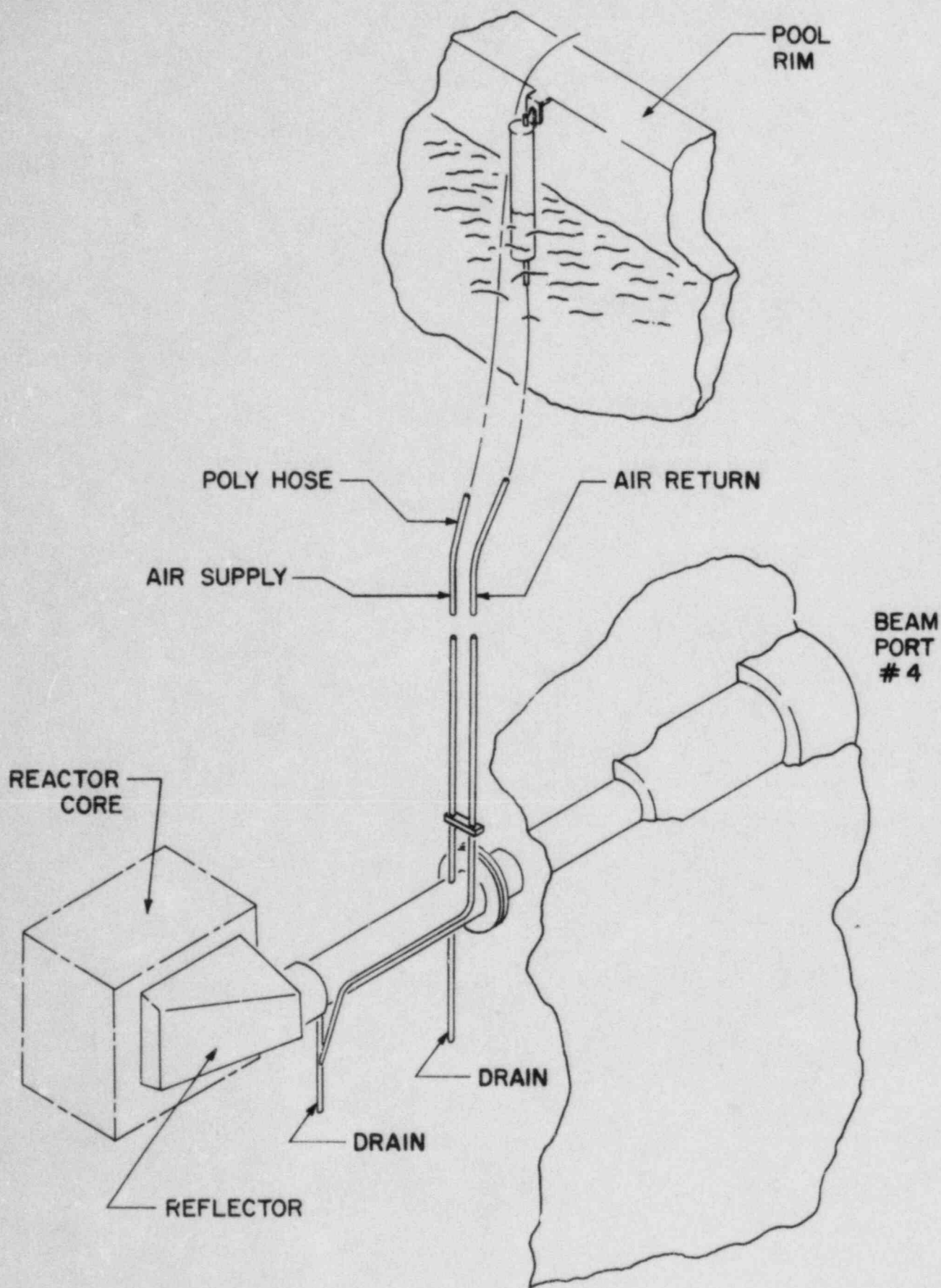


Figure 4. Water Shutter and Reflector Layout

Thermocouple Lead Repair on I.F. #7526

Instrumented fuel element #7526 developed problems in the thermocouple output due to the breakdown of the insulation at the connection of extension wires to the thermocouples. Repairs were undertaken to ready the I.F. for possible core use in the future. The method of repair used was by capacitance welding new extension leads to the I.F. thermocouples. Measurements taken after work was completed indicate two of the three connections were successfully repaired. Further tests will be performed prior to certifying the I.F. ready for core use.

C. Operational Problems

Reportable Occurrences

Reportable Occurrence No. 84-1

Failure to Perform Ventillation and Security System Surveillance Requirements

On 19 March 1984 it was discovered that a weekly surveillance check that serves to verify proper operation of the confinement building ventilation system had not been performed during the previous week. This requirement is specified in Section 4.4 of the Technical Specifications of License R-83. The apparent weekly operating period of non-compliance was 12 March through 16 March 1984. Additionally, a weekly check of the facility intrusion alarms was not performed as is specified by the NSC physical security operating procedure. The NSC currently provides physical protection of SNM in accordance with 10CFR73.67(f), (Physical Protection of SNM of Low Strategic Significance).

Reportable Occurrence No. 84-2

Loss of Linear Channel Indication at Power

On May 28, 1984, during normal reactor operations the nightshift senior reactor operator received a servo fault alarm and noted that the linear power channel indication had failed low. The SRO commenced a shutdown of the reactor in accordance with the standard operating procedures SOP III-C. Subsequent investigation revealed that the high voltage supply for the linear detector was de-energized and it appears that this occurred as the operator was taking log readings by brushing against the power supply switch. A pre-startup check performed May 29 indicated that the channel was functioning correctly. Although the staff of the Nuclear Science Center felt that the operator acted properly and in accordance with standard operating procedures, Technical Specifications Section 3.2.1 specify that the reactor will not be operated without this power monitoring instrument. This incident then was felt to constitute a reportable occurrence.

Reportable Occurrence No. 84-3Reactor Safety System Malfunction (Safety Channel #2)

On June 4, 1984, during startup of the NSCR at 1109 hours it was observed that Safety Channel #2 was not indicating. This was observed in the power range where this channel should initially respond (30 KW - 100 KW). Indications were normal on all other measuring channels. The reactor was shut down and the problem traced to a faulty connector in the signal cable to the safety channel #2 detector. The connector was replaced and instrument checks were performed. During startup of the reactor at approximately 1300 hours, safety channel #2 responded properly. The reactor was returned to normal operations.

Reportable Occurrence No. 84-4Reactor Safety System Malfunction (Fuel Element Temperature Channel)

On 26 June 1984 at 1310, following the return to a reactor power of 950 KW it was noted by the reactor operator that the fuel element temperature recorder had apparently failed to respond during the preceding power transient. This failure occurred following a temporary reduction in reactor power to load an experiment. The operator observed proper response on all reactor power level instruments in addition to a normal temperature indication on the Digital Temperature Instrument (DORIC) that was selected to the same fuel element thermocouple as the temperature recorder. The senior reactor operator and manager of reactor operations were informed and the reactor was shut down in accordance with standard operating procedure III-B. There was no indication that a safety limit or the limiting safety system setting were exceeded during the incident. Troubleshooting and repair of the temperature recorder was accomplished and the instrument was verified operational by NSC Management prior to returning to normal reactor operation.

Secondary Pump Failure

The secondary pump used in the cooling system at the NSC failed on October 29, 1984 due to motor winding failure. During the time of repair a pumper truck was placed on line to provide the cooling necessary during operation for previously scheduled reactor experiments. The pump was returned to service November 5, 1985.

D. Changes in Operating Procedures

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

SOP's

II-A	General Organization and Responsibilities
II-B	Operations Records (NSC Form 539)
II-C	Reactor Startup
II-G	Movement of Reactor Bridge
II-H	Fuel Manipulations
II-I	Reactor Core Manipulations
II-M	Response to Alarms
II-N	Response to Abnormal Reactivity Changes
II-O	Reactor Operator and Senior Reactor Operator Requalification Program
III-A	General (Reactor Maintenance and Surveillance)
III-B	Fuel Element Temperature Measuring Channel Maintenance and Surveillance
III-D	Log-N Measuring Channel Maintenance and Surveillance
III-E	Safety Power Measuring Channel Maintenance and Surveillance
III-F	Pulse Power Measuring Channel Maintenance and Surveillance
III-I	Scram Circuit Surveillance
III-J	Transient Rod Drive Maintenance and Surveillance
III-K	Control Rod Inspection
III-L	Control Rod Drive Maintenance
III-M	Annual Control Rod Calibration and Determination of Shutdown Margin
III-N	Reactor Bridge and Pool Light Maintenance
III-O	Reactor Pool Surveillance
III-Q	Special Nuclear Materials Accountability
III-R	Evacuation Horn System Surveillance
IV-B	Sample Handling Procedures
IV-C	Pneumatic Systems Operation
IV-D	Beam Port Experiments
IV-F	Neutron Radiography Beam Port #4
IV-G	In-Pool Irradiations
VI-A	General (Maintenance and Surveillance of Support Systems)
VII-B13, B17	Health Physics Maintenance and Surveillance
VII-C	Radioactive Materials Control
VII-D	Health Physics Training
VII-E	Personnel Dosimetry

E. Unscheduled Shutdowns

A total of seventeen unscheduled shutdowns occurred during 1984. Several were electronic in nature due to equipment age. The unscheduled shutdowns can be arranged in the following categories:

<u>Cause of Shutdowns</u>	<u>Number of Shutdowns</u>
Building power loss	5
Operator error	2
Electronics	10

F. Reactor Maintenance and Surveillance

1. A calibration of the fuel temperature measuring channel was completed on 1-6-84. The LSSS was set at 525°C (975°F).
2. A channel check of the fuel element temperature measuring channel was made daily by recording and comparing the fuel element temperature and the pool water temperature prior to reactor startup.
3. Control rod calibrations for 1984 were as follows:

Core VIII (1-6-84)

<u>Control Rod</u>	<u>Rod Worth</u>
SS #1	\$2.52
SS #2	1.80
SS #3	2.37
SS #4	4.27
RR	.94
TR	2.73
Shutdown Margin	3.92

4. The reactivity worth of all experiments was either estimated or measured, as appropriate before reactor operation with the experiment. The most reactive experiment irradiated had a worth of \$0.22.

5. The scram times of the control rods were measured for annual maintenance. The results are as follows:

Date	Control Rod	Time in Seconds
1-5-84	SS #1	.756
	TR	.932
1-6-84	SS #2	.700
1-6-84	SS #3	.652
1-5-84	SS #4	.748

All rod scram time checks performed as required throughout the year resulted in times less than the 1.2 second limit set by Technical Specifications.

6. A channel test of each of the reactor safety system channels for the intended mode of operation was performed prior to each day's operation. The pool level alarm was tested weekly.
7. Channel calibrations were made of the power level monitoring channels by the calorimetric method as follows:

Date	Indicated Power (Kw)	Actual Power (Kw)	% Error	Core Loading
1-20-84	400	434.4	+8.6%	VIII

8. The ventilation system was verified to be operable by conducting a test of the system each week throughout the year.
9. Emergency evacuation drills were conducted on 1-27-84 and 8-3-84.
10. Weekly checks were performed throughout the year to verify that the NSC security alarm system was operable.
11. Calibration dates for facility air monitors and area radiation monitors were as follows:

Monitoring System	Date of Calibration
Ch #1 - Stack Particulate	8-30-84
Ch #2 - Fission Product	9-13-84
Ch #3 - Stack Gas	9-5-84
Ch #4 - Building Particulate	8-31-84
Ch #6 - Building Gas	9-9-84
Area Radiation Monitors	9-28-84

12. A review of the NSC security plan was conducted by the NSC staff and the Reactor Safety Board on February 15, 1984.

IV. FACILITY ADMINISTRATION

A. Organization

The organization chart for reactor operations at the Nuclear Science Center is presented in Figure 5. During this reporting year Terry Rolon resigned as Reactor Supervisor and Barry Willits resigned as Manager of Reactor Operations. Greg Stasny was hired to replace Rolon, and Willits' position has not yet been filled. The Assistant Director, Dale Rogers, has assumed these duties. Bob Clements was hired as a part-time reactor operator, and both he and Scott Thomas received SRO licenses during the year. The problem of personnel turnover continues to exist primarily due to the loss of student workers who are employed on a part-time basis when full time help is not available.

B. Personnel

The following is a list of personnel at the Nuclear Science Center for the period of January 1, 1984 - December 31, 1984.

Facility Administration and Reactor Operations Staff

+Clements, R. H.	- Reactor Operator
+Feltz, D. E.	- Director
+Petesch, J. E.	- Reactor Supervisor
+Rogers, R. D.	- Assistant Director
+Rolon, T. R.	- Reactor Supervisor (Terminated)
+Sims, W. W.	- Reactor Operator
Stasny, G. S.	- Reactor Supervisor
+Thomas, S. R.	- Reactor Operator
+Willits, B. L.	- Manager, Reactor Operations (Terminated)

Technical Service and Maintenance

Brookshire, G.	- Student Worker
Fisher, T. H.	- Scientific Instrument Maker II

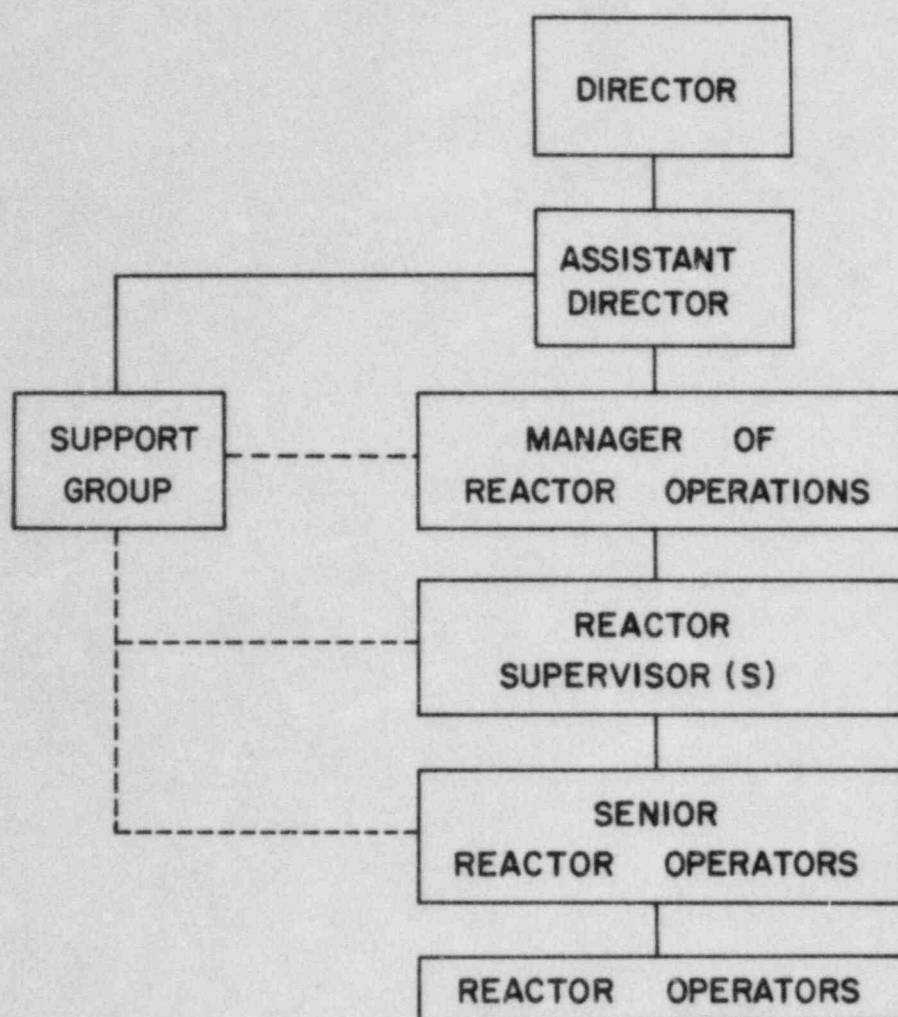


Figure 5. Nuclear Science Center Reactor Operations Organization Chart

Technical Service and Maintenance (Cont'd)

*Goodman, D. P.	- Student Technician
+Head, J. G.	- Manager, Technical Services
*Head, K. M.	- Engineering Research Associate
Horn, C. R.	- Mechanical Equipment Foreman
Jimba, B. W.	- Research Assistant (Terminated)
Johnson, G. A.	- Student Worker I
Khalil, N. S.	- Co-op Research Aide
Krohn, J. L.	- Engineering Research Associate
Mattern, J.	- Co-op Research Aide
Restivo, A. L.	- Engineering Research Associate
Schneider, L. F.	- Student Worker I
Sjoden, G. E.	- Student Technician (Terminated)
Thompson, J. C.	- Reactor Maintenance Technician
Whitworth, D. W.	- Draftsman
Yupari, R. B.	- Student Technician (Terminated)

*Licensed Reactor Operator

+Licensed Senior Reactor Operator

Clerical

Beck, K. D.	- Receptionist
Castleberry, M. K.	- Receptionist (Terminated)
Mitchell, Y.	- Secretary
Ribardo, J. E.	- Bookkeeper
Smith, D. J.	- Bookkeeper (Terminated)

Health Physics Staff

Sandel, P. S.	- Senior Health Physicist
Contreras, Y.	- Health Physicist (Terminated)
Deigl, H. J.	- Senior Health Physicist (Terminated)
Rodriguez, L.	- Health Physicist
Vasquez, G. M.	- Health Physicist

Texas Engineering Extension Service (Nuclear Training Staff)

Buchanan, R. J. - Training Specialist

C. Reactor Safety BoardCommittee CompositionChairman

F. Jennings, Director, Office of University Research
(January 1, 1984 - December 31, 1984)

Voting Members

R. Green, Assistant Professor, Small Animal Clinic
(January 1, 1984 - December 31, 1984)

R. R. Hart, Professor of Nuclear Engineering
(January 1, 1984 - December 31, 1984)

J. Hiebert, Professor of Physics
(September 1, 1984 - December 31, 1984)

R. A. Kenefick, Professor of Physics
(January 1, 1984 - August 31, 1984)

E. A. Schweikert, Professor of Chemistry
(January 1, 1984 - December 31, 1984)

F. Sicilio, Professor of Chemistry
(January 1, 1984 - December 31, 1984)

K. L. Wolf, Professor of Chemistry
(January 1, 1984 - December 31, 1984)

Ex-Officio Members

C. A. Erdman, Professor and Head of Nuclear Engineering
(January 1, 1984 - December 31, 1984)

D. E. Feltz, Director of Nuclear Science Center
(1 January 1984 - December 31, 1984)

R. D. Neff, Professor and University Radiological Safety
Officer
(January 1, 1984 - April 1984)

Ex-Officio Members (Cont'd)

J. Simek, Acting University Radiological Safety Officer
(April 1984 - December 1984)

Meeting Frequency

The Reactor Safety Board (RSB) met on the following dates during the calendar year 1984: 1/30/84, 1/30/84 (Subcommittee) 2/15/84, 4/20/84, 4/30/84, 5/8/84 (Subcommittee), 7/31/84 (Subcommittee), 8/10/84, 9/13/84 (Subcommittee), 10/1/84, 10/31/84, 11/30/84 (Subcommittee).

RSB Audits

During the reporting period RSB audits of NSC activities were conducted on the following dates: 1/20/84, 4/30/84, 7/20/84, 10/29/84.

APPENDIX I

Description of Projects Utilizing the NSCR

DESCRIPTION OF PROJECTS UTILIZING THE NSCR

A. Texas A&M UniversityNuclear EngineeringSORBER PERFORMANCE FOR URANIUM AND STRATEGIC ELEMENT RECOVERY
FROM SEAWATER

Personnel

Dr. Frederick R. Best -- Assistant Professor
Matt Whiteacre -- Graduate Assistant
Jose Pina -- Graduate Assistant

Studies were made into the relative performance of a variety of sorbers for use in the recovery of Uranium and other strategic elements from natural seawater. Both fixed and fluidized bed filters were tested. The Uranium and other element concentrations thus recovered were determined by activation analysis at the NSC.

NEUTRON TRANSMUTATION DOPING OF SEMICONDUCTORS

Personnel

Dr. Ron R. Hart -- Professor
Steve Lee -- Graduate Assistant
Ed Parma -- Graduate Assistant

Investigations continued into the neutron transmutation doping of semiconductor materials for use in infra-red detectors. The investigation included studies of the self-annealing effects in the materials and the effects and levels of impurities such as indium in GaAs.

FUSION REACTOR BLANKET RESEARCH

Personnel

Dr. T. A. Parish -- Associate Professor
Mike Schuller -- Graduate Assistant

Further studies in fusion reactor blanket research were performed. In these experiments, tritium was produced by irradiating lithium fluoride wafers. Measurements of tritium content were then made and compared to calculated values. The goal of this project is to determine the feasibility of a LiF and water slurry as a fusion reactor blanket.

AEROSOL DILUTION AND DISPEPSION AT THE NUCLEAR SCIENCE CENTER

Personnel

Dr. G. A. Schlapper -- Assistant Professor
Yenny Contreras Gonzalez -- Graduate Assistant

A study was made of the dilution and dispersion of an aerosol in the NSC to better characterize the potential personnel exposures in the event of a release of airborne contaminants. The results will aid in estimating potential exposure and in assessing and controlling the spread of contamination.

NUCLEAR ENGINEERING GRADUATE LAB IN REACTOR EXPERIMENTATION

Personnel

Dr. G. A. Schlapper -- Assistant Professor
NE 606 Graduate Students (15 Students)

Experiments performed included measurement of the neutron energy spectrum with threshold reaction foils in the Lab 4 pneumatic receiver, measuring the neutron energy spectrum through different filters in a beam port using Bonner spheres, attempting to find the prompt neutron lifetime in the NSCR by measuring the transfer function, measuring the gamma heating rate in samples in the pool and the irradiation cell, and attempting to develop a prompt gamma analysis facility using one of the beam ports.

Animal Science

DYNAMICS OF RUMINANT DIGESTION

Personnel

Dr. W. C. Ellis -- Professor
Roger Worley -- Graduate Assistant
Abban Lastovica -- Student

The investigation aims to measure the contributing dynamic processes in cattle fed a number of different roughage and roughage/chemical treatments and to integrate the results into models describing the animals' intake and digestibility as functions of basic attributes. The approach involves use of marker elements added to individual meals of the animals and involves neutron activation analysis of these markers.

Biochemistry and Biophysics

INVESTIGATION OF HISTORY OF WOOD OF CLASSIC VIOLINS

Personnel

Dr. Joseph Nagyvary -- Professor

An investigation of the composition of the wood from some classic violins was carried out by neutron activation analysis. The investigation attempted to determine the wood's history or possible treatment that produced the classic tonal quality that the violins are famous for. The suspected treatment was then to be tried on new wood violins to attempt to produce a modern "classic" violin.

Center for Trace Characterization

DETERMINATION OF SHORT LIVED NUCLIDES

Personnel

Dr. W. D. James -- CTC
Dr. J. A. Oyedele -- CTC

This investigation determined the presence of short lived nuclides present in samples following irradiation with thermal and epithermal neutrons. These measurements were performed to establish the enhancement of activation with epithermal neutrons for some elements.

BIOASSAY OF TRACE ELEMENTS IN RAT TISSUE

Personnel

Dr. V. O. Ogugbuaja -- CTC
Dr. W. D. James -- CTC

Biouptake of trace elements, particularly arsenic, by rats exposed to coal fly ash was determined. The investigation included exhaustive survey of trace elements in tissues, blood and animal excrements by neutron activation analysis.

TRACE ELEMENT CHARACTERIZATION OF FLY ASH

Personnel

Dr. A. R. McFarland -- Civil Engineering

The trace element composition of size fractionated fly ash was determined in an attempt to characterizing the combustion products of Texas lignites.

TRACE ELEMENTS IN MHD EFFLUENTS

Personnel

Dr. R. C. Attig -- University of Tennessee Space Institute
Dr. W. D. James -- CTC

This investigation involved the determination of trace elements in effluents from a magnetohydrodynamic coal combustion pilot plant. Efforts have been directed towards characterization of the trace element partitioning pattern for this alternative combustion technique.

DETERMINATION OF ELEMENTS IN REACTION PRODUCTS

Personnel

Dr. F. A. Cotton -- Chemistry
Dr. J. H. Lunsford -- Chemistry

These investigations attempted to determine the presence of several elements in chemical reaction products. Some of the elements included Zn, Cr, Cl, La, Na and Pd.

ELEMENTAL UPTAKE STUDIES OF RAT TISSUE

Personnel

Dr. J. A. Oyedele -- CTC
Dr. W. D. James -- CTC

The trace element composition of biological samples was determined and the resulting data analyzed to establish the degree of similarities of elemental uptake.

MECCA QUARRY SHALE REFERENCE MATERIAL STUDY

Personnel

Dr. M. D. Glascock -- University of Missouri
Dr. W. D. James -- CTC

This involved a collaborative study of Mecca Quarry shale to attempt to establish a well characterized reference material.

RARE EARTH DIGESTION MARKERS

Personnel

Dr. K. R. Pond -- North Carolina State

This presence of rare earth digestion markers was determined in fecal and digesta samples.

Chemistry

ANALYSIS OF MAYAN ARCHAEOLOGICAL CHERT

Personnel

Dr. Marvin Rowe -- Associate Professor

Mark Tobey -- Graduate Assistant

The study attempted to locate and characterize the sources of the chert used in constructing Mayan artifacts in Belize by use of neutron activation analysis of samples from possible sources.

ANALYSIS OF ITALIAN ARCHAEOLOGICAL CERAMICS

Personnel

Dr. Marvin W. Rowe -- Associate Professor

Mark Tobey -- Graduate Assistant

This study attempted to determine if the large archaeological site at Murlo, Italy was a ceramics factory providing ceramics for a wider area. The analysis involves trace analysis of the samples by NAA and fingerprinting the source of pottery from various outlying areas.

TRACE ELEMENT CHARACTERIZATION IN SOLID FOSSIL FUELS

Personnel

Dr. Ralph A. Zingaro -- Professor

Drew Ilger -- Graduate Assistant

James Jaganathan -- Graduate Assistant

Researchers investigated the trace element characterization of several types of coal. The study hopes to identify the analytical concentration of several coals to predict the possible environmental impact of using them as fuel.

OceanographyCHARACTERIZATION OF GULF OF MEXICO OILS, TARS AND SEA BOTTOM
BITUMENS

Personnel

Dr. James M. Brooks -- Lecturer
Mahlon Kennicutt, II -- Assistant Research Scientist

The investigation attempted to characterize oils by trace element analysis. This characterization may indicate different sources for various oil deposits and possibly help in the exploration for oil.

DISSOLUTION KINETICS OF DRILL MUD BARITE IN SEAWATER

Personnel

Dr. B. J. Presley -- Professor
Dr. P. N. Boothe -- Assistant Research Scientist
Gordon Smith -- Graduate Assistant

This research used activated drill mud barite to determine the magnitude and rate of barium release to seawater. The work involved laboratory dissolution experiments and some work was done in cooperation with the Center for Trace Characterization.

Petroleum EngineeringANALYSIS OF RELATION OF URANIUM AND THORIUM CONTENT TO SAMPLE
MESH SIZE

Personnel

Dr. Tibor Rozgonyi -- Professor
Clay Carney -- Graduate Assistant

The investigation studied environmental radiation levels in samples sifted through various size meshes to study the correlation between sample particle size and uranium and radium (thorium) content.

Veterinary Physiology and Pharmacology

DETERMINATION OF EXCHANGEABLE POTASSIUM IN THE CANINE

Personnel

Dr. Dan Hightower -- Professor
Brian Copcutt -- Graduate Assistant
David Followill -- Graduate Assistant

Comparisons were made between exchangeable potassium levels determined by counting of urine samples and whole body counting to determine the accuracy of whole body counting. Several dogs were injected with a solution containing potassium-42 to study the accuracy of whole body counting of canines.

Wildlife and Fisheries Science

IODINE LEVELS IN THYROID GLANDS OF COLLARED PECCARIES FED DIFFERENT DIETS

Personnel

Dr. W. E. Grant -- Associate Professor
Chris Carney -- Student

Iodine levels in the thyroid glands of a total of 7 peccaries (Tayassu tajacu) fed two different diets were determined by neutron activation analysis. The use of the iodine levels as physiological indicators of animal condition was explored.

B. Other UniversitiesLouisiana State University

AN ARTIFICIAL SOIL HORIZON MARKER IN AN ACCRETING LOUISIANA GULF COAST MARSH

Personnel

Dr. R. Knaus -- Associate Professor, Nuclear Science

The project involved attempting to establish methodology for the absolute measurement of accretion rates in marshlands by placing stable markers in the marsh. The marked sediment is easily identified later by neutron activation of the originally stable marker isotopes, thus giving a measure of the accretion of soil in the marsh.

McNeese State UniversityDETERMINATION OF THE CONCENTRATIONS OF HEAVY METALS IN
ENVIRONMENTAL SAMPLES

Personnel

Dr. James N. Beck -- Professor, Chemistry
Carol Webre -- Graduate Assistant

The concentration of heavy metals in environmental samples from around Lake Charles, Louisiana was determined by neutron activation analysis. Biological samples were also taken in the same area and studies have been made into lichens as heavy metal scavengers and the possible contamination of residents living near hazardous waste sites.

Sam Houston State University

NEUTRON TRANSMUTATION DOPING OF SEMICONDUCTORS

Personnel

Dr. B. Covington -- Assistant Professor, Physics
John Kainer -- Graduate Student

Continued studies were performed in the doping of semiconductor material by neutron transmutation of the original crystal material. The studies also included measuring the radiation damage induced in the crystal by the neutron bombardment.

ANALYSIS OF TECTITE SAMPLES FROM CENTRAL TEXAS

Personnel

Dr. Colleen Fitzpatrick -- Lecturer, Division of Chemistry
and Physics
John Minton, III -- Graduate Assistant

The metal content of several samples of tectite from central Texas and some iron meteorites was determined by neutron activation analysis.

Sul Ross State University

ANALYSIS OF GEOLOGIC SAMPLES

Personnel

Dr. Dennis O. Nelson -- Associate Professor and Chairman,
Geology
Dr. G. David Mattison -- Associate Professor, Geology
Dr. David Rohs -- Assistant Professor, Geology
Various Graduate Students

The studies performed include the determination of trace element contents of various rocks and minerals. The analysis is performed by neutron activation analysis of the geologic samples. Several projects are ongoing involving both faculty and a number of graduate students, and the results are incorporated into theses, papers and reported at many meetings and seminars.

Texas State Technical Institute - Harlingen

Personnel

Mr. Pedro Jimenez -- Chairman, Nuclear Technology

During 1984, 8 students in the Nuclear Technology program at TSTI-Harlingen participated in health physics and neutron activation analysis labs at the NSC providing the students a hands-on experience and lab work that would not be possible at the Harlingen campus.

Texas State Technical Institute - Waco

Personnel

Mr. Carl Kee -- Chairman, Nuclear Technology

During 1984, 45 students participated in several labs at the NSC including health physics, neutron activation analysis, and reactor operations to provide them with hands-on experience and training to supplement their classroom instruction in the Nuclear Technology program. The total time spent at the NSC by each student was approximately 164 hours.

University of Texas System Cancer Center - M. D. Anderson
Hospital

IN VITRO THERMAL NEUTRON TREATMENT OF LEUKEMIC CELLS

Personnel

Dr. Roy Tilbury -- Nuclear Medicine
Christopher H. Poynton, M.D. -- Fellow in Clinical Oncology
Michelle Glasky -- Graduate Assistant

Studies were carried out to determine the effects of a thermal neutron beam on boron tagged leukemic cells in vitro. The research was aimed at possibly developing a treatment method for leukemia.

C. Non-University Institutions

Texas Instruments

QUALITY ASSURANCE TEST OF SEMICONDUCTOR MATERIALS USING NAA

Personnel

Bruce Gnade -- Texas Instruments
Sandra Halfacre -- Texas Instruments

Samples of semiconductor material were activated at the NSC and shipped to Dallas where Texas Instruments personnel analyze them for trace impurities that might affect the performance of the material in a semiconductor device. The program is part of Texas Instrument's quality control and improvement effort.

M. D. Anderson Hospital

PRODUCTION OF RADIOISOTOPES FOR RESEARCH AND TREATMENT

Personnel

Jack Cundiff -- M. D. Anderson

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

Shell Development Company

Personnel

Leonard Griffin -- Shell Development

This ongoing project involves neutron activation analysis of various oil, petrochemical and related materials. The analysis is usually aimed at identifying one or more trace elements in the

NASA

ANALYSIS OF TERRESTRIAL AND LUNAR ROCK SAMPLES

Personnel

Jerry Wagstaff -- NASA

The NSC activates rock samples from various locales and returns them to Houston where they are analyzed for elemental composition. This is an ongoing project with the Space Administration.

RADIOISOTOPE PRODUCTION

During 1981, the NSC produced radioisotopes for several commercial users. These isotopes were used for a variety of work including well logging, gamma radiography, and various tracer studies. Some of the isotopes produced included: Co-60, Ir-192, Fe-59, Br-82, Ar-41, and Au-198. A list of some of the companies for which these radioisotopes were produced is given below.

Gulf Nuclear Corporation
Tracerco Incorporated
Teledyne Isotopes
Nuclear Sources and Services Incorporated

Gulf States Utilities

REACTOR OPERATOR TRAINING

During 1984, 15 employees of Gulf States Utilities went through a one week training course at the NSC as part of their training to become reactor operators for Gulf States. This training program helps these personnel to become familiar with reactor operations and helps fulfill part of the training required by the Nuclear Regulatory Commission for candidates for Reactor Operator positions at power plants.

APPENDIX II

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

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

1. Endahl, Gilbert R., "Techniques for Determining Intake by Grazing Animals", Ph.D. Dissertation in Animal Science, Texas A&M University, 1976.
2. O. F. Zeck, G. P. Genarro, Y. Y. Su and Y. -N. Tang, "Effect of Additives on the Reaction of Monomeric Silicon Difluoride with 1, 3-Butadiene", J. Amer. Chem. Soc., 98, 3474 (1976).
3. Conner, Michael C., "Lanthanides as Particulate Flow Markers in Ruminants", M. S. Thesis in Animal Science, Texas A&M University, 1977.
4. R. A. Ferrieri, E. E. Siefert, M. J. Griffin, O. F. Zeck and Y. -N. Tang, "Relative Reactivities of Conjugated Dienes towards Silicon Difluoride", J.C.S. Chem. Comm., 6 (1977).
5. M. D. Devous, Sr., "A Radiation-Induced Model of Chronic Congestive Heart Failure", Scott and White Hospital, Department of Radiology and Nuclear Medicine, May 1977.
6. M. D. Devous, Sr., "A Canine Model of Congestive Heart Failure", University of Florida, Department of Radiology and Department of Cardiology, November 1977.
7. D. E. Feltz, J. D. Randall, and R. F. Schumacher, "Report on Damaged FLIP TRIGA Fuel", Fifth Triga Owner's Conference, Tucson, Arizona, March 1977.
8. J. D. Randall, "Forensic Activation Analysis", NSCR Technical Report No. 36, November 1977.
9. Skinner, N. G., "Nuclear Engineering Aspects of Neutron Transmutation Doping of Silicon", Master's Project in Nuclear Engineering, Texas A&M University, 1977.
10. R. R. Hart, L. D. Albert, "Measurement of P-31 Concentrations Produced by Neutron Transmutation Doping of Silicon", Presented at International Conference on Neutron Transmutation Doping, University of Mo., April 1978.
11. D. Wootan, "Measurement of Neutron Flux in Thermal Rotisserie", Master's Thesis in Nuclear Engineering, November 1978.
12. Huang, W., J. Chatham, "Uranium in Lignite: I Geological Occurrence in Texas", Tenth International Congress on Sedimentology, Volume 1, A-L, pp. 317, 1978.

13. Huang, W., S. Parks, "Uranium Resources in Some Tertiary Sediments of Texas Gulf Coastal Plain: I Geologic Occurrences in the Lower Miocene Sediments", Tenth International Congress on Sedimentology, Vol. 1, A-L, pp. 318, 1978.
14. Huang, W., 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.
15. Presley, R. J., R. Pflaum, J. Trefry, "Fallout and Natural Radionuclides in Mississippi Delta Sediments", Environmental Oceanographic Science, Vol. 59, No. 4, April 1978.
16. Fishman, P. H., "Minerological Analysis and Uranium Distribution of the Sediments from the Upper Jackson Formation Karnes County, Texas", Masters' Thesis in Geology, December 1978.
17. Prasse, E. M., "Uranium and Its Relationship to Host Rock Minerology in an Unoxidized Roll Front in the Jackson Group, South Texas", Masters' Thesis in Geology, December 1978.
18. Ellis, W. C., Mathis, J. H., and Lascano, C. E., "Quantitating Ruminal Turnover", Fed. Proc., Vol. 38, 1979.
19. Lascano, C., W. C. Ellis, "An Evaluation of Lanthanides as Particulate Matter Markers", American Society of Animal Science (abstract), Tucson, Arizona, 1979.
20. Bachinski, S. W. and Scott, R. B., 1979, "Rare-Earth and Other Trace Elements Contents and the Origin of Mineetes: Grochim. Cosmochim. Acta", Vol. 43, 93.
21. Scott, R. B., Temple, D. G., and Peron, P., 1979, "Nature of Hydrothermal Exchange Between Oceanic Crust and Seawater at 26°N. Lat., Mid-Atlantic Ridge: In Benthic Boundary Layer Processes", an IOGC Symposium on the Benthic Boundary Layer.
22. Tiezzi, L. J., and Scott, R. B., 1979, "Crystal Fractionation in a Cumulate Gabbro, Mid-Atlantic Ridge, 26°N, Lat.: Jour. Geophys. Research".
23. McGoldrick, P. J., Keays, R. R. and Scott, R. B., 1979, "Thallium: A Sensitive Indicator of Rock/Seawater Interaction of Sulfur Saturation of Silicate Melts: Geochim. Cosmochim. Acta".

24. Zakoriadze, G., Scott, R. B., and Lilly, D. H., 1979, "Petrology and Geochemistry of the Palao-Kyushu Remnant Arc, Site 448, DSDP Leg 59: Trans American Geophys. Union", v. 50, 94.
25. Scott, R. B., 1979, "Petrology and Geochemistry of Ocean Plateaus", A TAMU Symposium on Ocean Plateaus.
26. Clearfield, A., and L. Kullberg, "On the Mechanism of Ion-Exchange in Zirconium Phosphates: An Equilibrium Study of Sodium-Potassium-Hydrogen Exchange on Crystalline Zirconium Phosphates", Jour. of Inorganic and Nuclear Chem., 1979.
27. O. F. Zeck, R. A. Ferrieri, C. A. Copp, G. P. Gennaro and Y. -N. Tang, "Gas Phase Recoil Phosphorus Reactions IV-Effect of Moderators on Abstraction Reactions", J. Inorg. Nucl. Chem., 41, 785 (1979).
28. Chatham, J. R., "A Study of Uranium Distribution in an Upper Jackson Lignite - Sandstone Ore Body, South Texas", Masters Thesis in Geology, May 1979.
29. Parks, S. L., "Distribution and Possible Mechanism of Uranium Accumulation in the Catahoula Tuff, Live Oak County, Texas", Masters' Thesis in Geology, May 1979.
30. Miller, M. E., "Uranium Roll Front Study in the Upper Jackson Group Alascosa County, Texas", Masters' Thesis in Geology, December 1979.
31. Ellis, W. C., J. H. Matis, and Carlos Lascano, "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.
32. Ellis, W. C., J. H. Matis, and Carlos Lascano, "Sites Contributing to Compartmental Flow for Forage Residues", Ann. Res. Vet., 1979.
33. Lascano, Carlos, "Determination of Grazed Forage Voluntary Intake", Ph.D. Dissertation in Animal Nutrition, December 1979.
34. Pond, Kevin, "Effect of Monensin on Intake Digestibility, Gastrointestinal Fill and Flow in Cattle Grazing Coastal Bermuda Pasture", Masters' Thesis in Animal Nutrition, August 1979.

35. Loza, Hector, "Effect of Protein Defficiency on Forage Intake and Digestibilty", Masters' Thesis in Animal Nutrition, May 1979.
36. Tenhet, Vicki L., "Penetration Mechanism and Distribution Gradients of Sodium-Tripoly-Phosphate in Peeled and Deveined Shrimp", Masters' Thesis in Animal Science, December 1979.
37. Ellis, W. C. and Lippke, Hagen, "A Continuous Infusion and Pulse Dose Marker Method for Determining Fecal Output", Proceedings of Southern Pasture and Forage Crop Improvement Conference, Nashville, Tennessee, May 1980.
38. Delaney, David S., "Effects of Monensin on Intake, Digestibility, and Turnover of Organic Matter and Bacterial Protein in Grazing Cattle", M. S. Thesis in Animal Science, Texas A&M University, 1980.
39. Telford, James P., "Factors Affecting Intake and Digestibility of Grazed Forages", Ph.D. Dissertation in Animal Science, Texas A&M University, 1980.
40. 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. Am. Chem. Soc., 102, 2285 (1980).
41. Rowe, M. W., E. W. Filberth, and H. J. Shaeffer, "Uranium in Huero and Guadalupe Mountain Indian Ceramics", Archaeometry Great Britain, 1980.
42. Ledger, E. B., T. T. Tieh, and M. W. Rowe, "Delayed Neutron Activation Determination of Uranium in Thirteen French Rock Reference Samples", Geostandards Newsletters, 1980.
43. Tieh, T. T., E. B. Ledger, M. W. Rowe, "Release of Uranium from Granitic Rocks During In Situ Weathering and Initial Erosion (Central Texas)", Chemical Geology, 1980.
44. "Core Modification of the Texas A&M Nuclear Science Center Reactor for Improved Commercial Utilization", J. P. Taft with John D. Randall and K. Walker, (March 1980).
45. "Organization and Management of Health Physics Support for a Research Reactor", E. F. Bates with R. D. Neff and J. D. Randall, (March 1980).

46. "Analysis of Uranium in Ore Samples by Delayed Neutron Activation Analysis", Radiochemical and Radioanalytical Letters, by K. L. Walker, October 1980.
47. "Formation of 1-Silacyclopenta-2, 4 diene Through Recoil Silicon Atom Reactions", E. E. Siefert, K. L. Loh, R. A. Ferrier, and Y.-N. Tang, J. Am. Chem. Soc., 102, 2285, (1980).
48. "Fluoride Atom Shift in 1, 2-Difluoroethyl Radicals", J.C.S. Chem. Comm., 814 (1980).
49. E. B. Ledger, T. T. Tieh, and M. W. Rowe, "Delayed Neutron Activation Determination of Uranium in Twelve Rock Reference Standards", Geostandard Newsletter, 4, 153-155, (1980).
50. Pond, K. R., and Ellis, W. C., "Effects of Monensin on Fecal Output and Voluntary Intake of Grazed Coastal Bermudagrass", Beef Cattle Research in Texas, 1981.
51. Ellis, W. C., Matis, J. H., and Pond, K. R., "Effect of Monensin on Gastrointestinal Fill and Turnover of Undigested Forage Residues in Animals Grazing Coastal Bermuda", Beef Cattle Research in Texas, 1981.
52. Delaney, D. S., Pond, K. R., Lascano, C. E., and Ellis, W. C., "Comparison of Fecal Output as Estimated by Two Marker Methods", Beef Cattle Research in Texas, 1981.
53. Delaney, D. S. and Ellis, W. C., "Effect of Monensin on Rumen Microbial Turnover", Beef Cattle Research in Texas, 1981.
54. Dr. Dan Hightower, "Whole Body Counting", Southwest Chapter of Society of Nuclear Medicine, 1981.
55. Jeff Watson and Billy Covington, "Neutron Transmutation Doped Silicon", American Association of Physics Teachers, 1981.
56. Lennart Kullberg and Abraham Clearfield, "Mechanism of Ion Exchange in Zirconium Phosphates - 31. Thermodynamics of Alkali Metal Ion Exchange on Amorphous ZrP", J. Phys. Chem., 1981.
57. Lennart Kullberg and Abraham Clearfield, "Mechanism of Ion Exchange in Zirconium Phosphates - 32. Thermodynamics of Alkali Metal Ion Exchange on Crystalline -ZrP", J. Phys. Chem., 1981.

58. Dennis Nelson, William McDonough, and David Mattison, "Trace Element Geochemistry of the Sawtooth Mountain Syenites, Transpecos Magmatic Belt of West Texas", Trans Pecos Volcanism Symposium, 1981.
59. "Reactions of Monomeric Difluorosilylene with Ethylene", E. E. Siefert, S. D. Witt, and Y.-N. Tang, J. Chem. Soc., Chem. Comm., 217-218 (1981).
60. "Unusual Compounds Synthesized via Nuclear Recoil Methods", Y.-N. Tang, Advances in Chemistry Series, No. 197, "Short-Lived Radionuclides in Chemistry and Biology", K. A. Krohn and J. W. Root (eds.), American Chemical Society, pp. 53-66 (1981).
61. Parma, E. J., "Gamma Abundance of Silicon-31", Master's Thesis in Nuclear Engineering, Texas A&M University, 1981.
62. Theriot, L. R., Daley, L., "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.
63. Ellis, W. C., Lascano, C. E., Teeter, R. and Owen, F. N., "Solute and Particulate Flow Markers", Proceedings of Symposium on Ruminant Protein Nutrition, Oklahoma State University, 1982.
64. Telford, J. P. and Ellis, W. C., "Duration of Grazing Effects on Gastrointestinal Fill, Turnover, Digestibility and Voluntary Intake of Grazed Oak Pasture", Beef Cattle Research in Texas, 1982.
65. Pond, Kevin R., "The Fragmentation and Flow of Forage Residues Through the Gastrointestinal Tract of Cattle", Ph. D. Dissertation in Animal Science, Texas A&M University, 1982.
66. Pond, K. R., Deswysen, A. G. Matis, J. H. and Ellis, W. C., "Chromium-mordanted and Rare Earth Marker Fiber for Particulate Flow Measurement", Beef Cattle Research in Texas, 1982.
67. Pond, K. R., Deswysen, A. G. Matis, J. H. and Ellis, W. C., "Rate of Passage Measurements as Affected by Dosing at Beginning or End of a Meal", Beef Cattle Research in Texas, 1982.

68. Pond, K. R., Deswysen, A. G., Matis, J. H. and Ellis, W. C., "Marker Technique - A Two Marker, Two Dose Method for Estimating Fecal Output, Fill and Flow", Beef Cattle Research in Texa 1982.
69. "Characterization of Uranium-Rich Organic Material Obtained from a South Texas Lignite", M. S. Mohan, R. A. Zingaro, R. D. Macfarlane and K. J. Irgolic, 1982, and Pittsburgh Energy Technology Center, May 18, 1982 by R. A. Zingaro.
70. "Biological Attributes of the West Hackberry Brine Disposal Site, Oceans 82", 4, 285 (1982) with D. Casserly, M. Vecchiono, R. Maples, R. Ilg, Gaston, D. Weston and L. Dervoen.
71. "Quick Separation of Manganese from Brine Solutions Radiochem Radioanal Letters 51, 65 (1982) with G. L. Grout and C. L. Webre.
72. "Annealing Studies of Transmutation Doped Silicon", paper presented at Texas Academy of Science Meeting in San Angelo in March 1982 by Jeff Watson and Billy Covington.
73. "Annealing Study of NTD Silicon: Boron", paper presented at Fourth International NTD Conference in Washington, D. C., in June 1982 by Jeff Watson and Billy Covington.
74. "Annealing Study of NTD Silicon: Boron", to be published in the proceedings of the Fourth International NTD Conference in 1982 by Jeff Watson and Billy Covington.
75. "Implications of Fission Track Ages from the Kaplan Geothermal Geopressure Zone, Vermilion Parish, Louisiana", R. K. Dokka, Transactions of Gulf Coast Association of Geological Societies, Vol. 32, pages 465-468 (1982).
76. William F. McDonough, Dennis O. Nelson, and G. David Mattison, "Major and Trace Element Variation in a Dynamically Evolving Silicon Magma Chamber", Trans-Pecos Volcanism, March 1982.
77. John H. Schieffer, G. David Mattison and Dennis O. Nelson, "The Mineralogy and Geochemistry of the Igneous Rocks of the Terlingua District, Brewster County, Texas", Trans-Pecos Volcanism, March 1982.

78. John H. Schieffer and G. David Mattison, "Nature and Origin of Alkaline and Calcic Veinlets in Xenoliths from the Terlingua District, West Texas. Geological Society of America, October 1982.
79. C. Conrad, "Uranium in the Oatman Creek Granite and Its Economic Impact", Masters Thesis in Geology, 1982.
80. W. Schaftenaar, "Uranium in Igneous Rock of the Central Davis Mountains of West Texas", Masters Thesis in Geology, 1982.
81. H. Deigl and D. E. Feltz, "Antiquity, Man and Machine". Paper presented at Eighth TRIGA User's Conference, Idaho Falls, Idaho, March 1982.
82. D. Rogers and J. D. Randall, "In-Pool Neutron Radiography of Damaged FLIP Fuel". Paper presented at Eighth TRIGA User's Conference, Idaho Falls, Idaho, March 1982.
83. Beasley, C. W., "Perfusion Measurement with Rubidium 81 to Krypton 81m Ratio", Ph.D., Dissertation in Veterinary Physiology and Pharmacology, Texas A&M University, 1982.
84. Brady, M. C., "Radiation Field Measurements in the TAMU Nuclear Science Center Irradiation Cell", Master's Thesis in Nuclear Engineering, Texas A&M University, 1982.
85. Parma, E. J. and Hart, R. R., "Measurements of the Gamma Abundance of ^{29}Si ", Proceedings of the Fourth International Conference on Neutron Transmutation Doping of Semiconductors, Gaithersburg, Maryland, June 1982.
86. Young, M. H. and Hart, R. R., "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.
87. Pond, K. R., Ellis, W. C. and Matis, J. H., "Digesta Flow Through the Ruminant's Digestive Tract", Beef Cattle Research in Texas, 1983.
88. Pond, K. R., Ellis, W. C., James, W. D. and Otte, M. G., "Analysis of Multiple Markers Used in Nutrition Research", Beef Cattle Research in Texas, 1983.

89. Welch, K. L., "Fluence Monitor Calibration of the Multiple Rotisserie Irradiation Device for Neutron Transmutation Doping", Master's Project in Nuclear Engineering, Texas A&M University, 1983.
90. Pgzoniski, L., Hanna, A. N., Suschny, O., "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.
91. Schieffer, J. H., Nelson, D. O., "Petrology and Geochemistry of Megacrysts, Xenoliths, and their Host Basalts from the Terlingua Mercury District of West Texas", Geological Society of America, Abstracts with Program, V. 13, 1983.
92. Nelson, D. O., Ott, K. L. and Tolley, R. D., "Geochemistry of Cibolo Creek I: Evaluation of Element Distribution in Stream Sediments", Earth Sciences, 1983.
93. Rudnick, R. L., "Geochemistry and Tectonic Affinities of a Proterozoic Bimodal Igenous Suite, West Texas", Geology, 1983.
94. McDonough, W. G., "The Geochemistry and Petrology of a Trachyte Comendite Suite from the Oligocene Paisano Volcano, West Texas", Master's Thesis in Geology, Sul Ross State University, 1983.
95. Kennicutt II, M. C., Keeney-Kennicut, W. L., Presley, B. J., and Fenner, F., "The Use of Pyrolysis and Barium Distributions to Assess the Areal Extent of Drilling Fluids in Surficial Marine Sediments", Environ. Geol. 4, pp. 239-249 (1983).
96. Presley, B. J., Sheu, D. D., "Orea Basin: Recent Deep-Sea Black Mud", Annual Meeting of the Geological Society of America, Indianapolis, Indiana (1983).
97. Whiteacre, M., "Sorber Performance Data on the Recovery of Strategic Elements from Seawater", Master's Project in Nuclear Engineering, Texas A&M University, 1983.
98. Best, F. R. and Whiteacre, M., "Sorber Performance Data on the Recovery of Strategic Elements from Seawater", International Meeting on Recovery of Uranium from Seawater, Tokyo, Japan, 1983.

99. Best, F. R., "Interpretation and Analysis of Sorber Performance Data on Recovery of Uranium from Seawater - II", International Meeting on Recovery of Uranium from Seawater, Tokyo, Japan, October 1983.
100. James, W. D., "Multiple Stable Isotope Markers Used in Nutrition Research", Annual American Nuclear Society Meeting, Detroit, Michigan, 1983.
101. Akanni, M. S., Ogugbuaja, V. O., James, W. D., "Trace Element Content of Magnetohydrodynamic Coal Combustion Effluents", Journal of Radioanalytical Chemistry, V. 79, No. 2, pp. 197-205, 1983.
102. Budnick, R. L., "Petrology and Geochemistry of the Carrizo Mountain Group", Geology, Spring 1983.
103. Simpkins, T. H., "The Geology and Geochemistry of the Agua-chili Mountain Fluorspar-Beryllium District". Presented at the Geology Society of America Meeting, Fall, 1983.
104. Schlapper, G. A., Neff, R. D., Davis, D. R., and Sandel, P. S., "Measurement of Routinely Encountered Neutron Doses in Research Facilities", Radiation Protection Management, October 1983.
105. Khalil, N., "A Test of the Efficiency of the Raw Water Stirring System Installed in Liquid Waste Holdup Tank 1", Technical Report Number 44, (1983).
106. Goodman, D. G., "Motor Driven Flux Wire Counter", Technical Report Number 45, 1983.
107. O'Donnell, J., "Determination of the Neutron Flux in the TAMU Nuclear Science Center Reactor During Pulse and Steady State Operation", Master's Thesis in Nuclear Engineering, Texas A&M University, 1983.
108. Followill, D. S., "Determination of Exchangeable Potassium in the Canine by Means of Whole-Body Counting", Master's Project in Nuclear Engineering, Texas A&M University, 1983.
109. Mohan, M. S., and Zingaro, R. A., "Trace Element Characterization of Deep Basin Lignites of Texas", Final Report to Texas Energy and Natural Resources Advisory Council, 1983.
110. Ilger, W. A., "A Study of Uranium in South Texas Lignite", Master's Thesis in Chemistry, Texas A&M University, 1983.

111. Daley, L. S., "ESR of Transition Metal 'Chromophores' in RuBP Case Supporting Neutron Activation and Optical Data Concepts of UV Light Activation Through Transition Metal Chromophores" in Blue Light Syndrome, 2 Horst Serx r, ed., Springer-Verlay, 1984.
112. Ilger, J. D., Ilger, W. A., Mohan, M. S. and Zingaro, R. A., "Characterization of Uranium in a South Texas Lignite", Eleventh Annual Meeting of Federation of Analytical Chemistry and Spectroscopy Societies, Philadelphia, September 1984.
113. Ellis, W. C., Matis, J. H., Pond, K. R., Lascano, C. E. and Telford, J. P., "Dietary Influences on Flow Rate and Digestive Capacity", Proceedings of Symposium on Herbivore Nutrition in the Sub-Tropics and Tropics, Johannesburg, South Africa, 1984.
114. Roth, L. D., Ellis, W. C. and Rouquette, F. M. Jr., "Sward Attributes and Nutritive Value of Coastal Bermudagrass as Influenced by Grazing Pressure", Proceedings of Forage and Grasslands Conference, Houston, 1984.
115. Machem, Richard V., "Effects of Physiological Status, Supplementation and Monensin on Forage Intake, Digestibility and Digesta Turnover", M. S. Thesis, Texas A&M University, 1984.
116. Roth, Larry R., "Effects of Grazing upon Sward Attributes and Utilization of Coastal Bermudagrass by Cattle", M. S. Thesis in Animal Science, Texas A&M University, 1984.
117. Whiteacre, Matt, "Experimental Determination of Elemental Recovery from Natural Seawater Achieved by Ion Exchange Resins", Master of Engineering project report, Texas A&M University, December 1984.
118. Tobey, M. H., Shafer, H. J. and Rowe, M. W., "Trace Element Investigations of Mayan Chert from Belize", International Symposium on Archaeometry, May 1984.
119. Tobey, M. H., Nielsen, E. O. and Rowe, M. W., "Elemental Analysis of Etruscan Ceramics from Murlo, Italy", International Symposium on Archaeometry, May 1984.
120. Charles, Martha, "The Application of a Scintillation Flask Technique for the Measurement of Radon Emanation", M. S. Thesis in Nuclear Engineering, Texas A&M University, May 1984.

121. Gonzalez, Yenny C., "Aerosol Dilution and Dispersion at the Nuclear Science Center Confinement Building", M. S. Thesis in Health Physics, Texas A&M University, December 1984.
122. Poynton, C. H., Tilbury, R. S., Head, J. G., Tindle, S., Dicke, K. A., Peters, L. and Reading, C. L., "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, UK, June 1984.
123. Oguybuaaja, V. O., "Bioaccumulation of Trace Elements From Coal Fly Ash in Rats", Ph.D. Dissertation, Texas A&M University, 1984.
124. Clevenger, T. E., Hinderberger, E. J., Yates, D. A. and James, W. D., "Analysis for Trace Elements in Magnetohydrodynamic (MHD) Pilot Plant Effluents", Environmental Science and Technology, 18, 253-257, 1984.
125. James, W. D., Arnold, F. F., Pond, K. R., Glascock, M. D., and Spalding, T. G., "Application of Prompt Gamma Activation Analysis and Neutron Activation Analysis to the Use of Samarium as an Intestinal Marker", Journal of Radio-analytical Chemistry, 83, 209-214, 1984.
126. McDonough, W. F. and Nelson, D. O., "Geochemical Constraints on Magma Processes in a Peralkaline System: The Paisano Volcano, West Texas", Geochemical et Cosmochimica Acta, Vol. 48, pp. 2243-2455, 1984.
127. Nelson, D. O., Nelson, K. Z., and Mattison, G. D., "Implications of Trace Element and Isotopic Composition for the Origins of Silicic Rocks of the East-Central Trans-Pecos Magmatic Belt of West Texas", GSA Abstracts, Vol. 16, No. 4, 1984.
128. Nelson, D. O., Nelson, K. L., and Mattison, G. D., "Reconnaissance Geochemistry of Rocks of the Trans-Pecos Magmatic Belt", Geological Society of America Abstracts, Vol. 16, No. 2, 1984.
129. 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.

APPENDIX III

Summaries of
Health Physics Support
Effluent Releases
Environmental Survey Program
Radiation and Contamination Control Program
and
Personnel Exposures

Summary of Health Physics
Support for the Operation of
the Nuclear Science Center Reactor
1984

____ Provided health physics monitoring support for processing 716 irradiations containing over 11,378 samples and approximately 1300 curies of radioactivity.

____ Certified 414 shipments of radioactive materials to off-site industry.

____ Certified 68 shipments of radioactive materials to other campus laboratories.

____ Provided monitoring support for processing and handling over 7,000 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 57 soil, water, vegetation, and milk samples.

____ Provided personnel monitoring support for ~ 35 persons on a daily basis and 4278 visitors as required.

____ Performed radionuclide identification and determined radioactivity concentrations for 48 releases of radioactive liquid effluents totaling 1,877,000 gallons 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 300 smear samples on a monthly basis.

____ Conducted radiation safety training for 71 NSC employees and experimental personnel using NSC facilities.

EFFLUENT RELEASE SUMMARY

Introduction

Summaries of radioactive effluents released from the Nuclear Science Center for 1984 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 1.43×10^{-11} $\mu\text{Ci/cc}$. Total radioactivity released for the year was 1.06×10^{-3} curies. These data are presented in Table 1.

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 1984 was 1.75 curies. This results in an annual average release rate of 2.35×10^{-8} $\mu\text{Ci/cc}$ 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% 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.

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 48 liquid waste releases totaling 2.84 E 06 gallons including diluents from the Nuclear Science Center during 1984. The total radioactivity released for 1984 was 8.76 E-01 Ci with an average concentration of 1.23 E-06 $\mu\text{Ci/ml}$. Summaries of the radioisotope data are presented in Table 3 through 15. Radioactivity concentrations for each isotope were below the limits specified in 10CFR20, Appendix B.

TABLE 1
PARTICULATE EFFLUENT RELEASES
ANNUAL SUMMARY
1984

Month	Exhaust Volume (cc)	Concentration ($\mu\text{Ci/cc}$)	Total Radioactivity (μCi)	(Ci)
January	6.31 E12	2.81 E-11	177	1.77 E-04
February	5.91 E12	4.09 E-12	24.1	2.4 E-05
March	6.31 E12	3.91 E-11	246	2.46 E-04
April	6.12 E12	5.9 E-12	36.1	3.61 E-05
May	6.31 E12	9.3 E-12	58.6	5.86 E-05
June	6.12 E12	1.79 E-11	109.5	1.09 E-04
July	6.31 E12	1.88 E-11	118.2	1.18 E-04
August	6.31 E12	1.38 E-11	87.1	8.71 E-05
September	6.12 E12	6.8 E-13	4.1	4.1 E-06
October	6.31 E12	2.3 E-11	145.7	1.45 E-05
November	6.12 E12	5.6 E-12	34.3	3.43 E-05
December	6.31 E12	5.1 E-12	32.2	3.22 E-05

Total Volume: 7.45 E 13cc

Annual Average Release: 1.43 E-11 $\mu\text{Ci/cc}$

Total Radioactivity Released: 1.06 E-03 Ci

TABLE 2
GASEOUS EFFLUENT RELEASES
ARGON-41
ANNUAL SUMMARY
1984

Month	Exhaust Volume(cc)	Concentration* ($\mu\text{Ci/cc}$)	Concentration** ($\mu\text{Ci/cc}$)	Ratio MPC	Total Radioactivity (Ci)*
January	6.31 E12	1.86 E-08	9.3 E-11	2.32E-03	1.17E-01
February	5.91 E12	1.92 E-08	9.6 E-11	2.4E-03	1.13E-01
March	6.31 E12	5.13 E-08	2.56 E-10	6.4E-03	3.23E-01
April	6.12 E12	1.63 E-08	8.1 E-11	2.0E-03	9.9E-02
May	6.31 E12	9.03 E-08	4.5 E-10	1.12E-02	5.69E-01
June	6.12 E12	1.09 E-08	5.4 E-11	1.3E-03	6.6E-02
July	6.31 E12	2.48 E-08	1.24 E-10	3.1E-03	1.56E-01
August	6.31 E12	3.06 E-08	1.53 E-10	3.8E-03	1.93E-01
September	6.12 E12	2.6 E-09	1.3 E-11	3.2E-04	1.59E-02
October	6.31 E12	6.1 E-10	3.0 E-12	7.5E-05	3.85E-03
November	6.12 E12	1.53 E-09	7.6 E-12	1.9E-04	9.36E-03
December	6.31 E12	1.47 E-08	7.3 E-11	1.82E-03	9.2E-02

Total Volume: 7.45 E13 cc

Annual Average Release:* $2.35 \times 10^{-8} \mu\text{Ci/cc}$

Total Radioactivity Released:* 1.75 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
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 SUMMARY
 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Ar-41	1	1.1E+08	2.09091E-07	3E-06	6.9697	2.3E-05
Co-57	12	1.832E+09	1.32129E-07	4E-04	.0330322	2.4206E-04
Co-58	13	2.144E+09	2.34095E-07	9E-05	.260106	5.019E-04
Co-60	30	4.158E+09	3.867E-07	3E-05	1.289	1.6079E-03
Au-198	1	1.1E+08	7.18182E-08	5E-05	.143636	7.9E-06
Ir-192	4	5.22E+08	2.36399E-07	4E-05	.590996	1.234E-04
Mn-54	23	3.306E+09	4.6951E-07	1E-04	.46951	1.5522E-03
Na-22	2	3.9E+08	2.13846E-06	3E-05	7.12821	8.34E-04
Na-24	2	2.59E+08	9.30502E-08	3E-05	.310167	2.41E-05
Zn-65	34	4.592E+09	9.33428E-07	1E-04	.933428	4.2863E-03
K-40	2	2E+08	2.865E-07	3E-06	9.55	5.73E-05

Total Number of Releases: 48

Total Volume Including Dilution: 7.104E+09 mL

Total Activity: 8.76E-03 Curies

Average Concentration Including Dilution: 1.23311E-06 $\mu\text{Ci/cc}$

TABLE 4
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 MONTHLY SUMMARY
 January 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	1.55E+08	3.11613E-08	4E-04	7.79032E-03	4.83E-06
Co-58	2	3.68E+08	9.88859E-08	9E-05	.109873	3.639E-05
Co-60	4	5.92E+08	2.87382E-07	3E-05	.957939	1.7013E-04
Mn-54	2	3.68E+08	2.6948E-07	1E-04	.269484	9.917E-05
Zn-65	3	4.82E+08	8.69502E-07	1E-04	.869502	4.191E-04

Total Number of Releases: 4

Total Volume Released (with dilution): 5.92E+08 mL

Average Concentration (with dilution): 1.2335E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 7.3023E-04 Curies

TABLE 5
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 MONTHLY SUMMARY
 February 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	3.07E+08	5.57003E-07	4E-04	.139251	1.71E-04
Co-58	1	3.07E+08	1.66775E-07	9E-05	.185306	5.12E-05
Co-60	4	7.53E+08	3.16189E-07	3E-05	1.05396	2.3809E-04
Mn-54	1	3.07E+08	4.98371E-07	1E-04	.498371	1.53E-04
Na-22	1	3.07E+08	2.6645E-06	3E-05	8.88165	8.18E-04
Zn-65	4	7.53E+08	6.49801E-07	1E-04	.649801	4.893E-04

Total Number of Releases: 4

Total Volume Released (with dilution): 7.53E+08 mL

Average Concentration (with dilution): 1.46547E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 1.1035E-03 Curies

TABLE 6
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 MONTHLY SUMMARY
 March 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-58	1	1.8E+08	4.96111E-07	9E-05	.551235	8.93E-05
Co-60	2	3.98E+08	5.09774E-07	3E-05	1.69925	2.0289E-04
Ir-192	1	1.8E+08	1.17778E-07	4E-05	.294444	2.12E-05
Mn-54	2	3.98E+08	4.90879E-07	1E-04	.490879	1.9537E-04
Zn-65	3	5.65E+08	1.06673E-06	1E-04	1.06673	6.027E-04

Total Number of Releases: 3

Total Volume Released (with dilution): 5.65E+08 mL

Average Concentration (with dilution): 1.97858E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 1.1179E-03 Curies

TABLE 7
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
April 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	1.08E+08	2.05556E-08	4E-04	5.13889E-03	2.22E-06
Co-60	1	1.08E+08	2.39815E-07	3E-05	.799383	2.59E-05
Mn-54	1	1.08E+08	1.59259E-07	1E-04	.159259	1.72E-05
Zn-65	1	1.08E+08	5.21296E-07	1E-04	.521296	5.63E-05

Total Number of Releases: 1

Total Volume Released (with dilution): 1.08E+08 mL

Average Concentration (with dilution): 9.44445E-07 $\mu\text{Ci/cc}$

Total Radioactivity: 1.02E-04 Curies

TABLE 8
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 MONTHLY SUMMARY
 May 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	2	2.37E+08	8.74262E-08	4E-04	.0218565	2.072E-05
Co-58	1	1.29E+08	5.4031E-07	9E-05	.600345	6.97E-05
Co-60	3	3.66E+08	6.7541E-07	3E-05	2.25137	2.472E-04
Ir-192	1	1.29E+08	3.11628E-07	4E-05	.77907	4.02E-05
Mn-54	2	2.37E+08	6.79325E-07	1E-04	.679325	1.61E-04
Na-24	1	1.29E+08	1.78295E-07	3E-05	.594315	2.3E-05
Zn-65	4	4.95E+08	2.02283E-06	1E-04	2.02283	1.0013E-03

Total Number of Releases: 4

Total Volume Released (with dilution): 4.95E+08 mL

Average Concentration (with dilution): 3.15657E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 1.5625E-03 Curies

TABLE 9
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
June 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	1.82E+08	4.62088E-08	4E-04	.0115522	8.41E-06
Co-58	3	4.23E+08	1.39551E-07	9E-05	.155056	5.903E-05
Co-60	5	7.09E+08	2.73724E-07	3E-05	.912412	1.9407E-04
Mn-54	3	4.23E+08	3.97187E-07	1E-04	.397187	1.6801E-04
Zn-65	5	7.09E+08	7.65416E-07	1E-04	.765416	5.4268E-04

Total Number of Releases: 6

Total Volume Released (with dilution): 8.38E+08 mL

Average Concentration (with dilution): 1.17088E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 9.812E-04 Curies

TABLE 10
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
July 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	1.3E+08	1.07692E-07	4E-04	.0269231	1.4E-05
Co-58	1	1.3E+08	4.38462E-07	9E-05	.48718	5.7E-05
Co-60	3	3.6E+08	4.35833E-07	3E-05	1.45278	1.569E-04
Mn-54	2	2.5E+08	5.908E-07	1E-04	.5908	1.477E-04
Zn-65	3	3.6E+08	1.25E-06	1E-04	1.25	4.5E-04

Total Number of Releases: 3

Total Volume Released (with dilution): 3.6E+08 mL

Average Concentration (with dilution): 2.28889E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 8.24E-04 Curies

TABLE 11
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 MONTHLY SUMMARY
 August 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	3	5.08E+08	4.5E-08	4E-04	.01125	2.286E-05
Co-58	2	3.98E+08	2.04774E-07	9E-05	.227526	8.15E-05
Co-60	3	4.96E+08	9.59274E-08	3E-05	.319758	4.758E-05
Ir-192	1	1.29E+08	2.1783E-07	4E-05	.544574	2.81E-05
Mn-54	4	6.61E+08	2.82632E-07	1E-04	.282632	1.8682E-04
Zn-65	4	6.61E+08	7.48866E-07	1E-04	.748866	4.95E-04

Total Number of Releases: 5

Total Volume Released (with dilution): 7.78E+08 mL

Average Concentration (with dilution): 1.2905E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 1.00401E-03 Curies

TABLE 12
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
September 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-60	2	1.27E+08	7.00787E-07	3E-05	2.33596	8.9E-05
Mn-54	2	1.27E+08	1.03937E-06	1E-04	1.03937	1.32E-04
Zn-65	4	2.18E+08	1.16697E-06	1E-04	1.16697	2.544E-04

Total Number of Releases: 4

Total Volume Released (with dilution): 2.18E+08 mL

Average Concentration (with dilution): 2.13945E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 4.664E-04 Curies

TABLE 13
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
October 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-60	2	2.08E+08	3.07692E-07	3E-05	1.02564	6.4E-05
Mn-54	2	2.08E+08	3.46154E-07	1E-04	.346154	7.2E-05
Zn-65	2	2.08E+08	6.49039E-07	1E-04	.649039	1.35E-04

Total Number of Releases: 3

Total Volume Released (with dilution): 3.07E+08 mL

Average Concentration (with dilution): 8.79479E-07 $\mu\text{Ci/cc}$

Total Radioactivity: 2.7E-04 Curies

TABLE 14
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE LIQUID EFFLUENT RELEASES
 MONTHLY SUMMARY
 November 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	7E+07	5.57143E-08	4E-04	.0139286	3.9E-06
Co-58	1	8.3E+07	6.38554E-07	9E-05	.709505	5.3E-05
Co-60	1	8.3E+07	1.92771E-06	3E-05	6.4257	1.6E-04
Ir-192	1	8.3E+07	4.09639E-07	4E-05	1.0241	3.4E-05
Mn-54	1	8.3E+07	2.40964E-06	1E-04	2.40964	2E-04
Na-22	1	8.3E+07	1.92771E-07	3E-05	.64257	1.6E-05
Zn-65	1	8.3E+07	3.61446E-06	1E-04	3.61446	3E-04
K-40	1	7E+07	6.14286E-07	3E-06	20.4762	4.3E-05

Total Number of Releases: 3

Total Volume Released (with dilution): 2.52E+08 mL

Average Concentration (with dilution): 3.24206E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 8.17E-04 Curies

TABLE 15
 NUCLEAR SCIENCE CENTER
 RADIOACTIVE EFFLUENT RELEASES
 MONTHLY SUMMARY
 December 1984

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Ar-41	1	1.1E+08	2.09091E-07	3E-06	6.9697	2.3E-05
Co-57	1	1.3E+08	1.23077E-08	4E-04	3.07692E-03	1.6E-06
Co-58	1	1.3E+08	5.84615E-08	9E-05	.0649573	7.6E-06
Co-60	1	1.3E+08	1.15385E-07	3E-05	.384615	1.5E-05
Au-198	1	1.1E+08	7.27273E-08	5E-05	.145455	8E-06
Mn-54	1	1.3E+08	1.46154E-07	1E-04	.146154	1.9E-05
Na-24	1	1.3E+08	8.46154E-09	3E-05	.0282051	1.1E-06
Zn-65	1	1.3E+08	1.46154E-07	1E-04	.146154	1.9E-05
K-40	1	1.3E+08	4.07692E-07	3E-06	13.5897	5.3E-05

Total Number of Releases: 3

Total Volume Released (with dilution): 3.7E+08 mL

Average Concentration (with dilution): 3.97297E-07 $\mu\text{Ci/cc}$

Total Radioactivity: 1.47E-04 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 remained basically unchanged from 1984 and reflect the continued use of retention facilities and sample analysis for laboratory effluents prior to their release. Sample analyses indicate that the activities are remaining at normal background levels in the unrestricted environment.

The environmental survey program was expanded in 1977 to include 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. These dosimeters are provided and processed by Texas Department of Health, Division of Occupational Health and Radiation Control. Ambient background for these measurements is determined from a control dosimeter located southeast of Easterwood Airport approximately 800 meters east of the Nuclear Science Center site. This location is at a right angle to the prevailing southeasterly winds which occur a large majority of the time on an annual basis.

Table 16 lists the average exposure rate above ambient background for a number of locations at the site boundary. The highest exposure points at the north and west location of the site boundary. Additionally, a dosimeter is located adjacent to the radioactive waste storage building and the instrument calibration range. Exposure data from this dosimeter is not considered as a result of reactor operations but does reflect the maximum site boundary exposure of 128 mR per year. This site boundary location is further protected from free access to the general public for an additional 100 meters of fenced Texas A&M University property.

Summaries of the environmental survey program for the last quarter of 1983 and the first two quarters of 1984 are presented in Tables 17-19 for gross beta activity. Summaries for the last two quarters of 1984 are not yet available and will be included in the 1985 annual report.

TABLE 16
ENVIRONMENTAL RADIATION MONITORING PROGRAM
INTEGRATED RADIATION EXPOSURE
29 October 1983 to 16 November 1984

<u>Site #</u>	<u>Location</u>	<u>Calculated Dose Rate (micro R/hr)</u>	<u>Calculated Dose Rate (mR/yr)</u>
1	Southeast of airport - fence by large oak tree at Fireman Training Center entrance - background	7	59
2	NSC back fence, northwest corner by gate	10	92
3	NSC back fence - middle, south of TLD #2	11	96
4	NSC north fence - corner - at calibration fence	12	106
5	NSC front gate - fence corner	8	68
6	NSC northeast fence corner on calibration range fence	15	128
7	East of calibration range barbed wire fence on small tree across drainage ditch	7	62
8	Easterwood airport fence north of stock tank	7	62
9	In evergreen tree in open field west of calibrator fence	7	61
10	South fence by trailers - east of reactor building	8	66
11	South fence - at corner	7	63

TABLE 17
ENVIRONMENTAL SURVEY PROGRAM
FOURTH QUARTER SUMMARY
1983

V E G E T A T I O N

Location	Number Samples	(pCi/gm)
White Creek	2	14
NSC Creek	4	21.5
NSC Site	8	13.3

W A T E R

		(pCi/mL)
NSC Creek	4	0.046
White Creek	2	Not available
Easterwood Fish Pond	2	<.040

S O I L

		(pCi/gm)
NSC Northwest Corner	2	10
NSC North	2	7.2
NSC Northeast	2	7.2

TABLE 18
 ENVIRONMENTAL SURVEY PROGRAM
 FIRST QUARTER SUMMARY
 1984

V E G E T A T I O N

Location	Number Samples	(pCi/gm)
NSC Creek	1	31
White Creek	1	33
NSC Outside	2	37
TAMU Landfill	1	33
TAMU Dairy	1	15

W A T E R

		(pCi/mL)
NSC Creek	2	0.035
White Creek	2	<0.004
Airport Fish Pond	2	0.018

S O I L

		(pCi/gm)
NSC Northwest	1	8.7
NSC North	1	9.9
NSC Northeast	1	5.5
Outside NSC	1	7.7

TABLE 19
 ENVIRONMENTAL SURVEY PROGRAM
 SECOND QUARTER SUMMARY
 1984

V E G E T A T I O N

Location	Number Samples	(pCi/gm)
White Creek	1	28.8
NSC Creek	1	16.0
NSC Inside	1	30.0

W A T E R

Radioactivity (pCi/mL)

		(pCi/mL)
Easterwood Airport	1	<0.015
White Creek	1	<0.015
NSC Creek	1	<0.015

S O I L

		(pCi/gm)
NSC Northwest	1	63
NSC North	1	56
NSC Northeast	1	40
Outside NSC	1	49

PERSONNEL EXPOSURES

Radiation exposures to personnel at the Nuclear Science Center for 1984 were well below the limits of 10CFR20. The maximum exposure received by an individual for the year was 260 mrem. A total of approximately 3.13 MANREM was received for 1984. More important, the exposures reflect an extended effort by all personnel to minimize and eliminate radiation exposures whenever practicable. These exposure data become more significant when one considers that in addition to routine reactor operations, over 11,378 samples containing approximately 1300 curies of radioactivity were produced and processed at the Nuclear Science Center in 1984.

The whole-body exposure data for NSC employees and experimental personnel are presented in Table 20. These data are presented in graded divisions as required under 10CFR20.202(a).

The access control procedures for visiting personnel were effective in preventing exposure to radiation. There were 4278 visitors to the Nuclear Science Center during 1984. The maximum exposure to any visitor as determined by film badges was less than the minimum measurable quantities. These values are 10 millirems for X or gamma, 40 millirems for hard beta, 20 millirems for fast neutrons and 10 millirems for thermal neutron radiations.

TABLE 20
SUMMARY OF WHOLE BODY EXPOSURES
1984

Whole Body Exposure Range (Rem)	Number of Persons In Range
No Measurable Exposure	11
Less than 0.100	28
0.100 - 0.249	3
0.250 - 0.499	1
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	0
Total Number of Individuals Reported:	43

SOLID RADIOACTIVE WASTE

There was a total of 56 ft³ of dry solid waste material packaged in plastic bags for disposal during 1984. These materials are transferred to the Radiological Safety Office, Texas License G-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 2.8 E-2 Ci. These data are in Table 21.

TABLE 21
SOLID RADIOACTIVE WASTE DISPOSAL
ANNUAL SUMMARY

1984

Radioisotope	Radioactivity (μ Ci)
Co-60	26381
Ir-192	284
Zn-65	1487
Mn-54	284

Total Volume: 56 ft³ contained in plastic bags.

Total Radioactivity: 2.8 E-2 Ci

RADIATION AND CONTAMINATION CONTROL PROGRAM

Introduction

The detection and elimination 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 systems 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. There were no unexpected radiation levels or improper exposures of radioactive materials detected during 1984. These surveys revealed only background radiations at the site perimeter fence.

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 stored materials with removable beta-gamma radioactivities of greater than 200 dpm/100 cm².

APPENDIX IV

Universities, Colleges, Industrial Organizations,
Government and State Agencies Served by the
NSC During Twenty Two Years of Operation

Other Universities and Colleges

Baylor University	Sam Houston State
Baylor, College of Medicine	University of New Hampshire
University of Texas	Catholic College for Women
Texas Women's University	Taft College
University California, Los Angeles	Bluefield College
Lamar State College of Technology	Potomac St. College
New Mexico State University	Thames Valley St. Tech. College
Rice University	Victoria College
Austin College	Tennessee Tech. University
Southern Methodist University	Wharton County Jr. College
California State Poly. College	Grayson County College
Washington University	West Virginia Inst. of Tech.
Hastings College	Galveston College
Winona State College	Arkansas Poly College
Wisconsin State University	Eastern Kentucky University
Milwaukee Institute of Technology	Sue Bennett College
Arkansas State College	Cheyney St. College
Ball State Teachers College	University of Genova
Texas Southmost College	University of Southern Louisiana
Stephen F. Austin College	University of Oklahoma
Louisiana State University	Somerset Community College
Xavier University	Grove City College
Temple University Penn.	Louisiana Tech.
Bemidji State College	Abraham Baldwin College
Chadron State College	Kent St. University
State University of Ohio	Pan American College
Alfred St. College	Tarleton St. College
Community College of the Finger Lakes	Columbus College
Nebraska Wesleyan University	Texas Tech University
Lock Haven St. College	Howard Payne College

Other Universities and Colleges (Cont'd)

San Bernadino Valley College	Prairie View A&M College
North Park College and Theological Seminary College	Longwood College
Fort Valley State College	S. D. School of Mines
Denison University	North Shore Community College
State University College, N.Y.	University of Wisconsin
Auburn University	Hill Jr. College
Clarion State College	McLennan Community College
University of Alaska	Southeast Missouri St. College
University of Arkansas	Southwestern State College
University of Houston	Mary Hardin Baylor
Southwest Texas State College	Texas State Technical Inst.
Iowa State University	North Texas State University
Blinn College	University of Arizona
State College of Arkansas	McNeese State University
The Defiance College	Texas Eastern University
San Antonio College	Henderson County Jr. College
Laredo Jr. College	Massachusetts Institute of Technology
University of Corpus Christi	University of Texas at Dallas
South Dakota State	Moody College
Arapahoe Jr. College	Sul Ross University
California St. College	East Texas State University
University of Texas-Tyler	University of Pittsburgh
UT System Cancer Center	UT Medical School
M.D. Anderson Hospital	San Antonio

Industrial Organizations

States Marine Lines	Comfacco
Southwest Research Institute	Rivera Foods
Humble Oil and Refining Co.	North American Aviation
Institute of Research and Instrumentation	Gulf Research
Estrada Incorporated	Xomox
Shell Chemical Company	Texas Nuclear
Mobil Oil Company	Bio Assay Lab-Bio Nuclear
Texas Instruments, Inc.	NAPKO Corp.
Todd Shipyards Corp.	D.W. Mueller, Consultant
Shell Development Co.	General Nuclear Corp.
Tennessee Gas Transmission Co.	Nuclear Enginmental Eng. Corp.
Lane Well Co.	Shell Development, Oakland Calif.
Petro-Tex Chemical Corp.	Nuclear Sources and Services
Babcock and Wilcox Co.	Exxon
Medical Arts	Atomic Energy Industrial
Texaco, Inc.	Hughes Research Lab
Monsanto Co.	TRACO Inc.
Hastings Radiochemical Works	Lloyd Barber and Associates
E.I. DuPont DeNemours and Co.	Temple Industries
Mission Engineering	Chemtrol Inc.
ESSO Research and Engineering	Jet Research
Diamond Alkali Co.	Resource Engineering
Dow Chemical Co.	Ranger Engineering
Celanese Co.	Turbine Lab
Independent Exploration Co.	Gulf Nuclear
Westinghouse Electric	Gulf Science and Technology
Avery Oil Company	Tech-Sil
Bell Helicopeter	Universal Technology Corporation
Spectronics	Eastern Whipstock
LGL, LTD.	Catalytic, Inc.

Industrial Organizations (Cont'd)

E-Systems	Halliburton Services
Monsanto, Inc.	Morris Engineering Company
Radian Corp.	
Nuclear Laboratory Services	
Core Laboratories	
Pacific Gas and Electric	
Houston Lighting and Power	
Broz Labs	
Balcones Research	
General Electric Company	
Gulf States Utilities	
Kansas Gas and Electric	
Teledyne	
Bendix	
Research Concepts	
American Hoechst	
Engineers/Designers, Inc.	
Tracerco	
TRIAD	

Government and State Agencies

M.D. Anderson Hospital
Houston Police Department
Houston, District Attorney
Brooks Medical Center
National Aeronautics and Space Administration
North East Radiological Health Lab
Department of the Army
Wichita Falls, District Attorney
Corpus Christi, District Attorney
Dallas County, District Attorney
Denton County, District Attorney
Jefferson County, District Attorney
Oklahoma Medical Examiner
U.S. Air Force
Osage County Oklahoma, District Attorney
Bureau of Economic Geology
Amarillo District Attorney
Orange Police Department
Fort Worth Police Department
Austin Police Department

APPENDIX V

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

TAMU Departments and Agencies

Department of Biochemistry and Biophysics
Department of Nuclear Engineering
Department of Oceanography
Activation Analysis Research Laboratory
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
Nuclear Science Center
Department of Veterinary Physiology and Pharmacology
Department of Radiation Biology
Center for Trace Characterization
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)

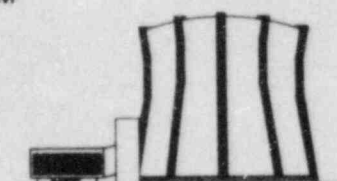
Department of Engineering Technology
Department of Civil Engineering
Fireman's Training School
Department of Archaeology
Department of Entomology
Department of Recreation and Parks
Department of Engineering Design Graphics
College of Architecture and Environmental Design
Center for Energy and Mineral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

TEXAS ENGINEERING EXPERIMENT STATION

THE TEXAS A&M UNIVERSITY SYSTEM

COLLEGE STATION, TEXAS 77843-3575

25 March 1985



NUCLEAR SCIENCE CENTER
409/845-7551

Mr. Cecil O. Thomas, Chief
Standardization and Special Projects Branch
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Reference: Docket 50-128

Dear Mr. Thomas:

In accordance with the reporting requirements of Technical Specifications 6.6.1 for the Texas A&M University Nuclear Science Center Reactor we hereby submit 3 copies of our annual report for the period of January 1, 1984 - December 31, 1984.

Sincerely,

Donald E. Feltz
Director

DEF/ym

Enclosures

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