DMB

TEXAS ENGINEERING EXPERIMENT STATION

THE TEXAS A&M UNIVERSITY SYSTEM

COLLEGE STATION, TEXAS 77843-3575

NUCLEAR SCIENCE CENTER
409/845-7551

27 March 1984

Mr. John T. Collins
Regional Administrator
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76012

Reference: Docket 50-128

Dear Mr. Collins:

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, 1983 - December 31, 1983.

Sincerely,

Donald E. Feltz

Donald E. Feltz
Director

DEF/ym

Enclosure

IE.25
1/1

Form AEC-427
(6/70)
AECM 3201

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

(See Instructions on Reverse Side)

1. AEC REPORT NO.	2. TITLE
ORO-4207-16	"Twentieth Progress Report of the Texas A&M University Nuclear Science Center"

3. TYPE OF DOCUMENT (Check one):

☐ a. Scientific and technical report — Contract No. DE-AC05-76ER04207 (formerly EY-76-C-05-4207)

☐ b. Conference paper not to be published in a journal:
Title of conference
Date of conference
Exact location of conference
Sponsoring organization

☒ c. Other (Specify) Facility Progress Report

4. RECOMMENDED ANNOUNCEMENT AND DISTRIBUTION (Check one):

☒ a. AEC's normal announcement and distribution procedures may be followed.
☐ b. Make available only within AEC and to AEC contractors and other U.S. Government agencies and their contractors.
☐ c. Make no announcement or distribution.

5. REASON FOR RECOMMENDED RESTRICTIONS:

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

Donald E. Feltz, Director

Organization

Nuclear Science Center, Texas A&M University

Signature	Date
Donald E. Feltz	3/27/84

FOR AEC USE ONLY

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

8. PATENT CLEARANCE:

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

ORO-4207-16

TWENTIETH PROGRESS REPORT OF THE TEXAS A&M UNIVERSITY NUCLEAR SCIENCE CENTER

JANUARY 1, 1983-DECEMBER 31, 1983

CONTRACT DE-AC05-76ER04207

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

TWENTIETH PROGRESS REPORT
of the
TEXAS A&M UNIVERSITY
NUCLEAR SCIENCE CENTER

January 1, 1983 - December 31, 1983

Prepared By

H. J. Deigl
J. G. Head
J. E. Petesch
R. D. Rogers
B. W. Willits

and the
Nuclear Science Center Staff

Submitted to

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

By

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

March, 1984

Table of Contents

Appendix III

Environmental Survey Program and Effluent Release Summary and Personnel Exposure Summary

Appendix IV

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

Appendix V

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

List of Tables and Figures

I. INTRODUCTION

The Nuclear Science Center is operated by the Texas Engineering Experiment Station as a service to the Texas A&M University System and the State of Texas. The 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, 1983 through December 31, 1983.

Reactor utilization improved slightly from 1982 with increases seen in total number of irradiations, number of samples irradiated, and total experiment hours. Reactor operation of 94.6 Mw-days for 1983 represents approximately a 1.4% increase over the previous year. It should be noted, however, that effective 1 September 1983 the operating schedule for the NSCR has been reduced to include only two fourteen hour shifts and three eight hour shifts per week unless special requests are made. It is not expected that this change will result in any significant decrease in reactor utilization. An NSC "Users Group" has been created and meets periodically to discuss experimenter needs and ways in which the NSC can be of better service. This increased communication between users and NSC management will hopefully improve utilization even more.

Core VIII, established in December 1982, was used throughout 1983. Pulse operations were reinitiated in February 1983 for the first time since 1976, and a total of 75 pulses ($116.38 total pulse reactivity) were executed. A detailed pulse test program to monitor peak core temperatures and to periodically inspect certain fuel elements was completed satisfactorily.

Several major facility projects, modifications, and improvements were completed during the past year. A total of 10 FLIP fuel elements and 41 Standard fuel elements were shipped in August 1983 to Argonne National Laboratory in Idaho Falls, Idaho. A new dual dryer system was installed in the facility dry air system, and the facility air monitor manifold was modified for more efficient operation. A new room was built outside the main confinement building to house the facility air monitor electronic equipment which is also to be upgraded in the near future. Improvements were also made to the south pneumatic station and the pneumatic system controller for laboratory #4, and new digital sample timers were added in the reactor control room. An upgrade of the demineralizer room started in 1982 was completed and involved repainting and floor resurfacing for better drainage.

Several operational problems occurred in 1983 but did not result in a significant loss in reactor operating time. During a scheduled core inspection prior to reinitiating pulsing operations two additional fuel elements failed to pass the inspection requirements and were, therefore, removed from the core and declared non-usuable for reactor operation. A leak in waste storage tank #2 was corrected by cleaning and patching. Both demineralizer room sump pumps failed during the year and had to be replaced. The secondary cooling pump also failed but was able to be mechanically corrected. A reportable occurrence from December 1982 concerning an overpower incident resulted in an NRC enforcement conference in March 1983. This conference was held with NSC administrative personnel to emphasize the need for proper operator training and administrative controls to avoid similar problems in the future.

Administratively during 1983 Donald E. Feltz was officially named Director following a short period of serving as Acting Director. Dale Rogers was named Assistant Director. Management and supervisory positions have been filled and these individuals have gained valuable experience during the past year. Personnel turnover has been stabilized at the present time.

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 1969 through December 1983. During the present reporting period the NSCR was used by approximately 1750 students (includes 1724 involved in tours or lab work and 28 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 5008 visitors were registered during 1983, including several public and private school groups. A total of 15 non-university organizations had programs that were dependent upon the NSCR.

During twenty one years of operation, the NSC has provided services to 40 departments at Texas A&M University, 103 other colleges and universities, 78 industrial organizations, and 20 federal and state agencies. (See Appendix IV and V for listings).

B. Utilization by the Texas A&M University System

A NSC "Users Group" was formed in September 1983. This group is comprised of 12 researchers representing 7 university departments and one outside state-supported organization. Dr. Gerald Schlapper of the Nuclear Engineering Department was elected Chairman of this group. Members were asked by the NSC staff to aid in the collection of research information to obtain a more detailed accounting of realized research funding to the TAMU System as a result of utilization of the NSC. This survey was conducted based on the following questions directed toward each experimenter contacted:

1. Did the research performed depend upon the reactor for an integral part of the results obtained?

2. What TAMU departments and/or other universities were involved in the research? What students, Masters or Ph.D., were involved?

3. What was the total dollar amount of the funding received?

4. Are there any proposals pending that rely upon the NSCR? If so, what are the dollar amounts?

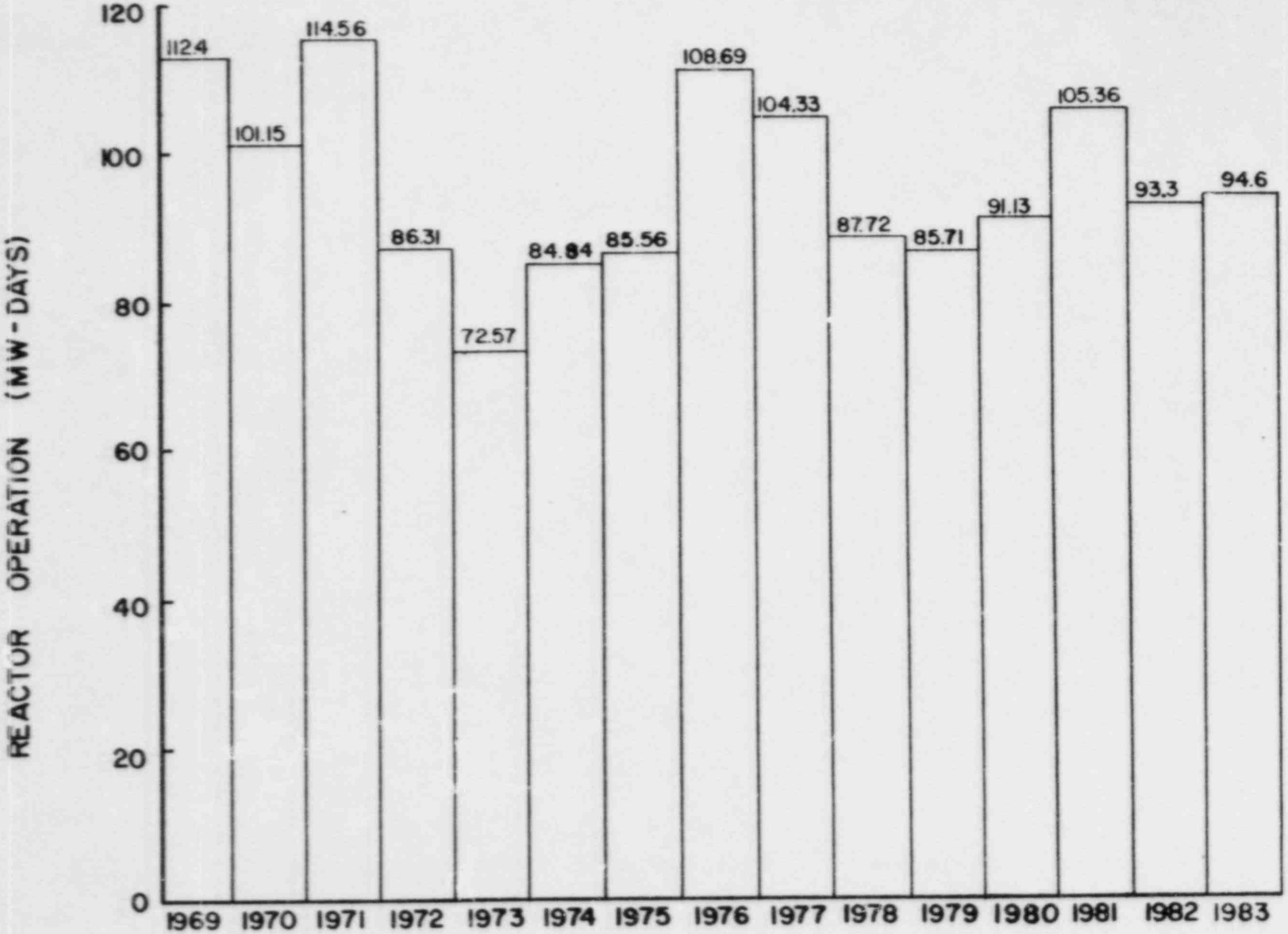

Figure 1. Yearly Reactor Operation

TABLE I

REACTOR UTILIZATION SUMMARY

	1983 Annual Total
*Number of Days Reactor Operated	229
Reactor Operation (MW-Days)	94.60
Number of Hours at Steady State	2376.9
Average Number of Operating Hours Per Week	47.5
Total Number of Pulses	75
Total Pulse Reactivity Insertion	$116.38
Number of Irradiations	865
Number of Samples Irradiated	16046
Sample Irradiation Hours	134218.8
Average Number of Irradiations per Operating Day	3.78
Irradiation Experiment-Hours	14931.9
Beam Port Experiment-Hours	40.4
Irradiation Cell Experiment Hours	0
Total Experiment-Hours	14972.2
Fraction of Utilization Attributable to Commercial Work	.39
Number of Visitors	5008

*Note: 50 Weeks of Operation Available

The results of this survey show that the highest percentage of research dollars was generated by the College of Science. This is due mainly to the neutron activation analysis program (NAA) conducted by the Center for Trace Characterization. The College of Geosciences leads the way in pending research dollars. It is interesting to note that 70% of these research dollars were the result of the use of the NAA programs offered by the NSC and CTC.

It is our conclusion that these figures justify more interest and support for the NSC from the university. At this time information is being gathered on the research dollar amounts realized by non-university users as a result of utilizing the NSC. Results of the survey of the TAMU users are presented in Table II.

Table II

Total Research Dollars to TAMU
Resulting From
Utilization of the NSCR

	Research dollars (81-83)	Percent of Total (81-83)	Research Dollars (Pending)
College of Veterinary Medicine	$250,000	11.6	$30,000
College of Engineering	370,142	17.2	244,855
College of Agriculture	80,000	3.7	325,000
College of Geosciences	272,500	12.7	550,000
College of Science	1,174,228	54.8	205,000
	$2,146,870	100	$1,354,855

During 1983 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. Y. N. Tang, Professor
Dr. A. Clearfield, Professor
Dr. R. Zingaro, Professor
Dr. M. S. Mohan, Visiting Professor

Students:

M. Tobey	B. Menta	W. Ilger
L. Garza	B. Roberts	D. Ilger

Civil Engineering

Faculty and Staff:
Dr. A. McFarland
B. Harbert, Lecturer

Students: B. Diot

Biology

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

Students:
V. Simmons
J. Terrio

Center for Trace Characterization

Staff:
Dr. D. James, Research Chemist
Dr. M. Akanni
V. Ogugbuaja, Technician
T. Woods, Technician

Nuclear Engineering Department

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

Students:

J. O'Donnell	K. Welch	M. Schuller
G. Sjoden	H. Giap	M. Whiteacre
S. Vrana	J. Pina	T. Powell
D. Goodman	S. Lee	E. Parma

Nuclear Science Center

Staff: R. D. Rogers, Assistant Director
Y. Contreras, Health Physicist
R. Land, Research Assistant
J. Head, Manager of Technical Services
K. Head, Research Associate

Animal Science Department

Faculty and Staff: Dr. W. C. Ellis, Professor
V. Latimer, Technician

Students: D. Delaney
B. Warrington
L. Roth

Radiological Safety Office

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

Students: R. Yupari
J. O'Donnell

Veterinary Physiology and Pharmacology

Faculty: Dr. D. Hightower, Professor

Students: D. Followill
B. Copcutt

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 III indicates the academic courses and the number of students using the facility.

C. Utilization by Other Educational Institutions

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

TABLE III

ACADEMIC USE OF THE REACTOR

Department	Course No.	Instructor	No. Students and Purpose
Architecture	633	Trost	13 - Tour
Building Construction	336	Woods	31 - Tour
Chemistry	116	Kolar	140 - Tour
Chemistry	116	Kolar	135 - Tour
Chemistry	116	Kolar	128 - Tour
Chemistry	116	Kolar	92 - Tour
Chemistry	116	Kolar	130 - Tour
Chemistry	116	Kolar	18 - Tour
Chemistry	116	Kolar	149 - Tour
Chemistry	116	Kolar	138 - Tour
Chemistry	116	Kolar	90 - Tour
Chemistry	116	Kolar	133 - Tour
Chemistry	116	Kolar	132 - Tour
Engineering Design Graphics	-	Vinson	12 - Tour
E.D.I.C.	354	Janke	25 - Tour
E.D.I.C.	354	Janke	15 - Tour
E.D.I.C.	354	Janke	22 - Tour
E.D.I.C.	354	Janke	10 - Tour
E.D.I.C.	354	Janke	38 - Tour
E.D.I.C.	406	Horn	26 - Tour
Industrial Education	144	Marshall	16 - Tour
Naval Science	-	Gastrock	4 - Tour
Naval Science	-	Gastrock	10 - Tour
Nuclear Engineering	101	Brady	74 - Tour
Nuclear Engineering	405	Randall	9 - Lab
Nuclear Engineering	405	Randall	15 - Lab/Class
Nuclear Engineering	405	Randall	12 - Lab/Class
Nuclear Engineering	405	Randall	12 - Lab/Class
Nuclear Engineering	408	Land	16 - Lab
Nuclear Engineering	479	Schlapper	14 - Class
Nuclear Engineering	479	Schlapper	15 - Lab
Nuclear Engineering	606	Randall	9 - Lab
Recreation and Parks	375	Kaiser	18 - Tour
Recreation and Parks	375	Kaiser	23 - Tour
		Total	1724

<u>McNeese State University</u> -- Lake Charles, Louisiana

Experimenter: Dr. Jim Beck -- Physics Department

<u>McLennan Community College</u> -- Waco, Texas

Faculty: Mr. Don Tatum -- Physics Department

Students: Physics Classes

<u>Sam Houston State University</u> -- Huntsville, Texas

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

Students: Physics Classes
J. Minton

<u>Baylor University</u> -- Waco, Texas

Faculty: Dr. Robert McLaurin
Dr. Wong

Students: Physics Classes

<u>Texas State Technical Institute</u> -- Waco, Texas

Faculty: Mr. Carl Kee -- Chairman
Nuclear Technology

Students: Nuclear Technology Classes

<u>Texas State Technical Institute</u> -- Harlingen, Texas

Faculty: Mr. Pedro Jimenez -- Chairman
Nuclear Technology

Students: Nuclear Technology Classes

<u>Louisiana State University</u> -- Baton Rouge, Louisiana

Faculty: Dr. R. Knaus

<u>Sul Ross University</u> -- Alpine, Texas

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

<u>Texas Tech University</u> -- Lubbock, Texas

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

Student: Mike Conner, Ph.D. Dissertation

Public and Private School Tours	No. of Students
Beaumont Charleton High School -- Beaumont, Texas	30
Cyprus Community School -- Houston, Texas	45
Montgomery High School -- Montgomery, Texas	19
Carlisle High School -- Henderson, Texas	25
Henderson High School -- Henderson, Texas	24
Harden Jefferson High School -- Sour Lake, Texas	15
Brookshire High School -- Brookshire, Texas	14
Tomball High School -- Tomball, Texas	24
Madisonville High School -- Madisonville, Texas	52
Fayetteville Jr. High School -- Fayetteville, Texas	33
St. Joseph School -- Bryan, Texas	36
Navasota High School -- Navasota, Texas	15
Others (Career Day) --	164

D. Utilization by Non-University Institutions

National Aeronautics and Space Administration -- Houston, Texas

Experimenters: M. Strait
Dr. D. Blanchard

Nuclear Sources and Services -- Houston, Texas

Experimenters: R. D. Gallagher
E. Johnson

Shell Development Company -- Houston, Texas

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

Texas Instruments -- Dallas, Texas

Experimenters: S. Halfacre
B. Gnade

Gulf Nuclear -- Houston, Texas

Experimenters: A. Payne
G. Pettyjohn

<u>M. D. Anderson Hospital</u> (University of Texas Medical Center)

Experimenters: Dr. R. Tilbury
Dr. C. Reading
Dr. C. H. Poynton
J. Cundiff

<u>Hughes Research Labs</u> -- Malibu, California

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

<u>Hughes Aircraft</u> -- Carlsbad, California

Experimenter: Mr. D. Bell

<u>General Electric Company</u> -- Mount Vernon, Indiana

Experimenter: G. R. Ashley

<u>Tracerco</u> -- Houston, Texas

Experimenters: W. Ramage
Dr. Ferguson
J. Landry

<u>Tech-Sil</u> -- Houston, Texas

Experimenter: M. Welch

<u>White Sands (U.S. Army)</u> -- White Sands Missile Range, New Mexico

Experimenter: Capt. J. Bliss

<u>Gulf Science and Technology</u> -- Cheswick, Pennsylvania

Experimenter: E. Miller

<u>Jim Beck, Consultant</u> -- Lake Charles, Louisiana

Experimenter: Dr. J. Beck

<u>Universal Technology Corporation</u> -- Dayton, Ohio

Experimenter: Dr. R. Hart

III. FACILITY OPERATIONS

A. Facility Safety and Operational Improvements

Demineralizer Room Upgrade

The degradation of the demineralizer room floor and the chemical contamination problems that result during demineralizer regeneration have seriously deteriorated the floor and sump. In addition, the chemical contamination was a serious hazard to personnel working in the demineralizer room. A project was undertaken and brought to completion that included the following major areas of improvement:

1) Provide an acid and caustic drain line directly from the caustic tank and the acid pump to the demineralizer room sump.

2) Minimize the amount of area of the floor that is exposed to chemical leakage and spillage by cutting a trench drain below the demineralizer piping and regeneration components that contribute to this contamination.

3) Provide an overall improvement in the demineralizer room drainage.

4) Recondition and coat the demineralizer room sump to minimize further chemical damage.

Figure 2 shows the demineralizer room floor plan in its present condition.

Facility Paging System Improvements

The NSC paging system was a source of continuous problems due to decreased performance of the outdated amplifier system and wiring problems that resulted in improper impedance matching of the paging speakers. A reliable paging and facility-wide communication system is vital to safe and efficient facility operation. The system wiring problems were investigated and systematically corrected, and individual phone units were repaired as necessary. A new amplifier was installed which resulted in a significant improvement in overall system quality and reliability. Further improvements are planned in the replacement of many of the outdated phone units as new units are purchased or made available.

B. Improvements to Reactor Systems and Experimental Facilities

Facility Air Monitor System Improvements

Several improvements to the facility air monitor system have either been made or are currently in progress. These improvements include the following:

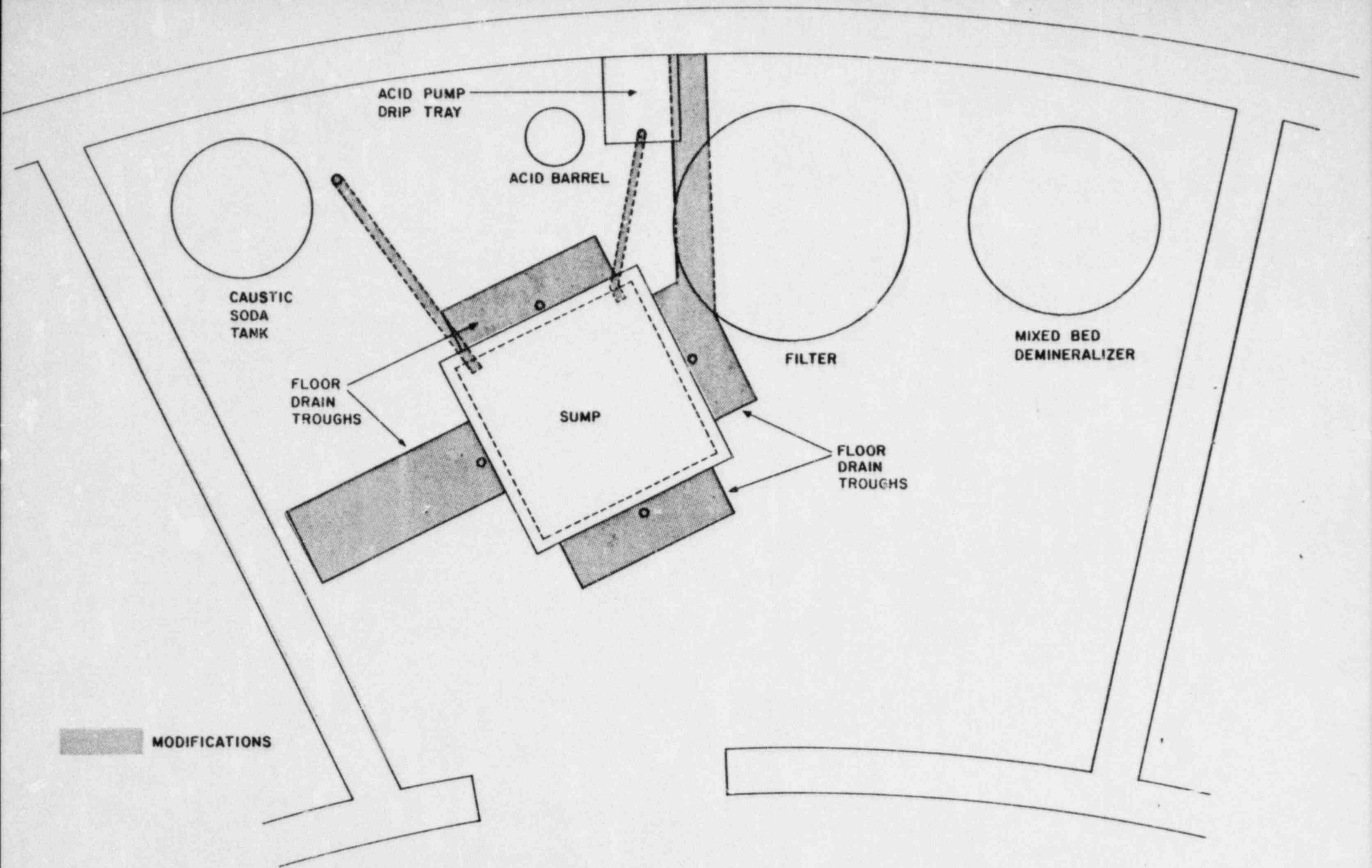

Figure 2. Demineralizer Room Floor Plan

1) The sampling lines to the Facility Air Monitor (FAM) units and the vacuum suction lines were either modified or replaced. The major area of improvement was in the suction line manifold, which controls air flow through the detectors, and in the flow meter layout. The lines to each unit, the valves, and the flowmeters were arranged in a more orderly manner than the previous system. Additionally, a flow diagram was provided beneath the suction lines on the manifold support structure. The modified system is as shown in Figure 3, and the design provides a means of cross connecting detectors such that required monitors can be backed up by those not required. In addition calibration and air flow standardization has been greatly simplified by use of convenient connections on the new manifold.

2) The FAM detector and electronic systems are currently in the process of being upgraded to a more state-of-the-art system. A separate room has been constructed within the mechanical equipment room to house the FAM electronic counting equipment in an air conditioned environment. The purpose of this change is to consolidate the electronics to control the operating environment, and to provide a centralized location in which to conduct a radiation hazard analysis during an emergency.

Laboratory #4 Pneumatic Controller

The pneumatic system controller for Laboratory #4 was modified into a more compact digital unit with a less complex set of control buttons. The modification is a convenience measure to the experimenter operating the pneumatic system. A "permit switch" in the reactor control room transfers control to the experimenter who selects the desired irradiation time.

Dry Air System Modification

In May 1983, the dry air supply system for the transient rod was modified by installing two new self regenerative dessicant dryers, a new air chiller, and associated oil and particle filters. The system, shown in Figure 4, has an increased air drying capacity and improved moisture removal capabilities.

Control Room Sample Timer

A new digital sample activation timer unit was designed and installed in the reactor control room. The timer is capable of timing the irradiation of six samples simultaneously. The modified timer improves the timing of irradiations by incorporating a warning feature that alarms two minutes prior to completion of the irradiation and again when the sample irradiation has been completed.

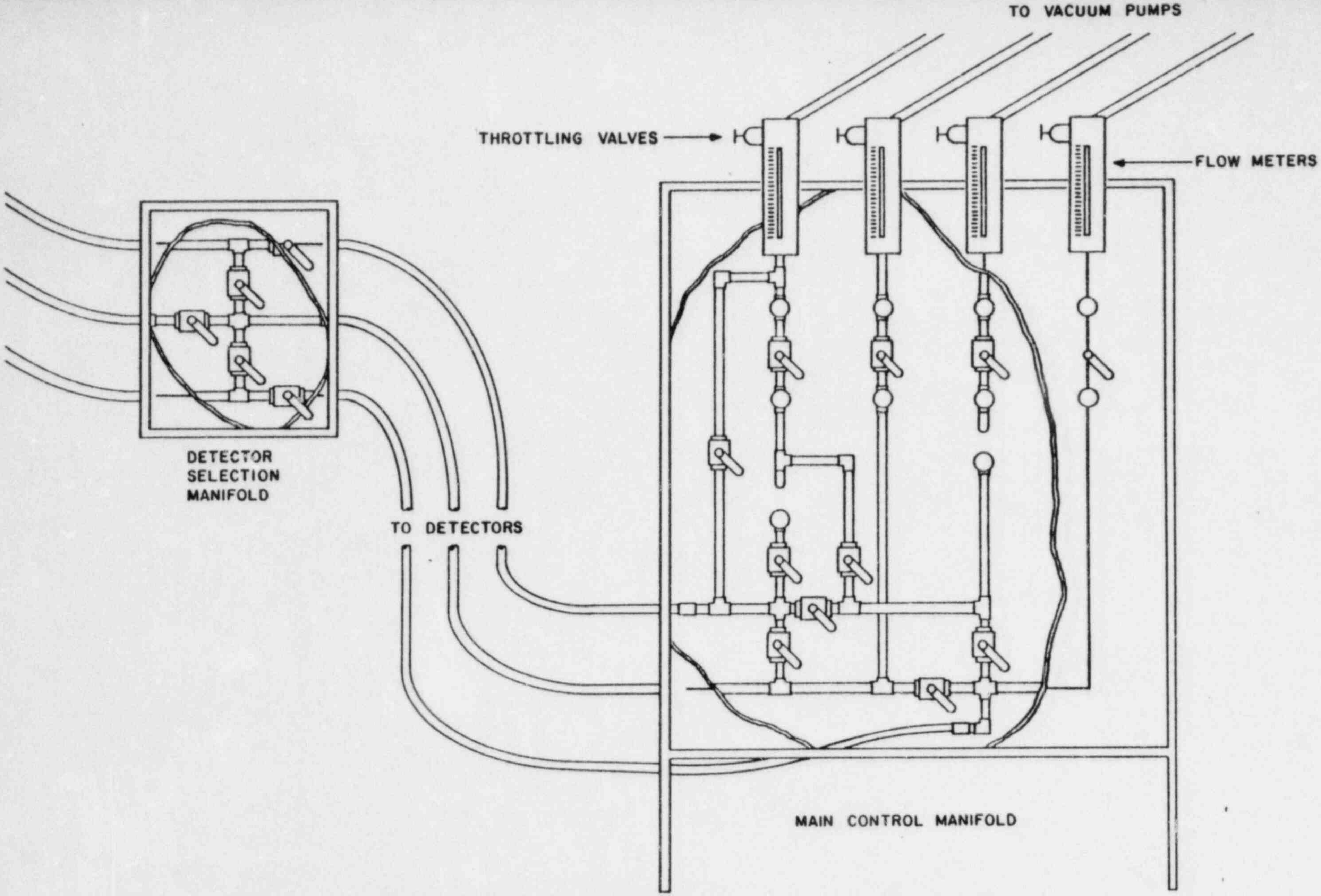

Figure 3. Facility Air Monitors Air Flow Manifold

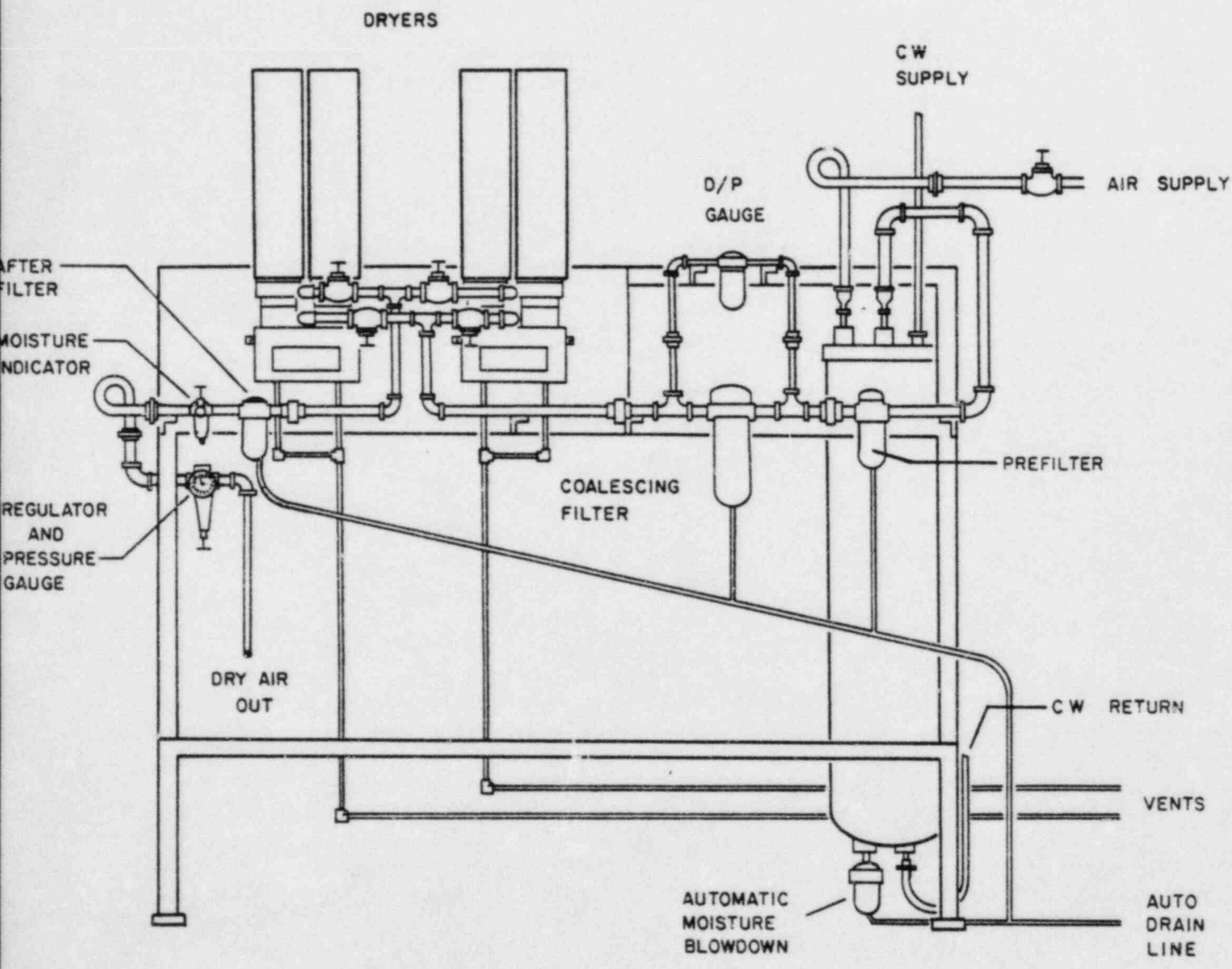

Figure 4. Facility Dry Air System

South Pneumatic Station Modification

The pneumatic control solenoids and associated CO_2 gas lines were modified, and the system, including the gas supply valves, was mounted on a wall bracket. The system line-up efficiency is increased significantly since the piping and valves are arranged in a symmetric configuration which enables the operator to visualilze and accomplish the desired system line-up. The south pneumatic station is presently as shown in Figure 5.

Beam Port #4 Modifications

Modifications have been proposed by the NSC staff to upgrade Beam Port #4 with the installation and calibration of a beam shaper, an improved beam port reflector, and a new water shutter. The beam shaper and filter is installed and the calibration and adjustments are being made at the present time. The plans for the reflector and water shutter are being completed, and the project should be completed in 1984.

C. Operational Problems

Failure of Demineralizer Room Sump Pumps

Through twenty-three years of service, regeneration chemicals slowly destroyed the carbon steel casings on the demineralizer sump pumps and both were rendered out of service. The pumps were removed and a temporary casing patch was used to return one of the pumps to service. Two new pumps with stainless steel casings and internal components were received and installed in July 1983, and the system was returned to service.

Waste Storage Tank Leakage

A leak in waste storage tank #2 was corrected by cleaning and patching. In addition a new water stirrer was installed, and the tank was returned to service in June 1983.

Failure of Two Additional Fuel Elements to Pass Fuel Inspection Criteria

In January 1983 during a partial core inspection of selected high temperature elements it was discovered that one element failed to pass the "go/no go" criteria which indicated that either excessive bowing or swelling had occurred. Since this inspection was being made prior to reinitiation of pulsing operations it was decided to inspect and measure all fuel elements in the reactor core. Considerable effort was involved in this, and the inspection was completed in a relatively short period of time. It should be noted that one additional element failed the inspection criteria. These two elements were included in the fuel shipment to ANL-West (Idaho Falls, Idaho) in August 1983.

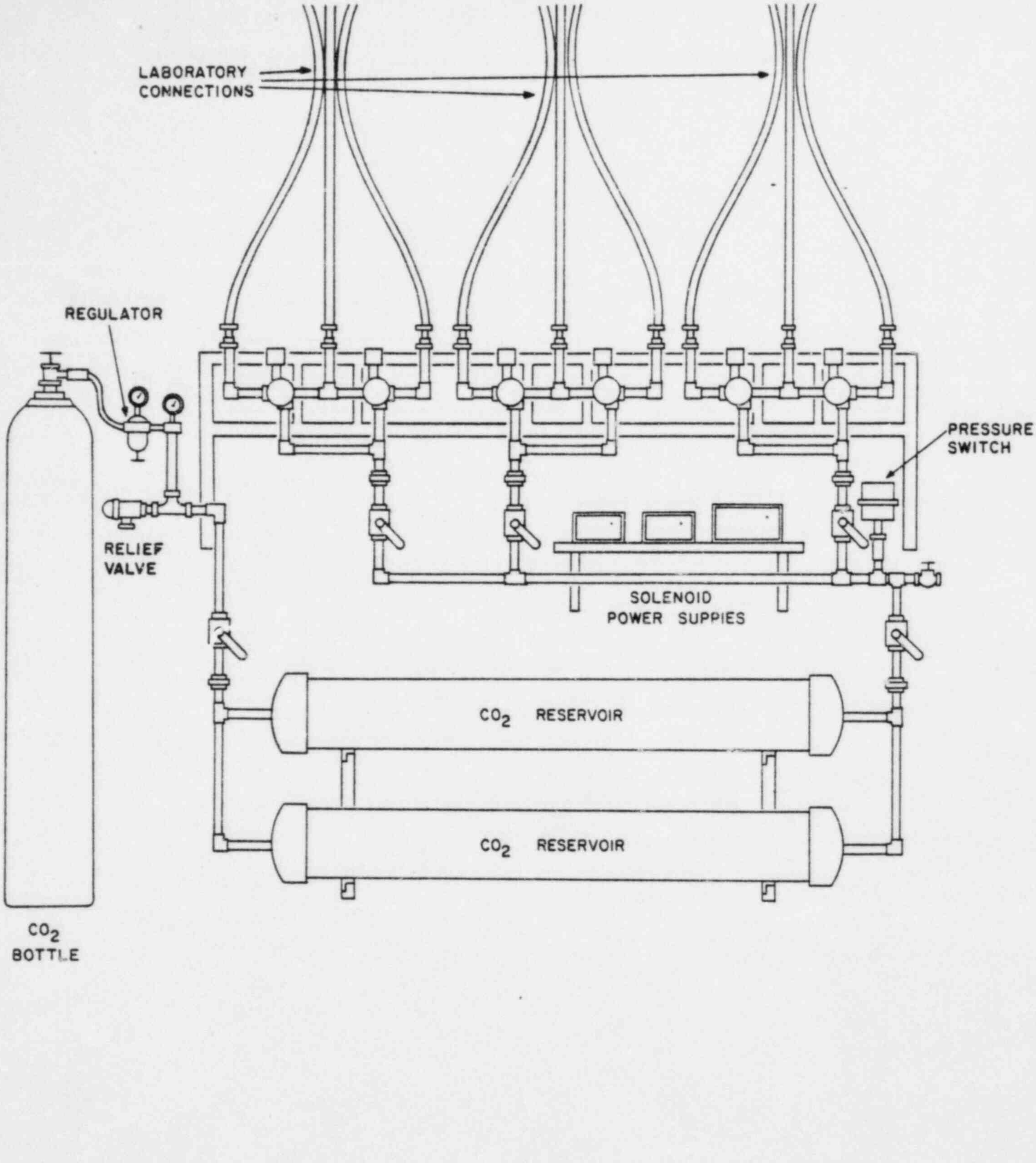

Figure 5. South Pneumatic Station

Secondary Cooling System Pump Failure

In September 1983 an excessive vibration in the secondary cooling pump was observed, and an investigation showed the most probable area of component failure to be the upper and/or lower bearings of the motor. Replacement bearings were obtained and installed while secondary cooling flow was maintained utilizing a fire department pumper truck, such that no reactor operating time was sacrificed. The pump was tested satisfactorily and returned to service, but it was noted that further maintenance may be necessary in the future due to overall wear of the pump shaft and bushings. Additionally, it is suspected that some settling of the pump and cooling tower foundations may have occurred and could be contributing to pump misalignment problems. Further investigation of this situation is planned as the maintenance schedule permits.

Control Rod Drive Units

Several incidents of dropped shim safety control rods during the year have been attributed to either deterioration of the scram magnet coil or deterioration of the coiled extension wiring through which the scram magnet current is supplied. A suitable replacement wiring was developed, and all shim safety rod drives (including the spare rod drive) were upgraded by replacing the original equipment with an equivalent coiled wiring. No further rod drops have since occurred that are directly attributable to deterioration of the coiled extension wiring. Additional shim safety rod drive unit problems that have been experienced are due to the critical upper and lower limit switch adjustments that must be made as a drive unit is installed and tested for operability. A design change of the limit switch adjustable mounting bracket is expected to be addressed by the NSC staff. The maintenance problems experienced with the rod drive units, as described above, have resulted in losses of scheduled hours of operation.

USNRC Enforcement Conference

A reportable occurrence from December 1982 concerning an overpower incident resulted in an NRC enforcement conference held in March 1983. Representatives from USNRC Region IV met with NSC administrative personnel to emphasize the need for proper administrative controls and improved operator training to avoid similar occurrences in the future. In addition a two year program has been implemented to upgrade existing standard operating procedures.

Reportable Occurrences

Bowing Observed in Fuel Elements #7463 and #7386

During a fuel element inspection being performed on 5 January 1983 it was discovered that element #7463 failed the go/no go test.

A slight bowing was observed and the element appeared to be somewhat puffy about midheight. There was not, however, any cladding rupture or apparent scratches. A complete core unloading and fuel inspection was performed and one additional element, #7486, failed the go/no go test due to bowing. Again, there was no cladding rupture or severe scratches present.

In reviewing the history of these two elements it was found that both elements were in the core since 1973 and had not been inspected since that time. In addition both rods were in approximately the same position relative to the transient rod during past pulsing operations. These elements were not inspected at the time fuel damage was first discovered in 1976 since other elements in similar core locations were found to have no visible deformation. It should also be noted that the elements inspected at the time of discovery of fuel damage were reinspected during this past shutdown and showed no signs of abnormal wear. Based on this information it is felt that elements #7463 and #7486 were bowed during pulsing operations prior to September, 1976 and have operated at steady state in that condition since that time. These two elements have been removed from the reactor core, and steady state reactor operation has continued.

Failure of Fuel Thermocouple During Reactor Startup

On January 10, 1983 during a reactor startup to 400 kilowatts it was noticed by the reactor operator that the fuel temperature indication was not tracking. This startup was the initial startup following a core loading during which the instrumented fuel element was handled. The thermocouple was verified operational prior to startup and indicated approximately ambient pool temperature. It was not until the reactor was above the point of adding heat that the operator noted no increase in fuel temperature. At that point the startup was discontinued, and the reactor was shutdown for investigation.

Shorted thermocouples wires were discovered in a terminal box causing the indication to read approximately ambient temperature at all times. The problem was corrected, but during subsequent operation at 400 kilowatts, it was noted that the fuel temperature indication was somewhat lower than that indicated on a second thermocouple (TC #2) in the same element. Therefore, the reactor was shutdown again, and the fuel temperature instrument was connected to the more conservative (highest) indication (TC #2 in IF #8795). The reactor has operated since that time with no further problems.

Possible Operation in Excess of Licensed Power Level

Due to an unexplained disagreement between the linear and safety channel indications the reactor was operated approximately 5% above its licensed power for nine hours on October 3, 1983. The incident

was initiated during reactor operation following movement of the reactor away from an experimental device known to have a negative reactivity worth. The startup performed following movement of the reactor resulted in slightly higher fuel temperature and safety channel indications. These differences were noted by the operators involved but were not pursued. During this time both safety amplifiers indicated 106% while the linear channel, considered to be the "prime standard" power indicator, indicated a power level of 1 Mw. The differences in core parameters were not questioned since minor shifts in safety amplifier readings had been observed on prior occasions due to xenon and experimental conditions in the core.

Calorimetrics were performed to determine reactor power, and operation has been limited to 95% power until a thorough study can be completed to determine actual core power as compared to linear channel indication. In addition an immediate upgrade program was initiated for reactor operations personnel.

D. Reactor Operations Related Items

Reinitiation of Pulsing Operation

Due to the need to pursue research and experimental studies utilizing the NSCR pulsing capabilities, a study was conducted to regain this capability. An extensive pulse test program was developed and presented for review by the Reactor Safety Board. The program was approved and initiated in February 1983 and phase I of this program was successfully completed and reported to the USNRC.

Facility License Renewal

A facility license R-83 was renewed by the USNRC in March 1983 and is valid for twenty years from date of issue. Compliance with license requirements and associated technical specification was immediately established.

Fuel Shipment

In August 1983 the NSC and ANL/West (Idaho) conducted the transfer of 41 Standard and 10 FLIP irradiated TRIGA fuel elements in a DOE/DOE shipment to the ANL/West facility. The shipment was performed following considerable advance preparation on the part of both facilities.

Revision of NSC Normal Schedule of Operation

In September 1983 the normal operation schedule of the NSCR was adjusted to include a second shift (14 hours of operation) on Monday and Tuesday only. A standard day of operation from 8:00 A.M. to 5:00 P.M. was established for Wednesday through Friday, although special arrangements can be made in advance for reactor operation at times other than those normally scheduled.

Measurement of Withdrawal Times For Transient Rod During Pulsing Operation

A timing device developed for the transient rod allows monitoring of rod withdrawal times during puling operation. This device (see Figure 6) consists primarily of a light source/phototransistor assembly mounted on the guide tube and a graduated photographic negative attached to the rod extension. A square wave signal of varying pulse width and repetition rate is generated dependent upon rod speed. The signal is captured on an oscilloscope with storage capability and can be compared to a neutron flux signal which is triggered by the first pulse generated by the timing device.

E. Changes in Operating Procedures

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

SOP Number	Subject
II-B	Operations Records
II-C	Reactor Startup
II-D	Steady State Operation
II-E	Pulsing Operation
II-F	Reactor Shutdown
II-J	Power Calibration
II-K	Control Rod Calibration
II-L	Pulse Calibration
III-C	Linear Power Measuring Channel Maintenance and Surveillance
III-G	Reactor Pulse Power Surveillance
III-P	Millivolt Potentiometer Maintenance and Surveillance
IV-A	Experiment Approval
VI-A	General
VII-A	Health Physics Administration
VII-B	Health Physics Maintenance and Surveillance

F. Unscheduled Shutdowns

A total of nineteen unscheduled shutdowns occurred during 1983. As can be seen several were electronic in nature due to equipment age. The unscheduled shutdowns can be arranged in the following categories:

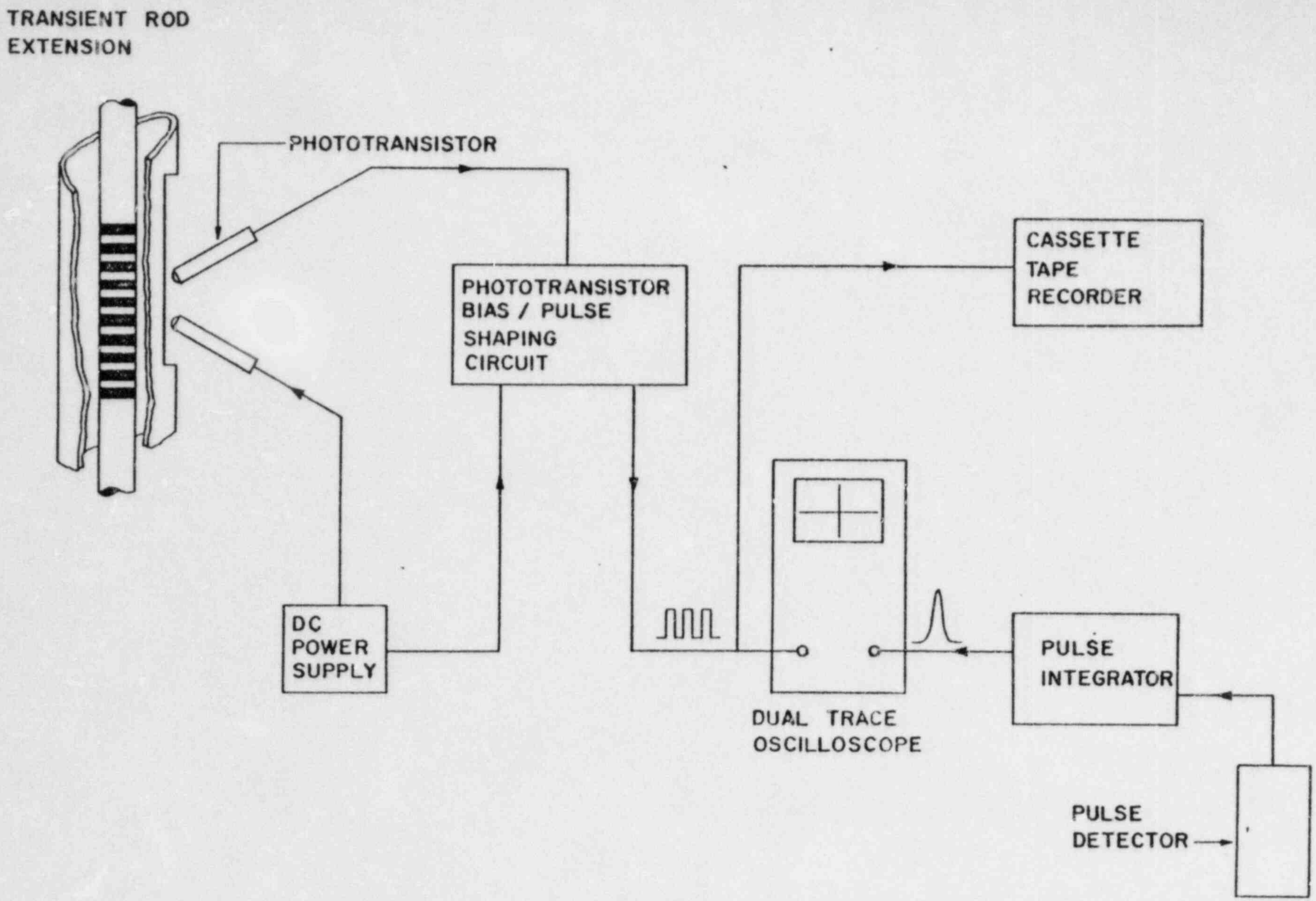

Figure 6. Transient Rod Timing Device

Cause of Shutdowns	Number of Shutdowns
Building power loss	6
Operator error	6
Electronics	7

G. Reactor Maintenance and Surveillance

1. A calibration of the fuel temperature measuring channel was completed on 1-10-83. 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 1983 were as follows:

Core VIII (12-3-83)

Control Rod	Rod Worth
SS #1	$2.64
SS #2	1.64
SS #3	2.21
SS #4	4.23
RR	.85
TR	2.74
Shutdown Margin	4.71

In addition to the above measurements several calibrations were performed on the transient rod to determine if there was a significant difference in total worth under various xenon and experiment load conditions. The following results were obtained in February:

Control Rod	Rod Worth
TR (2/4/83)	$2.89 (with xenon, reactor against beam port reflector).
TR (2/7/83)	2.72 (xenon free, against reflector).
TR (2/11/83)	2.69 (with xenon, away from reflector).
TR (2/14/83)	2.65 (xenon free, away from reflector).

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 $0.16.

5. Pulse operations of the NSCR were reinitiated in February 1983. At that time a detailed test program was implemented to determine the pulse reactivity limit corresponding to the technical specification limit of 830°C maximum core temperature. In addition visual and measurement inspections were required on potential high temperature elements throughout the program. Pulsing continued throughout the year with no indication of abnormal fuel wear or damage.

6. The scram times of the control rods were measured with the following results:

Date	Control Rod	Time in Seconds
1-8-83	SS #1	.956
	TR	1.16
1-9-83	SS #2	.596
	SS #3	.709
	SS #4	.732
1-12-83	SS #2	.648
1-18-83	SS #4	.692
2-25-83	SS #4	.628
	SS #4	.676
4-1-83	SS #1	.684
	SS #3	.676
4-18-83	TR	1.174
4-20-83	TR	.86
5-5-83	SS #4	.67
5-13-83	SS #1	.744
6-30-83	TR	.84
7-5-83	TR	.868
7-11-83	SS #2	.654
7-14-83	SS #1	.626
7-21-83	SS #2	.60
8-10-83	SS #3	.684
9-7-83	SS #1	.604
9-8-83	SS #1	.604
9-30-83	SS #1	.566

Date	Control Rod	Time in Seconds
10-14-83	SS #2	.594
10-21-83	SS #4	.670
	SS #2	.628
11-11-83	TR	.828
11-23-83	SS #2	.624
	SS #1	.608

7. 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.

8. 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
1-10-83	400	448	*+22.0	VIII
1-11-83	400	343	*-14.2	VIII
1-17-83	400	375	- 6.2	VIII
10-5-83	400	370	- 7.5	VIII
10-10-83	400	417	+ 4.0	VIII

*It should be noted that the large error was a result of detector repositioning during annual maintenance and was corrected prior to operating the reactor at licensed power.

9. The ventilation system was verified to be operable by conducting a test of the system each week throughout the year.

10. Emergency evacuation drills were conducted on 3-25-83 and 7-15-83.

11. Weekly checks were performed throughout the year to verify that the NSC security alarm system was operable.

12. Calibration dates for facility air monitors and area radiation monitors were as follows:

Monitoring System	Date of Calibration
Ch #1 - Stack Particulate	7-28-83
Ch #2 - Fission Product	6-4-83
Ch #3 - Stack Gas	7-28-83
Ch #4 - Building Particulate	7-22-83
Ch #6 - Building Gas	7-28-83
Area Radiation Monitors	10-7-83

13. A review of the NSC security plan was conducted by the NSC staff and the Reactor Safety Board on January 28, 1983.

IV. FACILITY ADMINISTRATION

A. Organization

The organization chart for reactor operations at the Nuclear Science Center is presented in Figure 7. During this reporting year Donald E. Feltz was named Director, and R. Dale Rogers was promoted to Assistant Director. Gary Waldrep resigned as Manager of Technical Services and was temporarily replaced by Dr. R. T. Perry. Jerald Head has since assumed the duties as Manager of Technical Services upon the transfer of Dr. R. T. Perry to the Nuclear Engineering Department at Texas A&M University. Barry Willits was assigned as Manager of Reactor Operations, and Terry Rolon was promoted to Reactor Supervisor following the resignation of Dan Rodgers. Barry Willits and Jerald Head received senior reactor operator licenses and Scott Thomas received his reactor operator license in 1983. A reduction in the reactor operating schedule effective in September resulted in a small cutback in personnel, and John Theis has terminated as Reactor Supervisor. The NSC does, however, employ students 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, 1983 - December 31, 1983.

Facility Administration and Reactor Operations Staff

+Feltz, D. E.	- Director
+Petesch, J. E.	- Reactor Supervisor
+Rodgers, D. J.	- Reactor Supervisor (Terminated)
+Rogers, R. D.	- Assistant Director
+Rolon, T. R.	- Reactor Supervisor

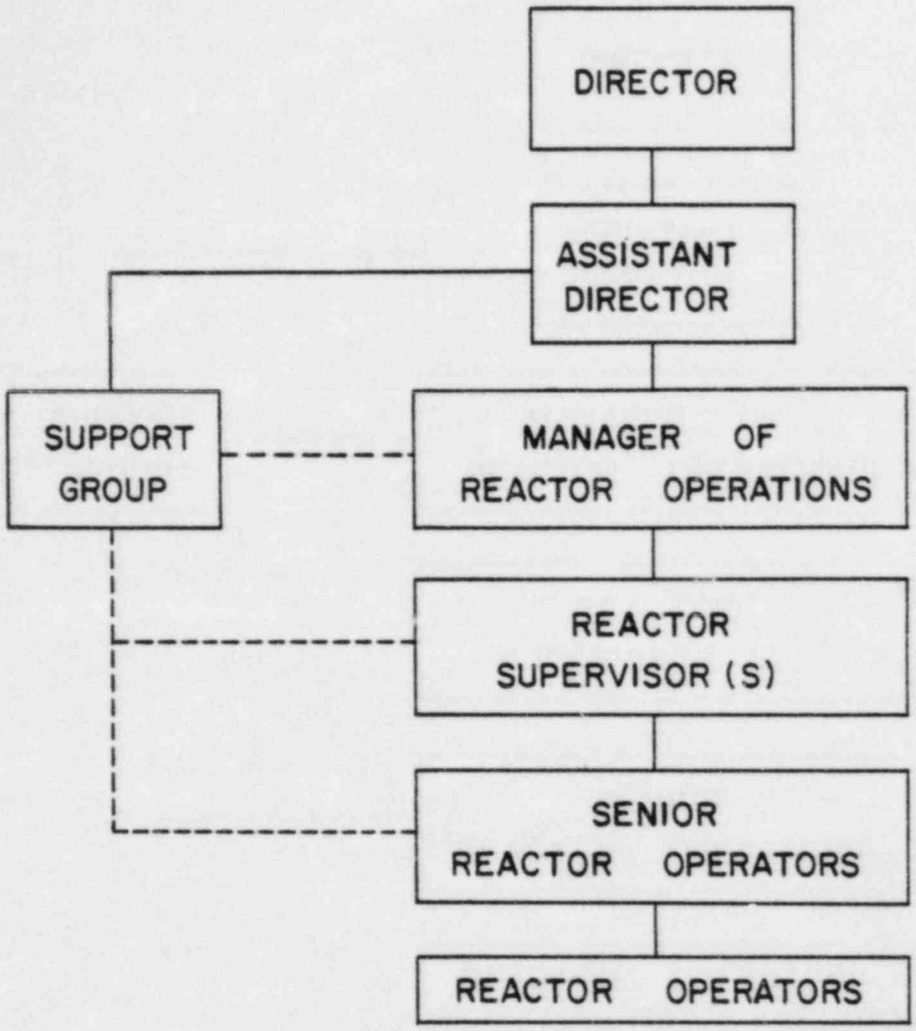

Figure 7. Nuclear Science Center Reactor Operations Organization Chart

Facility Administration and Reactor Operations Staff (Cont'd)

+Sims, W. W.	- Reactor Operator
+Theis, J. W.	- Reactor Supervisor (Terminated)
*Thomas, S. R.	- Reactor Operator
+Willits, B. L.	- Manager, Reactor Operations

Technical Service and Maintenance

Deigl, C.	- Draftsman (Terminated)
Fisher, T.	- Scientific Instrument Maker II
Goodman, D.	- Student Technician
+Head, J. G.	- Manager, Technical Services
*Head, K. M.	- Engineering Research Associate
Horn, C. R.	- Mechanical Equipment Foreman
Johnson, G.	- Student Worker I
Khalil, N.	- Co-op Research Aide
*Land, R.	- Engineering Research Associate (Terminated)
Mattern, J.	- Co-op Research Aide
Perry, R. T.	- Manager, Technical Services (Terminated)
Restivo, A. L.	- Engineering Research Associate
Schneider, L.	- Student Worker I
Thompson, J.	- Reactor Maintenance Technician
Thompson, L.	- Reactor Maintenance Supervisor (Terminated)
+Waldrep, G. W.	- Manager, Technical Services (Terminated)
Whitworth, D. W.	- Draftsman
Yupari, R.	- Student Technician (Terminated)

*Licensed Reactor Operator
+Licensed Senior Reactor Operator

Clerical

Huss, K.	- Receptionist (Terminated)
Mitchell, Y.	- Secretary
Ribardo, J.	- Bookkeeper

Health Physics Staff

Contreras, Y.	- Health Physicist
Deigl, H. J.	- Senior Health Physicist
Rodriguez, L.	- Health Physicist
Stehle, W.	- Health Physicist (Terminated)

Texas Engineering Extension Service (Nuclear Training Staff)

Bradley, D.	- Secretary (Terminated)
Buchanan, R. J.	- Training Specialist
Dunn, R. F.	- Instructor (Terminated)
Holste, C.	- Instructor (Terminated)
White, R.	- Instructor (Terminated)

C. Reactor Safety Board

Committee Composition

Chairman

F. Jennings, Director, Office of University Research
(January 1, 1983 - December 31, 1983)

Voting Members

Dr. F. Sicilio, Professor of Chemistry
(January 1, 1983 - December 31, 1983)

Dr. R. L. Watson, Professor of Chemistry and Associate Dean of Science
(January 1, 1983 - August 31, 1983) (Term completed)

Dr. R. R. Hart, Professor of Nuclear Engineering
(January 1, 1983 - December 31, 1983)

Dr. E. A. Schweikert, Professor of Chemistry
(January 1, 1983 - December 31, 1983)

Dr. K. L. Wolf, Professor of Chemistry
(September 1, 1983 - December 31, 1983) (Initial appointment)

R. Green, Assistant Professor, Small Animal Clinic
(January 1, 1983 - December 31, 1983)

Dr. R. A. Kenefick, Professor of Physics
(January 1, 1983 - December 31, 1983)

Ex-Officio Members

Dr. C. A. Erdman, Professor and Head of Nuclear Engineering
(January 1, 1983 - December 31, 1983)

D. E. Feltz, Director of Nuclear Science Center
(January 1, 1983 - December 31, 1983)

Dr. R. D. Neff, Professor and University Radiological Safety Officer
(January 1, 1983 - December 31, 1983)

Meeting Frequency

The Reactor Safety Board (RSB) met on the following dates during the calendar year 1983: 1/18/83, 4/13/83, 7/5/83 (Subcommittee), 7/25/83, 10/28/83.

RSB Audits

During the reporting period RSB audits of NSC activities were conducted on the following dates: 1/14/83, 4/12/83, 7/11/83, 11/7/83.

APPENDIX I

Description of Projects Utilizing
the NSCR

DESCRIPTION OF PROJECTS UTILIZING THE NSCR

A. <u>Texas A&M University</u>

<u>Nuclear Engineering</u>

NEUTRON DOSIMETRY OF A U-Zr HYDRIDE FUELED REACTOR

Personnel

Dr. Gerald A. Schlapper -- Professor
John O'Donnell -- Graduate Assistant

Neutron spectral measurements were made in various locations in the reactor core. These measurements were made using threshold foils during both steady-state and pulse operations. Information obtained will be used in other pending research involving the NSCR.

SELF-ANNEALING EFFECTS ON NEUTRON TRANSMUTATION DOPED SILICON

Personnel

Dr. Ron R. Hart -- Professor

A study was performed for Universal Technology Corporation to determine the effect of self-annealing on energy levels in neutron transmutation doped (NTD) silicon. This project was a joint effort involving the University of Missouri Research Reactor (MURR) and the NSCR. Silicon samples doped at the NSC were compared to those doped at MURR where self-annealing due to gamma heating is significant. These results were then used by the Air Force Wright Aeronautical Laboratory (AFWAL) to characterize NTD silicon for detectors.

NEUTRON FLUX PROFILE MEASUREMENTS IN THE NSCR

Personnel

Dr. Gerald A. Schlapper -- Professor
Glenn Sjoden -- Student

Reactor flux profile studies were performed using bare and cadmium covered cobalt wires. Information gained is part of an increasing effort to better characterize the NSCR.

KINETICS AND CONTROL OF A SPACE REACTOR DESIGN

Personnel

Dr. Gerald A. Schlapper -- Professor
Steve Vrana -- Graduate Assistant

Comparisons of measured and calculated response of the NSCR during pulsing were made to test a computer based kinetics model. This model is being developed for research pending with the U.S. Air Force.

FLUENCE MONITOR CALIBRATION OF MRID FOR NTD OF SILICON

Personnel

Dr. Ron R. Hart -- Professor
Kenneth L. Welch -- Graduate Assistant
Jerald G. Head -- Technical Services
Tom Fisher -- Electronics Technician

A current integrating device, designed and constructed by NSC staff, was calibrated for use with a self-powered neutron detector to monitor MRID during irradiations of Silicon ingots. This system should provide more accurate predictions of Phosphorus concentrations achieved.

ANALYSIS OF SORBER PERFORMANCE ON THE RECOVERY OF URANIUM FROM SEAWATER

Personnel

Dr. Frederick R. Best -- Assistant Professor
Huan Giap -- Undergraduate
Jose Pina -- Graduate Assistant

The uranium concentration profile for hydrous titanium oxide pellets and acrylic amidoxime resins POG503 and 501 were determined using track-etch techniques. Measurements showed that all three sorbers have an inert core region that contained no uranium so that the uranium concentration in the enriched rind is much higher than the bulk uranium concentrations measured by other techniques.

FUSION REACTOR BLANKET RESEARCH

Personnel

Dr. T. A. Parish -- 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.

SORBER PERFORMANCE DATA ON THE RECOVERY OF STRATEGIC ELEMENTS FROM SEAWATER

Personnel

Dr. Frederick R. Best -- Assistant Professor
Matthew M. Whiteacre -- Graduate Assistant

NAA was used to determine the total elemental analysis of 17 different sorbers exposed to natural seawater for periods of 3 to 7 days. Potentially interesting quantities of aluminum, vanadium, chromium, cobalt, and molybdenum were found.

DEVELOPMENT OF AN AUTOMATIC FLUX WIRE COUNTER

Personnel

Dr. G. A. Schlapper -- Professor
David Goodman -- Student

Interest in reactor flux profiles led to the development of an automatic flux wire counting device to eliminate the tedious procedures used in the past. The device consists of a stepping motor, a beta scintillator detector and a multichannel scaler. Beta particle emitting wires can then be counted continuously to yield a flux profile for the core without having to cut the wire into smaller pieces.

Chemistry

COMPLEXES AND CATIONS SUPPORTED ON THE SURFACE AND BETWEEN LAYERS OF ZIRCONIUM PHOSPHATE I. COPPER (II) AND ITS AMMONIA COMPLEXES

Personnel

Dr. A. Clearfield -- Professor
Bharati Menta -- Post Doctorate

Neutron activation analysis was used to determine cation content of complexes placed on the surface of Zirconium Phosphate and to determine the ion exchange of alkali metal cations. This information may be valuable in the development of fuel cells based on Zirconium Phosphate conductors.

STABILITY OF $HZr_2(PO_4)_3$ AT HIGH TEMPERATURES

Personnel

Dr. A. Clearfield -- Professor
Brian Roberts -- Graduate Assistant

The compound $NaZr_2(PO_4)_3$ is the end member of a solid solution series of general composition $Na_{1+x}Zr_2Si_xP_{3-x}O_{12}$. These compounds are of interest because the solids for which x = 1.8-2.3 are fast ion conductors. The question arises as to whether the protonic forms of these compounds would also be fast proton conductors. There is at present a great deal of interest in obtaining heat stable proton conductors for use in a variety of fuel cells. Our interest stems from curiosity as to the mechanism of proton conduction in solids as well as the practical use of these materials. Thus, the problem to be solved is the preparation of $HZr_2(PO_4)_3$, the determination of its stability to high temperature and eventually to measure the conductivity.

A STUDY OF URANIUM IN SOUTH TEXAS LIGNITE

Personnel

Dr. Ralph Zingaro -- Professor
Wayne A. Ilger -- Graduate Assistant

The delayed neutron counting system was used to determine the actual uranium content in South Texas Lignites. This was part of a project funded by the Welch Foundation and TENRAC to determine the quantity and oxidation state of uranium in lignite.

TRACE ELEMENT CHARACTERIZATION OF DEEP BASIN LIGNITES OF TEXAS

Personnel

Dr. Mysore S. Mohan -- Professor
Dr. Ralph A. Zingaro -- Professor
Wayne Ilger -- Graduate Assistant
Drew Ilger -- Graduate Assistant

NAA was used for trace element and uranium analysis of lignite samples from South Texas. This work was performed to determine analytical concentration and chemical form of the elements in order to predict technological and environmental impact of the use of these lignites as fuel.

ANALYSIS OF CHERT SAMPLES IN RELATION TO ANCIENT CULTURES

Personnel

Dr. M. Rowe -- Professor
Mark Tobey -- Student

This investigation was performed as a joint effort between the Archaeology and Chemistry Departments. Chert samples were analyzed using neutron activation analysis in conjunction with the NSCR and the Canberra Scorpio analyzing system. Trace metals and rare earth elements in tool samples were identified so that matches between environments and cultures could be made. This work resulted in a trip for the experimenter to gather further data and extend the range of the findings. Studies will continue into 1984.

Center for Trace Characterization

ANALYSIS OF NIGERIAN DOMESTIC SOAPS

Personnel

Dr. M. Akanni -- Visiting Professor
Dr. W. D. James -- Professor

Neutron activation analysis was used to determine trace element concentrations in soaps from Nigeria. This study was an application of a new technique to determine composition of soaps made from ashes.

BIOAVAILABILITY OF As., ETC. FROM FLY ASH

Personnel

Dr. W. D. James -- Professor
Victor Ogugbuaja -- Graduate Assistant

Neutron activation analysis was used to determine trace element concentrations in rats due to ingestion of fly ash. This study, funded by EPRI, was performed in conjunction with Battelle Columbus Laboratories.

NAA OF VIOLIN WOODS

Personnel

Dr. Dennis James -- Professor
Dr. J. Nagyvary -- Professor, Biochemistry/Biophysics

Samples of wood from violins were analyzed in an attempt to discover the wood treatment processes used during construction. Analyses seem to indicate that the wood was treated with seawater. Results may lead to a rediscovery of ancient violin construction techniques. Articles on these results were published in Science Digest, Discover, and Science '84.

MEASUREMENTS OF BA, CR, AND V IN MARINE SEDIMENTS

Personnel

Dr. Dennis James -- Professor
Dr. B. Presley -- Oceanography

Further studies were conducted of trace element concentrations in marine sediments. In particular, Ba, Cr, and V released from offshore drilling sites was traced into the environment in marine sediments. This is a new approach for sediment tracking.

FATE OF TRACE ELEMENTS IN MHD COAL COMBUSTION

Personnel

Dr. W. D. James -- Professor
Dr. M. Akanni -- Visiting Professor

Neutron activation analysis was used to determine the trace element distribution patterns in effluents from magneto hydrodynamic coal combustion and the results compared to those from conventional coal burning facilities.

PRELIMINARY FIRE ANT DIET MARKER STUDIES

Personnel

Dr. W. D. James -- Professor
Dr. S. B. Vinson -- Professor, Entomology

Stable isotope tracer techniques are gaining widespread use in animal science applications. A similar study may also be possible to gain information on the feeding habits of the fire ant. Some preliminary measurements of rare earth content of fire ants was performed using NAA

Civil Engineering (Air Quality Control)

CHARACTERIZATION OF TEXAS LIGNITES

Personnel

Dr. Andrew McFarland -- Professor
Dr. Dennis James -- CTC
Bob Diot -- Graduate Assistant

Neutron activation analysis was performed by CTC to characterize and determine the environmental control implications of Texas lignite. Preliminary studies of asbestos were also performed by NAA and by analysis of thermoluminescent glow curves. Further work with asbestos is pending in fiscal year 1984.

Radiological Safety Office

URANIUM CONTENT IN LIGNITE SAMPLES

Personnel

Dr. R. D. Neff -- Professor
John O'Donnell -- Graduate Student

The NSC delayed neutron counting system was used to determine the uranium content in lignite samples. This work was a continuation of studies to determine the biological hazards of coal combustion.

Biology

RADIATION INDUCED MUTATIONS IN PROTOZOA

Personnel

Dr. Karl Aufterheide -- Professor
Venetia Simmons -- Student
James Terrio -- Student

Attempts were made to induce mutations in cultures of common protozoa using radiation. Research had already been performed using x-ray and ultraviolet radiation exposures. Further studies were made at the NSC using thermal neutrons and gamma radiation as the mutagen.

Animal Science

FLOW OF INGESTED FORAGE PARTICLES THROUGH THE G.I. TRACT OF CATTLE

Personnel

Dr. W. C. Ellis -- Professor
Vivian Latimer -- Lab Technician
Larry Roth -- Graduate Assistant
Dave Delaney -- Graduate Assistant
Bobby Warrington -- Graduate Assistant

Further studies of cattle G.I. tracts were made using rare earth tracers. Ingested forage particles were activated and quantities of rare earth tracers added to the feed were measured at various points along the G.I. tract.

Veterinary Physiology and Pharmacology

DETERMINATION OF EXCHANGEABLE POTASSIUM IN THE CANINE BY MEANS OF WHOLE BODY COUNTING

Personnel

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

Comparisons were made of the amounts of exchangeable potassium measured by the urinary method and those measured by whole body counting to determine the accuracy of whole body counting of canines. Several dogs were injected with a potassium-42 chloride solution and measurements made of the ^{42}K concentration in urine samples. until the isotope had equilibrated. The known amount of ^{42}K injected minus that excreted through the urin was compared to the data obtained from a whole body count.

B. Other Universities

Sam Houston State University

NEUTRON TRANSMUTATION DOPING AND ACTIVATION ANALYSIS OF LASER PRODUCED PLASMA DEPOSITS

Personnel

Dr. B. Covington -- Assistant Professor, Physics
Dr. C. K. Manka -- Assistant Professor, Physics

Continued tests of neutron transmutation doped (NTD) semiconductor materials were peformed to determine more practical applications of this technique. Studies were also performed using NAA to determine aluminum released from a laser produced plasmas. Further research is to be performed using dysprosium as the activant.

Texas State Technical Institute (Harlingen, Texas)

Personnel

Mr. Pedro Jimenez -- Chairman, Nuclear Technology

During June of 1983, eight students and two staff members from the Nuclear Technology Department spent three days at the NSC for hands-on training in the following topics:

Activation Analysis and Ge(Li) Spectrometry
Reactor Pool Water Analysis
Shipment of Radioactive Materials
Decontamination Exercise
Survey Instrument Calibration
Gas-Proportional Counting
Air Sampling

Texas State Technical Institute (Waco, Texas)

Personnel

Mr. Carl Kee -- Chairman, Nuclear Technology

During 1983, the TSTI Nuclear Technology enrollment was 68 students. During their tenure each student spent approximately 164 clock hours at the NSC. Therefore, TSTI students spent approximately 11,152 student hours at the NSC undergoing training in health physics.

Louisiana State University

USE OF RARE EARTHS AS STABLE TRACERS

Personnel

Dr. R. Knaus -- Assistant Professor

Studies were made of the slow, natural leaching of Indium, Dysprosium, and Samarium stable tracers into a small stream from the carcasses of five 10-15 pound rainbow trout. Samples were gathered from above (background) and below the point where the trout were allowed to decay naturally. NAA was then used to analyze these samples.

Sul Ross State University

GEOLOGIC STUDIES

Personnel

Dr. Dennis O. Nelson -- Associate Professor
Dr. G. David Mattison -- Associate Professor
Dr. David Rohs -- Assistant Professor

A number of geologic studies were performed using neutron activation analysis. These studies include:

1. Geochemistry of the Igneous Rocks of the Davis Mountains, West Texas.

2. Geochemistry of the Igneous Rocks of Clarion Island, Mexico.

3. Geochemistry of the Igneous Rocks of the Big Bend Park, West Texas.

4. Geochemistry of the Igneous Rocks of Black Gap, Texas.

5. Geochemical Characterization of Deep-Water Carbonates.

6. Composition of Benthic Organisms in a Fresh Water Stream.

7. Geochemistry of Tertiary Volcanic Rocks, Mexico.

C. Non-University Institutions

Texas Instruments

QUALITY ASSURANCE TESTS OF SEMICONDUCTOR MATERIALS USING NAA

Personnel

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

Silicon samples, activated at the NSC and shipped back to TI in Dallas, were analyzed for trace element impurities. Elements of interest include Au, Cr, W, Sb, Pt, La, Ga, Co, and K. Results were used to improve production techniques and increase the quality of semiconductors being produced.

White Sands Missile Range

USE OF ^{24}Na AS A MISSILE PROJECTILE TRACER

Personnel

Captain John Bliss -- White Sands Missile Range

A device containing Na_2Co_3 was activated to produce 1 Curie of ^{24}Na. This device was then flown to White Sands Missile Range and attached to a missile which was fired and then aborted in mid-flight. The ^{24}Na gammas then provided a means of locating the warhead of the missile even though it had buried in the sand. The test was performed to benchmark trajectory models used to determine the location of missile warheads after being aborted.

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. 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).

2. 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).

3. 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.

4. M. D. Devous, Sr., "A Canine Model of Congestive Heart Failure", University of Florida, Department of Radiology and Department of Cardiology, November 1977.

5. 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.

6. J. D. Randall, "Forensic Ac vation Analysis", NSCR Technical Report No. 36, November 197

7. Skinner, N. G., "Nuclear Engineering Aspects of Neutron Transmutation Doping of Silicon", Master's Project in Nuclear Engineering, Texas A&M University, 1977.

8. 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.

9. D. Wootan, "Measurement of Neutron Flux in Thermal Rotisserie", Master's Thesis in Nuclear Engineering, November 1978.

10. Huang, W., J. Chatham, "Uranium in Lignite: I Geological Occurrence in Texas", Tenth International Congress on Sedimentology, Volume 1, A-L, pp. 317, 1978.

11. 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.

12. 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.

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

14. 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.

15. 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.

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

17. 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.

18. 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.

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

20. 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".

21. 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.

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

23. 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.

24. 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).

25. Chatham, J.R., "A Study of Uranium Distribution in an Upper Jackson Lignite - Sandstone Ore Body, South Texas", Masters' Thesis in Geology, May 1979.

26. Parks, S.L., "Distribution and Possible Mechanism of Uranium Accumulation in the Catahoula Tuff, Live Oak County, Texas", Masters' Thesis in Geology, May 1979.

27. Miller, M.E., "Uranium Roll Front Study in the Upper Jackson Group Alascosa County, Texas", Masters' Thesis in Geology, December 1979.

28. 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.

29. Ellis, W.C., J.H. Matis, and Carlos Lascano, "Sites Contributing to Compartmental Flow for Forage Residues", Ann. Res. Vet, 1979.

30. Lescano, Carlos, "Determination of Grazed Forage Voluntary Intake", Ph.D. Dissertation in Animal Nutrition, December 1979.

31. 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.

32. Loza, Hector, "Effect of Protein Defficiency on Forage Intake and Digestibility", Mast.rs' Thesis in Animal Nutrition, May 1979.

33. Tenhet, Vicki L., "Penetration Mechanism and Distribution Gradients of Sodium-Tripoly-Phosphate in Peeled and Deveined Shrimp", Masters' Thesis in Animal Science, December 1979.

34. 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).

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

36. 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.

37. 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.

38. "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).

39. "Organization and Management of Health Physics Support for a Research Reactor", E.F. Bates with R.D. Neff and J.D. Randall, (March 1980).

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

41. "Formation of 1-Silacyclopenta-2,4diene Through Recoil Silicon Atom Reactions", E.E. Siefert, K.-L. Loh, R.A. Ferrieri, and Y.-N. Tang, J. Am. Chem. Soc., 102, 2285, (1980).

42. "Fluoride Atom Shift in 1,2-Difluoroethyl Radicals", J.C.S. Chem. Comm., 814 (1980).

43. 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).

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

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

46. 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.

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

48. 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.

49. "Reactions of Monomeric Difluorosilylene with Ethylene", E.E. Siefert, S.D. Witt, and Y.-N. Tang, J. Chem. Soc., Chem. Comm., 217-218 (1981).

50. "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).

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

52. 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 Carboxyglase Activity", Texas Journal of Science, December, 1981.

53. "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.

54. "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.

55. "Quick Separation of Manganese from Brine Solutions Radiochem Radioanal Letters 51, 65 (1982) with G. L. Grout and C. L. Webre.

56. "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.

57. "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.

58. "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.

59. "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).

60. 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.

61. 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.

62. John H. Schieffer and G. David Mattison, "Nature and Origin of Alkalic and Calcic Veinlets in Xenoliths from the Terlingua District, West Texas. Geological Society of America, October, 1982.

63. C. Conrad, "Uranium in the Oatman Creek Granite and Its Economic Impact", Masters Thesis in Geology, 1982.

64. W. Schaftenaar, "Uranium in Igneous Rock of the Central Davis Mountains of West Texas", Masters Thesis in Geology, 1982.

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

66. 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.

67. Beasley, C. W., "Perfusion Measurement with Rubidium 81 to Krypton 81m Ratio", Ph.D., Dissertion in Veterinary Physiology and Pharmacology, Texas A&M University, 1982.

68. 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.

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

70. 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.

71. 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.

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

73. 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.

74. 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.

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

76. 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.

77. Kennicutt II, M. C., Keeney-Kennicutt, 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).

78. Presley, B. J., Sheu, D. D., "Orea Basin: Recent Deep-Sea Black Mud", Annual Meeting of the Geological Society of America, Indianapolis, Indiana (1983).

79. Whiteacre, M., "Sorber Performance Data on the Recovery of Strategic Elements from Seawater", Master's Project in Nuclear Engineering, Texas A&M University, 1983.

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

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

82. 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.

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

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

85. 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.

86. 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).

87. Goodman, D. G., "Motor Driven Flux Wire Counter", Technical Report Number 45, 1983.

88. 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.

89. 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.

90. 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.

91. Ilger, W. A., "A Study of Uranium in South Texas Lignite", Master's Thesis in Chemistry, Texas A&M University, 1983.

92. 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 Senger, ed., Springer-Verlay, 1984.

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 1983

_____ Provided health physics monitoring support for processing 1198 irradiations containing over 19,655 samples and approximately 2236 curies of radioactivity.

_____ Certified 624 shipments of radiaoctive materials to off-site industry.

_____ Certified 117 shipments of radioactive materials to other campus laboratories.

_____ Provided monitoring support for processing and handling over 11,466 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 55 soil, water, vegetation, and milk samples.

_____ Provided personnel monitoring support for ~ 35 persons on a daily basis and 5008 visitors as required.

_____ Performed radionuclide analyses and packaged approximately 29.2 Ft^3 of dry solid radioactive waste for disposal.

_____ Performed radioisotope identification and determined radioactivity concentrations for 43 releases of radioactive liquid effluents totaling 2,600,000 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 64 NSC employees and experimental personnel using NSC facilities.

EFFLUENT RELEASE SUMMARY

Introduction

Summaries of radioactive effluents released from the Nuclear Science Center for 1983 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 6.86 E-12 µCi/cc. Total radioactivity released for the year was 3.98 E-04 curies. There were 4 radioisotopes with > 8 day half-lives identified from isotopic analyses of the filter papers in addition to the < 8 day half-lives of the decay daughters of Radon-Thorium. 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 1983 was 1.77 curies. This results in an annual average release rate of 2.46 E-08 µCi/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 43 liquid waste releases totaling 2.84 E 06 gallons including diluents from the Nuclear Science Center during 1983. The total radioactivity released for 1983 was 5.54 E-03 Ci with an average concentration of 5.34 E-07 µCi/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
1983

Month	Exhaust Volume (cc)	Concentration (µCi/cc)	Total Radioactivity (µCi)	(Ci)
January	6.31 E 12	6.85 E-12	43.22	4.32 E-05
February	5.91 E 12	2.05 E-12	13.89	1.39 E-05
March	6.31 E 12	5.03 E-12	31.74	3.17 E-05
April	6.12 E 12	1.07 E-12	6.55	6.55 E-06
May	6.31 E 12	1.07 E-12	6.75	6.75 E-06
June	6.12 E 12	1.18 E-12	7.22	7.22 E-06
July	6.31 E 12	4.8 E-12	30.29	3.03 E-05
August	6.31 E 12	3.75 E-12	23.66	2.37 E-05
September	6.12 E 12	2.39 E-11	146.27	1.46 E-04
October	6.31 E 12	6.82 E-12	43.03	4.30 E-05
November	6.12 E 12	1.70 E-12	10.40	1.04 E-05
December	6.31 E 12	2.38 E-11	15.02	1.50 E-05

Total Volume: 7.45 E 13 cc

Annual Average Release: 6.86 E-12 µCi/cc

Total Radioactivity Released: 3.78 E-04

TABLE 2
GASEOUS EFFLUENT RELEASES
ARGON-41
ANNUAL SUMMARY
1983

Month	Exhaust Volume (cc)	Concentration* (μCi/cc)	Concentration** (μCi/cc)	Ratio MPC**	Total Radio-activity (Ci)*
January	6.31 E 12	1.02 E-08	5.10 E-11	1.28 E-03	6.44 E-02
February	5.91 E 12	8.31 E-09	4.16 E-11	1.04 E-03	4.91 E-02
March	6.31 E 12	4.59 E-09	2.29 E-11	5.73 E-04	2.90 E-02
April	6.12 E 12	1.11 E-08	5.55 E-11	1.39 E-03	6.79 E-02
May	6.31 E 12	2.04 E-08	1.02 E-10	2.55 E-03	1.28 E-01
June	6.12 E 12	5.99 E-08	3.00 E-10	7.50 E-03	3.67 E-01
July	6.31 E 12	3.45 E-08	1.73 E-10	4.33 E-03	2.18 E-01
August	6.31 E 12	2.23 E-08	1.12 E-10	2.80 E-03	1.41 E-01
September	6.12 E 12	2.92 E-08	1.46 E-10	3.65 E-03	1.79 E-01
October	6.31 E 12	2.17 E-08	1.09 E-10	2.73 E-03	1.37 E-01
November	6.12 E 12	1.89 E-08	9.45 E-11	2.36 E-03	1.16 E-01
December	6.31 E 12	5.40 E-08	2.70 E-10	6.75 E-03	3.41 E-01

Total Volume: 7.45 E 13 cc

Annual Average Release*: 2.46 E-08 μCi/cc

Total Radioactivity Released*: 1.77 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
1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Ce-141	1	1.26E+08	4.73016E-08	9E-05	.0525573	5.96E-06
CS-137	1	3.41E+08	1.96188E-09	2E-05	9.80939E-03	6.69E-07
Cd-115	2	2.51E+08	3.20717E-07	3E-05	1.06906	8.05E-05
Co-57	3	6.46E+08	3.97833E-08	4E-04	9.94582E-03	2.57E-05
Co-58	16	2.988E+09	1.98527E-07	9E-05	.220586	5.932E-04
Co-60	39	5.971E+09	5.22174E-07	3E-05	1.74058	3.1179E-03
Au-198	1	1.52E+08	1.16447E-08	5E-05	.0232895	1.77E-06
Ir-192	3	6.41E+08	6.69392E-08	4E-05	.167348	4.2908E-05
Mn-54	23	3.799E+09	2.66146E-07	1E-04	.266146	1.01109E-03
Na-22	2	4.5E+08	1.45778E-08	3E-05	.0485926	6.56E-06
Na-24	3	4.29E+08	1.67483E-07	3E-05	.558275	7.185E-05
Tb-160	1	9.85E+07	4.31472E-07	4E-05	1.07868	4.25E-05
Zn-65	25	4.001E+09	1.05439E-06	1E-04	1.05439	4.2186E-03

Total Number of Releases: 43

Total Volume Including Dilution: 1.038E+10 mL

Total Activity: 5.544E-03 Curies

Average Concentration Including Dilution: 5.34104E-07 µCi/cc

TABLE 4
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
January 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Cd-115	1	1.42E+08	2.07746E-07	3E-05	.692488	2.95E-05
Co-58	3	3.516E+08	8.04608E-08	9E-05	.0894008	2.829E-05
Co-60	7	8.646E+08	1.86398E-07	3E-05	.621328	1.6116E-04
Mn-54	6	7.106E+08	1.02927E-07	1E-04	.102927	7.314E-05
Na-24	1	1.42E+08	1.23239E-08	3E-05	.0410798	1.75E-06
Zn-65	6	7.106E+U8	2.37405E-07	1E-04	.237405	1.687E-04

Total Number of Releases: 7

Total Number Released (with dilution): 8.646E+08 mL

Average Concentration (with dilution): 5.34779E-07 µCi/cc

Total Radioactivity: 4.6237E-04 Curies

TABLE 5
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
February 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-58	2	3.29E+08	1.27964E-07	9E-05	.142182	4.21E-05
Co-60	5	6.30339E+08	3.23509E-07	3E-05	1.07836	2.0392E-04
Au-198	1	1.52E+08	1.16447E-08	5E-05	.0232895	1.77E-06
Ir-192	1	1.67E+08	1.18563E-07	4E-05	.296407	1.98E-05
Mn-54	3	4.68E+08	1.18547E-07	1E-04	.118547	5.548E-05
Tb-160	1	9.85E+07	4.31472E-07	4E-05	1.07868	4.25E-05
Zn-65	2	3.29E+08	4.05471E-07	1E-04	.405471	1.334E-04

Total Number of Releases: 6

Total Volume Released (with dilution): 7.28839E+08 mL

Average Concentration (with dilution): 6.4707E-07 µCi/cc

Total Radioactivity: 4.7161E-04 Curies

TABLE 6
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
March 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Cd-115	1	1.1E+08	4.63636E-07	3E-05	1.54545	5.1E-05
Co-58	1	1.1E+08	4.77273E-07	9E-05	.530303	5.25E-05
Co-60	3	3.7E+08	4E-07	3E-05	1.33333	1.48E-04
Mn-54	3	3.7E+08	2.22757E-07	1E-04	.222757	8.242E-05
Na-22	1	1.1E+08	5.6E-08	3E-05	.186667	6.16E-06
Na-24	1	1.1E+08	2.89091E-07	3E-05	.963636	3.18E-05
Zn-65	1	1.1E+08	1.70909E-06	1E-04	1.70909	1.88E-04

Total Number of Releases: 3

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

Average Concentration (with dilution): 1.57162E-06 µCi/cc

Total Radioactivity: 5.815E-04 Curies

TABLE 7
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
April 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-58	3	4.93E+08	1.86004E-07	9E-05	.206671	9.17E-05
Co-60	4	6.6E+08	4.25909E-07	3E-05	1.4197	2.811E-04
Mn-54	3	4.93E+08	3.09939E-07	1E-04	.309939	1.528E-04
Zn-65	3	4.93E+08	6.69777E-07	1E-04	.669777	3.302E-04

Total Number of Releases: 5

Total Volume Released (with dilution): 7.7E+08 mL

Average Concentration (with dilution): 1.11078E-06 µCi/cc

Total Radioactivity: 8.553E-04 Curies

TABLE 8
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
May 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Zn-65	1	1.75E+08	7.54286E-08	1E-04	.0754286	1.32E-05

Total Number of Releases: 1

Total Volume Released (with dilution): 3.439E+08 mL

Average Concentration (with dilution): 3.83833E-08 µCi/cc

Total Radioactivity: 1.32E-05 Curies

TABLE 9
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
June 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-58	1	1.32E+08	3.69697E-07	9E-05	.410774	4.88E-05
Co-60	5	6.59E+08	8.44917E-07	3E-05	2.81639	5.568E-04
Ir-192	1	1.33E+08	1.7218E-07	4E-05	.430451	2.29E-05
Zn-65	2	2.46E+08	1.09431E-06	1E-04	1.09431	2.69E-04

Total Number of Releases: 5

Total Volume Released (with dilution): 6.59E+08 mL

Average Concentration (with dilution): 1.46115E-06 µCi/cc

Total Radioactivity: 9.629E-04 Curies

TABLE 10
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
July 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-60	2	3.85E+08	7.61039E-07	3E-05	2.5368	2.93E-04

Total Number of Releases: 2

Total Volume Released (with dilution): 3.85E+08 mL

Average Concentration (with dilution): 7.61039E-07 µCi/cc

Total Radioactivity: 2.93E-04 Curies

TABLE 11
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
August 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Ce-141	1	1.26E+08	4.73016E-08	9E-05	.0525573	5.96E-06
Co-60	2	2.48E+08	6.08065E-07	3E-05	2.02688	1.508E-04
Zn-65	1	1.22E+08	2.34426E-07	1E-04	.234426	2.86E-05

Total Number of Releases: 3

Total Volume Released (with dilution): 7.41E+08 mL

Average Concentration (with dilution): 2.49258E-07 µCi/cc

Total Radioactivity: 1.847E-04 Curies

TABLE 12
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
September 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-57	1	1.53E+08	1.50327E-08	4E-04	3.75817E-03	2.3E-06
Co-58	1	1.78E+08	7.30337E-07	9E-05	.811486	1.3E-04
Co-60	3	4.5E+08	1.00289E-06	3E-05	3.34296	4.513E-04
Mn-54	1	1.78E+08	9.83146E-07	1E-04	.983146	1.75E-04
Na-24	1	1.78E+08	2.15169E-07	3E-05	.717228	3.83E-05
Zn-65	2	3.31E+08	3.28731E-06	1E-04	3.28731	1.0881E-03

Total Number of Releases: 3

Total Volume Released (with dilution) 4.5E+08 mL

Average Concentration (with dilution): 4.19511E-06 µCi/cc

Total Radioactivity: 1.8878E-03 Curies

TABLE 13
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
October 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-60	2	3.45E+08	1.71594E-07	3E-05	.571981	5.92E-05
Mn-54	1	2.2E+08	4.11818E-08	1E-04	.0411818	9.06E-06
Zn-65	1	1.25E+08	2.976E-07	1E-04	.2976	3.72E-05

Total Number of Releases: 2

Total Volume Released (with dilution): 3.45E+08 mL

Average Concentration (with dilution): 3.05507E-07 µCi/cc

Total Radioactivity: 1.054E-04 Curies

TABLE 14
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
November 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-57	2	4.93E+08	4.74645E-08	4E-04	.0118661	2.34E-05
Co-58	3	7.13E+08	2.77419E-07	9E-05	.308244	1.978E-04
Co-60	4	9.1E+08	7.95495E-07	3E-05	2.65165	7.239E-04
Mn-54	4	9.1E+08	5.03088E-07	1E-04	.503088	4.5781E-04
Zn-65	4	9.1E+08	2.0967E-06	1E-04	2.0967	1.908E-03

Total Number of Releases: 4

Total Volume Released (with dilution): 9.1E+08 mL

Average Concentration (with dilution): 3.64099E-06 µCi/cc

Total Radioactivity: 3.133E-03 Curies

TABLE 15
NUCLEAR SCIENCE CENTER
RADIOACTIVE LIQUID EFFLUENT RELEASES
MONTHLY SUMMARY
December 1983

Isotope	No. of Releases	Volume mL	Conc. µCi/cc	MPC µCi/cc	MPC Percent	Activity Curies
Co-60	1	1.09E+08	2.90826E-07	3E-05	.969419	3.17E-05
Mn-54	1	1.09E+08	3.69725E-08	1E-04	.0369725	4.03E-06
Zn-65	1	1.09E+08	2.34862E-07	1E-04	.234862	2.56E-05

Total Number of Releases: 1

Total Volume Released (with dilution): 1.09E+08 mL

Average Concentration (with dilution): 5.62385E-07 µCi/cc

Total Radioactivity: 6.13E-05 Curies

ENVIRONMENTAL SURVEY PROGRAM

Introduction

The environmental survey samples were collected in accordance with the schedules of the cooperative surveillance program between the Texas State Department of Health and 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 1983 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 radiaoctive 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 337 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. A dosimeter at this location reveals only background radiations.

Summaries of the environmental survey program for 1983 are presented in Tables 16-20 for gross beta activity.

TABLE 16
ENVIRONMENTAL RADIATION MONITORING PROGRAM
INTEGRATED RADIATION EXPOSURE

29 July 1982 to 28 October 1983

Station Number	Location	Exposure (mR/Year)	Average Exposure Rate (mR/Day)
1	NW corner - Firemans Training School	59	0.16
2	Fence corner west of TLD Station #4	84	0.22
3	Back fence south of TLD Station #2	92	0.25
4	West corner NSC & calibration fence	95	0.26
5	Fence NSC front gate	69	0.18
6	East corner NSC & calibration fence	337	0.92
7	Easterwood Airport fence north of stock tank	65	0.17
8	Evergreen tree in open field west of calibration fence	53	0.14
9	Fence by trailers next to NSC	61	0.16
10	Fence 50' from TLD Station #9	69	0.19
11	Fence by aluminum gate by Easterwood Airport	62	0.17

TABLE 17
ENVIRONMENTAL SURVEY PROGRAM
FIRST QUARTER SUMMARY
1983

V E G E T A T I O N

Location	Number Samples	(pCi/gm)
NSC Creek	2	47
NSC Outside	1	15
NSC Inside	1	22
TAMU Landfill	1	63

M I L K

		(pCi/L)
TAMU Dairy	1	159

W A T E R

		(pCi/mL)
NSC Creek	1	0.010
White Creek	2	0.014
Upper Brazos	1	0.005
Sanitary Outflow	1	0.060
Airport Fish Pond	1	0.160
Lower Brazos	2	0.010

TABLE 18
ENVIRONMENTAL SURVEY PROGRAM
SECOND QUARTER SUMMARY
1983

V E G E T A T I O N

Location	Number Samples	(pCi/gm)
White Creek	3	35.5
NSC Creek	2	47.0
NSC Inside	3	25.3
TAMU Landfill	2	45.0
Highway 6 and Rock Prairie	2	28.8
Neinast Site	1	47.0
A&M Dairy	1	15.0

W A T E R

Radioactivity (pCi/ml)

		(pCi/mL)
Sanitary Outflow	1	0.140
Easterwood Airport	1	0.090
White Creek	3	0.175
NSC Creek	2	0.070
Lower Brazos River	1	0.060
Upper Brazos River	1	0.050

M I L K

Radioactivity (pCi/mL)

		(pCi/mL)
TAMU Dairy	1	0.141

TABLE 19
ENVIRONMENTAL SURVEY PRCGRAM
THIRD QUARTER SUMMARY
1983

V E G E T A T I O N

Location	Number Samples	(pCi/gm)
White Creek	3	25.2
NSC Creek	2	7.7
NSC Site	3	25.4
NSC Offsite	1	9.5

M I L K

		(pCi/mL)
TAMU Dairy	1	0.021

W A T E R

		(pCi/mL)
NSC Creek	3	0.030
White Creek	3	0.058
TAMU Sanitary Outflow	1	0.021
Easterwood Fish Pond	1	0.026
Lower Brazos	1	0.032
Upper Brazos	1	0.031

PERSONNEL EXPOSURES

Radiation exposures to personnel at the Nuclear Science Center for 1983 were within the limits of 10CFR20. The maximum exposure received by an individual for the year was 610 mrem. A total of approximately 4.45 MANREM was received for 1983. More important, the exposures reflect an extended effort by all personnel to minimize and eliminate radiation exposures whenever practicable. These exposure data becomes more significant when one considers that in addition to routine reactor operations, over 19,000 samples containing approximately 22.00 curies of radioactivity were produced and processed at the Nuclear Science Center in 1983.

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 5,008 visitors to the Nuclear Science Center during 1983. 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

1983

Whole Body Exposure Range (Rem)	Number of Persons In Range
No Measurable Exposure	17
Less than 0.100	13
0.100 - 0.249	9
0.250 - 0.499	6
0.500 - 0.749	1
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:	46

SOLID RADIOACTIVE WASTE

There was a total of 29.2 ft^3 of dry solid waste material packaged in plastic bags for disposal during 1983. These materials were transferred to the Radiological Safety Office, Texas License 6-448, for disposal. This material consisted of laboratory glassware, irradiation containers, decontamination materials, and expendable protective clothing and equipment, e.g., paper, shoe covers, plastic bags and gloves. This material contained Co-60, Ir-192, Cs-137, Zn-65, Ce-141, Mn-54, Cr-51, Br-82, Cd-109 and mixed fission products with the total radioactivity being 3.1 E-2 Ci. These data are in Table 21.

TABLE 21
SOLID RADIOACTIVE WASTE DISPOSAL
ANNUAL SUMMARY

1983

Radioisotope	Radioactivity (μCi)
Co-60	28784
Ir-192	928
Cs-137	92
Zn-65	495
Ce-141	60
Mn-54	71
Cr-51	30
Cd-109	50
Mixed Fission Products	578

Total Volume: 29.2 Ft^3 contained in plastic bags.

Total Radioactivity: 3.1 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 system consisting of nine (9) detector channels located throughout the Reactor and Laboratory Buildings. This system is equipped with alarm settings and remote readouts in the control and reception rooms. Radiation levels and operational checks are recorded on a daily basis. This system functions as a radiation safety monitor for the early detection of impending radiation hazards. The Nuclear Science Center Facilities and site boundaries are surveyed monthly with beta-gamma sensitive instruments. These measurements are taken to determine proper storage and identification of radioactive materials and that visitor and routine work areas are free of radiation hazards. Additionally, radiation monitoring support is provided for the reactor operations and experimenter groups to insure the safe handling of radioactive materials and control of personnel exposures. There were no unexpected radiation levels or improper exposures of radiaoctive materials detected during 1983. 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 cm^2.

APPENDIX IV

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

Other Universities and Colleges

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

Other Universities and Colleges (Cont'd)

State University of Ohio

Alfred St. College

Community College of the Finger Lakes

Nebraska Weslyan University

Lock Haven St. College

San Bernadino Valley College

North Park College and Theological Seminary College

Fort Valley State College

Denison University

State University College, N.Y.

Auburn University

Clarion State College

University of Alaska

University of Arkansas

University of Houston

Southwest Texas State College

Iowa State University

Blinn College

State College of Arkansas

The Defiance College

San Antonio College

Laredo Jr. College

University of Corpus Christi

South Dakota State

Arapahoe Jr. College

California St. College

University of Texas-Tyler

Pan American College

Tarleton St. College

Columbus College

Texas Tech University

Howard Payne College

Prairie View A&M College

Longwood College

S. D. School of Mines

North Shore Community College

University of Wisconsin

Hill Jr. College

McLennan Community College

Southeast Missouri St. College

Southwestern State College

Mary Hardin Baylor

Texas State Technical Inst.

North Texas State University

University of Arizona

McNeese State University

Texas Eastern University

Henderson County Jr. College

Massachusetts Institute of Technology

University of Texas at Dallas

Moody College

Sul Ross University

East Texas State University

University of Nebraska

Industrial Organizations

States Marine Lines	Comfaco
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 Co.	Texas Nuclear
Mobil Oil Co.	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 Environmental 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

Industrial Organizations (Cont'd)

Westinghouse Electric

Avery Oil Company

Bell Helicopter

Spectronics

LGL, LTD.

E-Systems

Monsanto, Inc.

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

Gulf Science and Technology

Tech-Sil

Universal Technology Corporation

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 One Years of Operation

TAMU Department 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

TAMU Departments (Cont'd)

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

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