TEXAS ENGINEERING EXPERIMENT STATION

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

NUCLEAR SCIENCE CENTER
409/845-7551

March 23, 2000 2000-0108

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: 1999 Annual Report

Reference: NRC Facility License R-83, Docket 50-128

Dear Sir:

Attached you will find the 1999 Annual Report for the Texas A&M University System Nuclear Science Center. If you have any questions or comments, please contact me at (409) 845-7551.

Sincerely,

W. D. Reece

W. D. Reece, Director

WDR/rmw

Attachment: 1999 Annual Report

xc: 211/Central File
NRC License File
NRC Correspondence File

A020

Texas A&M University System
Texas Engineering Experiment Station

Nuclear Science Center

<u>1999 Annual Report</u>

Facility Operating License R-83

3575 TAMU
College Station, Texas
77843-3575

March 2000

Contents

1.0 Introduction

The Texas A&M University Nuclear Science Center (NSC) is a multi-disciplinary research and education center supporting basic and applied research in nuclear related fields of science and technology as well as providing educational opportunities for students in these fields as a service to the Texas A&M University System and the state of Texas. The NSC also provides services to commercial ventures requiring radiation or isotope production services.

The NSC reactor, an 1-MW, pool-type TRIGA reactor, is at the heart of the NSC facilities which includes a 2-MW micro-beam accelerator, a ^{60}Co gamma calibration range, a real-time neutron radiography facility, hot cells and manipulators, three radiation measurement laboratories, radiochemical laboratories, seven HPGe gamma spectroscopy systems, and a variety of instruments for radiation detection and measurement.

The NSC reactor is designed for easy load/unload of various types of samples and is being actively used to produce various kinds of radioisotopes for industry, hospitals, and academic users. The NSC is also nationally recognized for its neutron activation analysis (NAA) services to many research and academic institutions in the western part of the United States. The NSC reactor also actively supports the Nuclear Engineering Department on campus, one of the largest nuclear engineering programs in the United States. The NSC has become one of the major attractions on campus. Last year alone, the NSC had 2,908 visitors, which include elementary, middle, high school, and college students, faculty members, clients, and national laboratory and industrial scientists and engineers. Through these tours, the NSC is emphasizing the importance of nuclear energy in the United States.

With the strong support from the University, the NSC is continuously increasing the diversity of its facilities and services. Recently, the NSC developed a ^{125}Xe irradiation system to produce ^{125}I for medical brachytherapy sources and currently working on the development of a new Fast Flux Irradiation Device (FFID) which will have a cooling system to remove the heat generated in the device. The NSC is planning to produce ^{60}Co gamma irradiation sources for food irradiation on campus. Recently, the NSC has built a 2-MW micro-beam accelerator facility for radiation biology study.

This annual report has been prepared by the NSC staff to satisfy the reporting requirements of Technical Specification 6.6.1 of the facility operating license R-83 and of the Department of Energy University Reactor Fuel Assistance Program subcontract No. C87-101594 (DE-AC07-76ER02426). The facility license currently extends to March 2003.

1.1 Nuclear Science Center Staff

The staff at the Nuclear Science Center is divided into four groups: Reactor Operations, Health Physics, Maintenance, and Administration (see Figure 1). Personnel directly involved with the operation and maintenance of the reactor are NRC-licensed operators. The NSC is committed to its educational responsibilities and many members of the staff are part or full-time students at Texas A&M University.

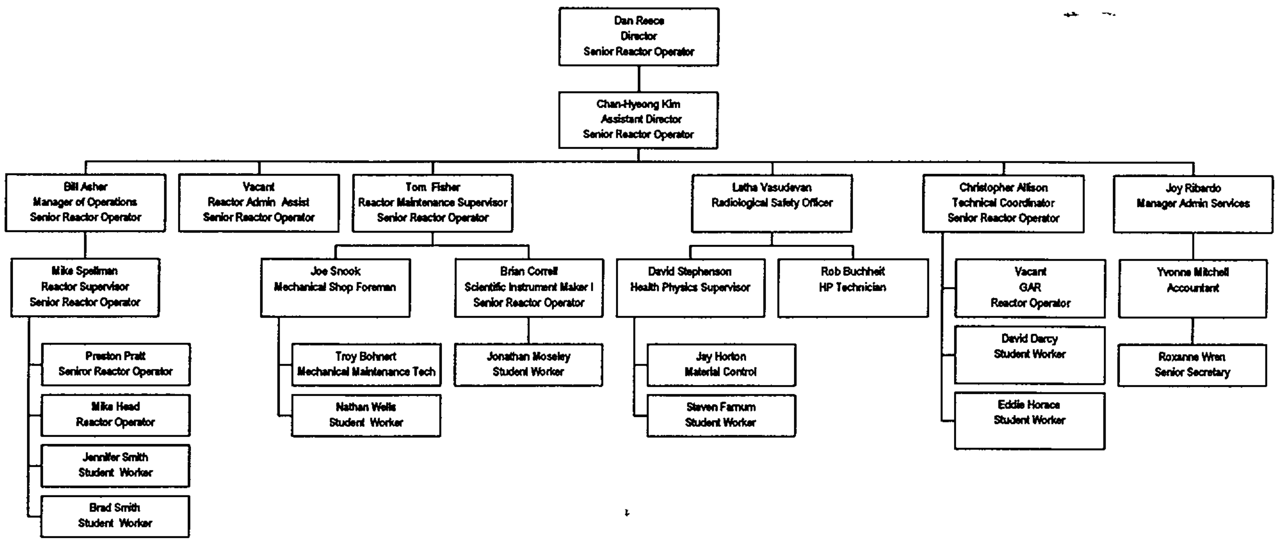

Figure 1. Nuclear Science Center Staff.

The Nuclear Science Center (NSC) is operated by the Texas Engineering Experiment Station (TEES) of the Texas A&M University System. The Director of the Nuclear Science Center (NSC) is responsible to the Deputy Director of the TEES for the administration and the proper and safe operation of the facility.

In addition to the internal structure, the Reactor Safety Borad (RSB) is established to advise the Deputy Director of the TEES and the Director of the NSC on issues or policy pertaining to reactor safety. The Texas A&M University Environmental Health and Safety Department (EHSD) provides assistance when it is required for emergencies and for special operations as agreed.

2.0 Reactor Utilization for 1999

The Nuclear Science Center (NSC) reactor has been in operation since 1962. The reactor is an 1-MW, MTR-converted type TRIGA reactor. The reactor uses highly enriched fuel (70%), but will be converted to 20% enriched fuel core when DOE funds become available. Core VIII-A is the current core configuration and has been in use since March 1986. The NSC reactor is pulse operational and is pulsed up to powers of approximately 1,100 MW for nuclear engineering laboratories, staff training, and public tours.

The NSC reactor operated for 2,166 hours in 1999 with a total integrated power of 86.73 MW-days. There were 560 irradiations and services performed at the NSC during the reporting period. The NSC provided services to TAMUS departments, other universities, research centers and secondary schools in and outside the state of Texas. Many departments at TAMU and other universities used the reactor regularly in 1999. The NSC reactor had about 90% of availability in 1999.

Table 1. 1999 Reactor Utilization Summary

Days of Reactor Operation	232
Integrated Power (MW-days)	86.73
Number of Hours at Steady-State	2166.17
Number of Pulses	56
Number of Reactor Irradiations (RFS)	560
Beam Port/Thermal Column Experiment Hours	716.35
Hours Irradiation Cell Use	17.033
Number of Visitors	2908
Unscheduled Shutdowns	12

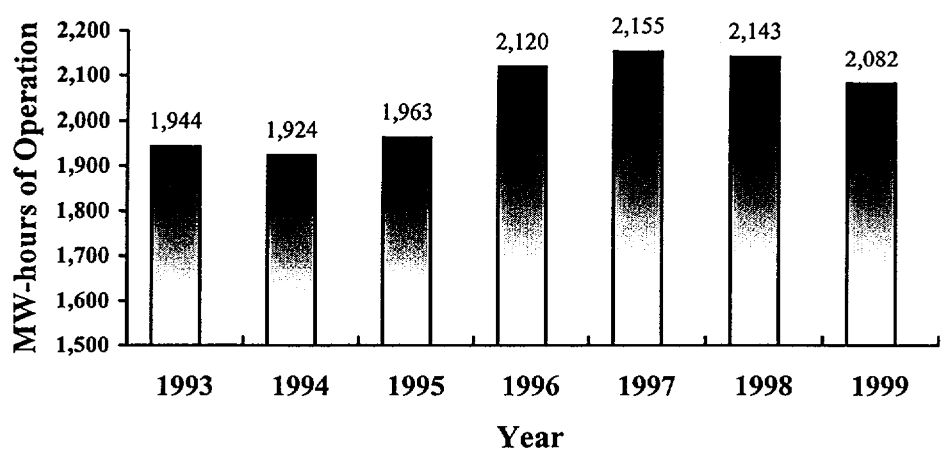

Figure 2. Annual Reactor Utilization

2.1 Research Enhancement Program (REP)

The Research Enhancement Program (REP) was established by the 70th Texas Legislature in 1987 to "encourage and provide for research conducted by faculty members." The REP replaced the former "Organized Research" program. The TAMU Office of the Vice President for Research administers the REP funds. REP funds are generally allocated to the NSC early in the fiscal year. TAMUS faculty that desire to use the many irradiation services at the NSC reactor must apply at the NSC to receive local funding for each individual project. This proposal method is flexible and does not hinder a project's start-up time.

2.2 TAMU Academic Support Program

Texas A&M University (TAMU) provides funding for the reactor for such academic activities as nuclear engineering laboratories, neutron activation analysis demonstrations and laboratories, graduate student thesis and dissertation research, and undergraduate research projects. The program has been very successful and is crucial for many graduate students whose chosen research uses the NSC reactor in some way but is not supported by any research grants. The NSC's reputation as a multi-disciplinary institution is reflected in the wide range of academic users from the university.

2.3 DOE University Reactor Sharing Program

The DOE University Reactor Sharing Program provides funds for reactor experimentation to those institutions that do not normally have access to a research reactor. The Nuclear Science Center (NSC) has participated in the program since 1980 with great success. During the 1998-1999 contract year, 12 research institutions utilized the NSC with the support of the Reactor Sharing Program. Additionally, the funding provided reactor tours and "hands-on" projects to many secondary schools.

The research projects supported by the program range from geological dating to the production of high current superconducting magnets. The funding gave several small colleges and universities the opportunity to use the NSC facilities for teaching courses in nuclear processes, specifically neutron activation analysis and gamma spectroscopy. The Reactor Sharing Program supported the use of the Fast Flux Irradiation Device for multiple users at New Mexico Institute of Mining and Technology and the University of Nevada at Las Vegas. This device has been characterized and has been found to have near optimum neutron fluxes for $^{39}Ar/^{40}Ar$ dating.

2.4 Commercial Activity and External Research

The NSC provides services to a variety of users who have their own funding. The majority of commercial activities are related to isotope production of radioactive tracers for support of the Texas petroleum and chemical industries. Another commercial activity uses the converted Thermal Column area for the production of micropore filters that are used in ultra-pure water systems in the semiconductor industry. A significant amount of research at the reactor is funded by outside research grants.

The NSC has many years of experience in the production of radioisotopes and has developed several customer-specific methods for radioactive sample handling. The production of radioisotopes generally involves handling high-activity radioactive materials during unloading, therefore, the staff take many precautions to minimize their exposures during the transfer of materials to shipping shields.

3.0 Facility and Procedure Changes

3.1 Facility Modifications

The following items were authorized facility modifications and maintenance in accordance with 10 CFR 50.59. The approvals were documented in NSC staff meeting minutes or RSB meeting minutes as appropriate.

1. Replacement of the capacitors in the 15-volt power supply in Safety Amplifier #1 (January 4, 1999)

On January 4, 1999, Safety Amplifier #1 failed to comply with two portions of the daily pre-start checklist. During the daily checks the meter indicated 146% on the 100% scale and the scram was activated at 84-85% as opposed to the specified 115%. Examination of the drawer indicated that two of the filter capacitors within the 15-volt power supply had failed.

The defective capacitors were rated for 1700 μF and 35 volts. Exact replacements for these capacitors could not be found and thus it was proposed to use capacitors rated for 2200 μF and 50 volts. The staff discussed this option and decided that the replacement capacitors did not present any unreviewed safety questions, decrease any safety margins, or violate any of the NSC Technical Specifications. The new capacitors were installed and Safety Amplifier #1 was tested and placed back into service.

2. Replacement of the 15-volt power supply for Safety Amplifier #1 (January 5, 1999)

After the capacitors were replaced in the 15-volt power supply for Safety Amplifier #1, it began to burn out diodes. Following several review and troubleshooting sessions, the staff determined that the 15-volt power supply for Safety Amplifier #1 needed to be replaced. An exact replacement was located but could not be delivered to the NSC until the following week. In order to get the reactor back in operation, the staff decided to use a portable, precision power supply until the replacement arrived. The staff reviewed several different scenarios and concluded that neither the temporary power supply nor the new replacement supply presented any unreviewed safety questions, reduced any safety margins, or violated any of the NSC Technical Specifications.

The portable power supply was hard wired into the drawer and stored within the reactor console. The appropriate portions of the Safety Amplifier annual maintenance were performed along with the daily channel checks prior to reactor operation. The temporary supply was replaced once the new power supply arrived at the NSC. Once again the appropriate maintenance and channel checks were completed prior to reactor operation.

3. Minor modifications to the control rod controllers (January 29, 1999)

Following several events involving the control rod controllers, it became evident that the controllers needed to be modified. The first incident involved the controller logic circuits being blown due to a voltage surge from the gang switch. The second incident was the "up" and "down" buttons began to stick during operation. Exact replacements for the switches were located but were very expensive. The last incident involved the recovery from a facility power outage. After the power was restored to the controllers, they would activate with an arbitrary number displayed. This often produced a "jam" indication that would prevent the rod from being inserted or withdrawn. In the past unplugging the controller and then plugging it back in and hoping to get an indication of less than 100% had corrected this problem.

In order to prevent these incidents from occurring in the future, the following modifications were made to the controllers:

1. Modification of the controller logic to isolate each of the controllers during gang operation. This prevents the possibility of future surge damage.
2. Replacing the "up" and "down" buttons with inexpensive replacements that perform the same functions.
3. Addition of a "reset" switch on the rear panel of each controller that simulates the simultaneous rod down and engaged signals. This automatically resets the indication to 1%.

The NSC staff discussed each of the modifications prior to approving the work package and considered every possible failure mode that could arise from the changes. None of the changes altered the operability of the control rods or the controllers and did not prevent the rods from being scrammed in any configuration. The staff concluded that each of the changes were in accordance with 10 CFR 50.59 and did not result in an increased risk, a reduction in a safety margin, or a violation of NSC Technical Specifications.

4. Installation of the STAR monitoring computer into the reactor console (April 15, 1999)

The NSC began involvement in the STAR project and needed a data acquisition system to monitor reactor parameters. To help facilitate this project the NSC installed a data acquisition system and computer into the reactor console on April 23, 1999. This system monitors the water systems temperatures, the fuel temperature, the linear power level, and the log power level and then outputs the data to an onscreen display and a text file on the computer hard drive.

The staff reviewed the proposed addition to the console prior to approving the work package and concluded that the computer and data acquisition system would have no adverse effects on the operation of the fuel temperature monitoring channel, the log power channel, or the linear power channel. They also agreed that the change did not present any unreviewed safety questions, reduce any safety margins, or violate any of the NSC Technical Specifications according to 10 CFR 50.59.

The staff also mandated that the system be connected in parallel to the current equipment so that a comparison could be made. Once the system had proven to be reliable, the older equipment was to be removed, with the exception of the fuel temperature recorder and scram circuit. In addition to this requirement, the Semi-Annual Fuel Temperature Measuring Channel Surveillance was completed following the installation, the system was deliberately shorted to check for changes in the fuel temperature indication, and the reactor was brought to power in steps to compare fuel temperatures to previous start-ups. All of these requirements were satisfactorily completed.

5. Replacement of the thermocouple selector switch for fuel temperature, pool temperature, and irradiation cell temperature (April 28, 1999)

The thermocouple selector switch that toggles the digital display between the fuel temperature, the bulk pool temperature, and the irradiation cell temperature began to malfunction and provide no indication of temperature. An exact replacement for the switch was found and installed upon staff approval. The staff concluded that the "like-for-like" replacement met the requirements of 10 CFR 50.59 and thus required no further review.

6. Modification of FAM Channel #3 to allow for the detection of Xe-125 (May 11, 1999)

The NSC has begun production of Xe-125, which decays to I-125, for commercial uses. The NSC did not have a FAM channel capable of monitoring releases of Xe-125 and thus decided to modify FAM channel #3 (stack gas) to provide Xe-125 monitoring in addition to Ar-41.

FAM channel #3 uses a 3 x 3 NaI detector in conjunction with an SCA to monitor the 1.29 MeV gamma peak from Ar-41. The staff proposed using a second SCA in parallel that could be set to monitor the 188 keV and 243 keV gamma peaks from Xe-125. The output from this SCA could be sent to a separate input channel on the FAM computer and analyzed as a separate FAM channel. Due to the large activity levels associated with the Xe-125 production runs, the staff decided it was necessary for this channel to provide an alarm that could shutdown the air handling system. This new channel would also need to supply visual and audible alarms within the control room whenever the alarm limits were exceeded.

After reviewing all the issues associated with the proposed FAM modification, the staff agreed that the modification did not violate any of the NSC Technical Specifications, did not reduce any safety margins, and did not create or increase the probability of an accident evaluated or not evaluated in the NSC SAR. The NSC staff approved this modification as MA #51 and, after RSB approval, implemented the modification to FAM channel #3 as the new FAM channel #5. FAM channel #5 provides a digital readout, combined analog readout with FAM channel #3, graphical trend data, visual and audible alarms, and an air handling system shutdown on alarm set points. Standard Operating Procedures are being written to incorporate the new FAM channel #5.

7. Replacement of the FAM System recorder with a FAM computer program (July 19, 1999)

On July 15, 1999 the FAM system recorder failed during a back-up battery replacement. Repairs and replacement parts turned out to be extremely expensive and difficult to obtain. The NSC staff determined that it was more feasible to replace the system recorder with a new computer based system that performed the same tasks. The old recorder received FAM signals from the FAM computer, visually displayed the current values, printed trend data, and relayed air handling system shutdown signals to the central exhaust controller. The proposed system would include all of the same functions yet allow more flexibility and easier system maintenance.

The NSC staff reviewed the proposed system and identified two credible failure scenarios. The first involved power failure to the computer. The system was designed such that a loss of power would result in a shutdown of the air handling systems. This was similar to the old system. The second scenario consisted of a computer "lock-up". If a "lock-up" were to occur, the FAM readings would not be updated and the air handing system shutdowns would be disabled. This was exactly the same response as the old system. The computer program was designed such that the operator would be able to easily identify a computer "lock-up" by watching a system clock on the computer and verifying that the FAM readings were continuously updating. The computer "lock-up" could then be corrected by resetting the computer.

After a thorough review, the NSC staff concluded that the proposed change was in accordance with 10 CFR 50.59 and did violate any of the NSC Technical Specifications. They approved the proposed change as MA #52 and, upon approval of the RSB, implemented the new system. The system was thoroughly tested and documented to be fully functional before the reactor was operated.

8. Repair and modification of the single element fuel handling tool (November 12, 1999)

The flexible tool used to handle single fuel elements was broken during preparations for fuel-handling operations in early November 1999. The NSC staff proposed repairing the tool with a stainless steel central wire that would replace the existing damaged control wire. This change did not introduce any unreviewed safety questions and did not increase the risk or probability of an accident. In accordance with 10 CFR 50.59 the staff approved the repair of the tool so that fuel-handling activities could proceed as planned.

9. Modification of the computer program for FAM channel #5 (December 2-3, 1999)

During the calibration of FAM channel #3 with Ar-41 gas, NSC staff noticed that the count rate on FAM channel #5 also drastically increased. FAM channel #3 and FAM channel #5 share the same detector but use different SCA's with different energy ranges. The increase in the channel #5 counts was due to the increased Compton continuum of the Ar-41 gamma rays. This increase often caused the alarm set point for FAM #5 to be exceeded and thus the air handling systems were shutdown.

In an effort to prevent this type of shutdown, the NSC staff proposed changing the computer program for FAM channel #5 so that the count rate would be obtained from the following equation:

$$(\text{New \#5 reading})=(\text{actual \#5 reading})-(0.81)*(\text{\#3 reading})$$

The correction factor of 0.81 was derived from comparisons between channel #3 and channel #5 under varying conditions. After a thorough review, this modification was made to the program and tested under varying conditions. The tests revealed that the channel #5 indication became negative under very high count rates for channel #3. This situation was rectified by altering the correction factor until a suitable value was found for all channel #3 count rates. The final value for the correction factor was 0.62.

Before finalizing the modification, the NSC staff thoroughly reviewed the proposed modification and tested the system using a simulated Xe-125 source. The source check indicated that the system was still responding correctly. The staff concluded that the modification was in accordance with 10 CFR 50.59 and did not increase the probability of occurrence or consequence of an accident or malfunction evaluated or unevaluated in the NSC SAR, did not decrease a safety margin, and did not change or violate NSC Technical Specifications.

3.2 Experiment Authorizations and Modifications

1. Modification of ERA #2-10 to allow delayed neutron experiments during reactor pulsing (May 5, 1999)

ERA #2-10 deals with analyzing delayed neutron spectra using the Fast Flux Pneumatics Receiver (FFPR) and samples of uranium, neptunium, and americium. The original version required that the reactor be in steady state during all experiments. The experimenters requested that the reactor be pulsed during some of their experiments.

The NSC staff reviewed the original ERA #2-10 and attempted to devise new accident scenarios that could result from pulsing during these experiments. None were conceived. The staff agreed to alter the ERA so that the samples could be shot into the core shortly before the pulse and then be ejected approximately 2 seconds following the pulse initiation. The sample would then be counted and analyzed in a similar fashion to the original experiments.

Based upon the requirements of 10 CFR 50.59, the NSC staff approved the change to ERA #2-10 since it did not violate NSC Technical Specifications, did not present an unreviewed safety question, and it did not increase the probability of an accident or malfunction. The staff also required that all of the other restrictions within the original ERA #2-10 be maintained and observed during the new experiments.

2. Revision of EA #26: I-125 Production (June 2, 1999)

The RSB originally approved the commercial production of I-125 from Xe-125 in November 1999 under EA #26. As a revision to this Experiment Authorization, the NSC explicitly outlined the restrictions and limitations involved in the irradiation and handling of the Xe-125/I-125. These revisions were more restraining than those of the previous version of EA #26 and thus presented no additional risks or probability of accidents in accordance with 10 CFR 50.59. In conjunction with EA #26 the NSC also submitted revisions and changes to the NSC Technical Specifications to the NRC. These changes and revisions provided for a Xe-125 FAM channel, I-125 air monitoring system, and Xe-125 release limits.

4.0 Reactor Maintenance and Surveillance

4.1 Scheduled Maintenance

Calibrations were performed on the Fuel Element Temperature Channel, Area Radiation Monitors and the Linear, Log, and Safety Power Channels as required by the Technical Specifications. All surveillances required by the reactor license were performed.

Control rod worth and scram time measurements were performed in August 1999. The total rod worth was found to be $16.82. The most reactive control rod is Shim Safety #4 with a worth of $4.73. The shutdown margin was determined to be $4.21 and core excess was measured as $5.89. Scram times on all rods were less than 1.2 seconds.

A calorimetric calibration was performed following each maintenance period. Fuel inspections were performed as required by the Technical Specification with no abnormalities noted.

The cold critical reactivity worth for each reactor experiment was measured prior to full experiment approval. The most reactive fixed experiment has been found to be the Fast Flux Pneumatic Receiver (-$1.35) with the negative worth caused by high boron loading.

4.2 Unscheduled Maintenance

01-05-99	Cooling fan for the electrical panel in the Heat Exchanger Room was replaced because of faulty bearings.
01-14-99	Camlock caps were chained to the distribution panel, in the tunnel, to prevent their loss when not in use.
01-28-99	The F.A.M. Chart Recorder's mechanism was realigned to prevent it from destroying ribbons.
02-10-99	A new 150 lb. pop off valve was installed on the facility air compressor, after it was found stuck open.
02-12-99	A lifting collar was added to the Iodine irradiator so that it could be more easily handled.
02-18-99	The failing display module on the F.A.M. chart recorder was replaced with a new one.
02-24-99	A new long tube with a Camlock cap was completed.
03-04-99	The railing above the irradiation cell entrance was modified for easier access to the man lift.
03-12-99	The F.A.M. alarms and air handing shut downs were connected to the F.A.M. chart recorder in the control room.
04-19-99	The gate drive belts were replaced and the control box was cleaned out and tested, after fire ants invaded it causing a contactor to stick and burn the belts.
04-23-99	The LED identification in the Regulating Rod controller was replaced.
04-26-99	The paper drive belt for F.A.M. Channel 2 was replaced after breaking.
05-11-99	The thermocouple switch for the Fuel Temperature Channel's digital meter was replaced.

05-11-99 The Beam Port 1 gate alarm was moved back to Beam Port 1 from the film storage area and a surveillance camera was installed.

05-15-99 Evacuation horns were installed in the Machine Shop and the Accelerator Building.

06-01-99 A computer to monitor the Log Power, Linear Power, Fuel Temperature, and Reactor Cooling temperatures was installed.
It is planned that the computer will eventually replace all the chart recorders in the control room. The troubled Reactor Cooling Recorder was eliminated with this upgrade.

06-01-99 The Central Exhaust filter damper indication in the Reception Room was repaired after several of the indicating LEDs had failed.

07-16-99 Xenon channel was added to the F.A.M. system.

07-21-99 The F.A.M. Chart Recorder failed and was replaced with a computer. The cost of repairing the recorder far exceeded its value.

08-31-99 The paper drive mechanism for F.A.M. Channel 2 was realigned and instructions on loading paper so that it doesn't hang up was given to the H.P. staff.

09-07-99 The wiring for the Thermal Column gate alarm was repaired and then rerouted to prevent future damage.

09-13-99 The Cooling Tower fill valve was replaced after developing a leak.

09-22-99 Electrical connection to the gate security camera were reworked after camera failed to work.

09-23-99 Drive belts on the front gate wore out and were replaced.

09-29-99 The Hand and Foot monitor in the M.H.A. was replaced with a monitor using G.M. tubes to eliminate the excessive cost of using P-10 gas.

09-29-99 Light socket for the Irradiation Cell warning was replaced.

09-30-99 The electrical connections to the gate camera were repaired.

10-21-99 The paper drive on the Log Power chart recorder was repaired.

11-12-99 The water level control switch for the secondary water cooling-tower failed, and was replaced.

12-02-99 The control rod #3 drive was replaced with a spare unit because of loss of position indication.

12-08-99 A plastic inspection window was installed to observe the Central Exhaust Filter dampers.

12-17-99 A G.M. detector was installed in the exhaust stack ductwork and connected to a meter in the Reception Room, to detect any high level releases of Xe-125.

4.3 Emergency Planning and Review

The Facility Emergency Plan was revised as of December 14, 1999 (1) to incorporate the changes in supporting organizations since the last revision, (2) to specifically include Xe-125 accidental release in the emergency classification, and (3) to incorporate other minor changes. The revised plan was approved by NSC staff and distributed to the corresponding RSB member and the supporting organizations. The NSC is applying for the upgrade of the Physical Security Plan from the Low Strategic to Moderate Strategic Level. The NSC is now preparing for the answers to the comments from the U.S. NRC. All required external audits were completed for the Emergency and Security Plans during the reporting period.

4.4 Unscheduled Shutdowns

There were twelve unscheduled reactor shutdowns occurred during 1999. Three shutdowns resulted from a loss of facility electrical power. The remaining causes are detailed below:

1-19-99	Vibration created within the control rod drive motor disengaged the control rod armature from the electromagnet.
1-26-99	Broken connection on the control rod drive caused the failure of control rod magnetic power.
2-16-99	Mechanical vibration during sample handling disengaged the control rod armature from the electromagnet.
4-2-99	The cross-over point between the two circuits in the wide range monitor caused a spike in the reactor period resulting in a reactor scram.
9-8-99	One of the safety channels (#2) overshot during reactor startup. Reactor power did not exceed 1 MW.
9-16-99	Electronic glitch in "Steady State/Pulse" mode switch caused a reactor scram when it is turned (two times for the same day).
9-17-99	Electronic glitch in "Steady State/Pulse" mode switch caused a reactor scram when it is turned.
10-15-99	One of the safety channels (#2) overshot during reactor startup. Reactor power did not exceed 1 MW.

5.0 Health Physics Surveillances

The purpose of Health Physics surveillance is to ensure safe use of radioactive materials in Nuclear Science Center's (NSC) research and service activities and also to fulfill the regulatory requirements of U.S. Nuclear Regulatory Commission and State agencies. A dedicated Health Physics group is maintained at the NSC reactor facility as an integral part of the organization. They are responsible for chemical and physical safety concerns as well as radiological. The TAMU Environmental Health and Safety provides additional support to the NSC Health Physics group upon request.

5.1 Radioactive Shipments

The Health Physics monitoring and technical support that was provided in 1999 assured minimal exposure during sample handling, shipment of radioactive material, and normal reactor operation. The radiation exposures were maintained ALARA. During 1999, about 437 radioactive samples were handled of which 333 were sent to various research facilities including Texas A&M University campus and the rest retained at the Nuclear Science Center facility. A total of 238 curies was handled in 1999.

5.2 Personnel Monitoring

Personnel Monitoring was provided to approximately 42 personnel. All radiation exposure to personnel was below the limit set forth in 10CFR20. Two individuals received doses greater than 10% of the annual limit; their exposures were recorded as 920 mrem, and 600 mrem deep dose equivalent for the year. Airborne monitoring during sample handling continued to show no significant airborne activity. Therefore total effective dose equivalent will equal deep dose equivalent for 1999. A total of 4.47 manrem was recorded for all of 1999. When total manrem/curie was determined for 1999, the dose per curie equaled 0.0188, the same as for 1998. During 1999, 2908 visitors toured the Nuclear Science Center. Minimal exposures were measured with pocket ion chambers worn by these visitors when compared with the pocket ion chamber readings of their respective tour guides. NSC employees who were likely to exceed 10% of their total annual dose wore TLDs/film badges and extremity dosimetry that were provided by Landauer, a NVLAP accredited supplier. Landauer also provided the analysis reports of the exposure received.

5.3 Facility Monitoring

Surveys of the Nuclear Science Center facilities were performed to assess radiological hazards to NSC workers. Radiation levels and sources of radioactive contamination were routinely monitored. Approximately 350 smear samples were collected and evaluated each month. All accessible areas at the NSC are surveyed for radiation and contamination levels monthly. In areas where contamination is expected, access / egress controls are in place and are evaluated on shorter intervals. Area monitors were placed at strategic locations in the reactor facility which provides dose equivalent (mrem) on a monthly basis. The following table summarizes the annual accumulated dose equivalent (mrem) recorded on the area monitors for 1999.

Table 2. Total Dose Equivalent (mrem) Recorded on Area Monitors

Monitor ID	Location	Accumulated Dose Equivalent (mrem)
BLDG MNTR 1	Upper Research Level Mezzanine	680
BLDG MNTR 2	Lower Research Level Mezzanine	300
BLDG MNTR 3	Lower Research Level	20
AREA	Control Room	140
AREA	Upper Research Level	360
AREA	Hand and Foot Monitor Room	810

5.4 Particulate Effluent Monitoring

Radioactive particulates were monitored at the base of the central exhaust stack and summarized on a monthly basis. The annual average release concentration was 3.42 E-11μCi/cc. Total activity released for 1999 was 2.21E-3 Ci. The following table summarizes monthly particulate effluent releases during 1999.

Table 3. Monthly Particulate Effluent Releases

Quarter	Month	Average Release Conc. (uCi/cc)	Diluted Concentration (uCi/cc)	Exhaust Volume (cc)	Total Release (Ci)
I	January	5.25E-11	2.63E-13	6.32 E+12	3.32E-04
	February	1.50E-11	7.50E-14	5.71E+12	8.57E-05
	March	6.70E-11	3.35E-13	6.32 E+12	4.23E-04
	Average:	4.48E-11	2.24E-13	6.12E+12	2.80E-04
			Total:	1.84E+13	8.41E-04
II	April	1.88E-11	9.42E-14	6.12E+12	1.15E-04
	May	9.69E-12	4.84E-14	6.32E+12	6.12E-05
	June	4.02E-11	2.01E-13	6.12E+12	2.46E-04
	Average:	2.29E-11	1.14E-13	6.19E+12	1.41E-04
			Total:	1.86E+13	4.22E-04
III	July	3.85E-11	1.92E-13	6.32E+12	2.43E-04
	August	3.65E-11	1.82E-13	6.32E+12	2.31E-04
	September	7.89E-12	3.94E-14	6.12E+12	4.83E-05
	Average:	2.76E-11	1.38E-13	6.25E+12	1.74E-04
			Total:	1.88E+13	5.22E-04
IV	October	1.43E-11	7.15E-14	6.32E+12	9.05E-05
	November	1.79E-11	8.97E-14	6.12E+12	1.10E-04
	December	9.24E-12	4.62E-14	6.32E+12	5.84E-05
	Average:	4.15E-11	2.07E-13	1.88E+13	2.59E-04
			Total:	1.88E+13	4.27E-04
Annual Summary	**Average:**	3.42E-11	1.71E-13	9.33E+12	2.13E-04
			Total:	7.44E+13	2.21E-03

5.5 Gaseous Effluents Monitoring

Argon-41 is the major gaseous effluent produced and released at the Nuclear Science Center. This effluent is monitored at the central exhaust stack. Total Argon-41 released during 1999 was 17.2 Ci with an annual average release concentration of 2.28E-7 uCi/cc and with a diluted concentration of 1.14E-09 uCi/cc. The following table summarizes monthly gaseous effluent releases during 1999.

Table 4. Monthly Gaseous Effluent Releases

Quarter	Month	Average Release Conc. (uCi/cc)	Diluted Concentration (uCi/cc)	Exhaust Volume (cc)	Total Release (Ci)
I	January	2.59E-08	1.29E-10	6.32E+12	1.64E-01
	February	2.65E-08	1.32E-10	5.71E+12	1.51E-01
	March	8.16E-08	4.08E-10	6.32E+12	5.16E-01
	Average:	4.46E-08	2.23E-10	6.12E+12	2.77E-01
			total:	1.84E+13	8.30E-01
II	April	2.70E-08	1.35E-10	6.12E+12	1.65E-01
	May	8.46E-08	4.23E-10	6.32E+12	5.35E-01
	June	5.10E-08	2.55E-10	6.12E+12	3.12E-01
	Average:	5.42E-08	2.71E-10	6.19E+12	3.38E-01
			total:	1.86E+13	1.01E+00
III	July	9.72E-09	4.86E-11	6.32E+12	6.15E-02
	August	2.96E-08	1.48E-10	6.32E+12	1.87E-01
	September	8.99E-08	4.50E-10	6.12E+12	5.50E-01
	Average:	4.31E-08	2.15E-10	6.25E+12	2.66E-01
			total:	1.88E+13	7.99E-01
IV	October	1.05E-08	5.23E-11	6.32E+12	6.61E-02
	November	2.83E-07	1.42E-09	6.12E+12	1.73E+00
	December	2.02E-06	1.01E-08	6.32E+12	1.28E+01
	Average:	7.70E-07	3.85E-09	6.25E+12	4.85E+00
			total:	1.88E+13	1.46E+01
Annual Summary	**Average:**	2.28E-07	1.14E-09	6.20E+12	1.43E+00
			total:	7.44E+13	1.72E+01

5.6 Liquid Effluents Monitoring

Radioactive Liquid effluents are maintained in collection tanks prior to release from the confines of the Nuclear Science Center. Sample activity concentrations and isotope identifications were determined prior to each release. There were 39 releases in 1999, totaling 2.57E+5 gallons excluding dilution from the Nuclear Science Center. Including dilution, the total volume released was 4.95E+05 gallons. The total radioactivity released was 3.88 E-03 Ci with an annual average concentration of 2.07 E-06 μCi/cc. Summaries of the release data are presented in the table below. Radioactivity concentrations for each isotope found were below the Effluent Concentration limits specified in 10CFR20, Appendix B. Some of the major radionuclides identified in the waste stream are Na^{24}, Sc^{46}, Sb^{124} and Co^{60}.

Table 5. Monthly Liquid Effluent Releases

Quarter	Month	Number of Releases	Volume Released (cc)	Total Radioactivity (Ci)	Average Concentration (uCi/cc)
I	January	1	3.23E+07	6.98E-06	2.16E-07
	February	3	1.32E+08	2.64E-04	2.00E-06
	March	2	8.39E+07	1.26E-04	1.50E-06
	Quarter Total:	6	2.48E+08	3.97E-04	1.60E-06
II	April	5	1.99E+08	8.89E-05	4.46E-07
	May	8	3.08E+08	3.38E-04	1.10E-06
	June	3	1.33E+08	2.23E-04	1.68E-06
	Quarter Total:	16	6.41E+08	6.50E-04	1.01E-06
III	July	7	3.55E+08	1.79E-03	5.05E-06
	August	3	1.50E+08	8.98E-05	6.01E-07
	September	2	9.56E+07	2.98E-04	3.12E-06
	Quarter Total:	12	6.00E+08	2.18E-03	8.76E-06
IV	October	2	1.04E+08	4.95E-04	4.76E-06
	November	1	8.94E+07	2.29E-05	2.56E-07
	December	2	1.94E+08	1.01E-04	5.21E-07
	Quarter Total:	5	3.87E+08	6.18E-04	1.60E-06
Annual Summary	**Total:**	39	1.88E+09	3.88E-03	2.07E-06

6.0 Environmental Monitoring

In conjunction with representatives from the Texas State Department of Health, Bureau of Radiation Control, a quarterly environmental survey program is conducted to insure compliance with federal regulations. This program consists of TLD monitors located at various locations on the NSC site and two background monitors one located at 3.84 miles NW of facility and the other at 0.25 miles SE of facility. The collection, analysis, and evaluation of NSC creek soil, and milk samples from the dairy downwind of the facility are included in the program.

6.1 Environmental Survey Samples

The environmental samples were collected in accordance with the schedules of the cooperative surveillance program between the Texas State Department of Health and the Texas A&M University. NSC creek sediment and milk samples from the dairy were analyzed using an intrinsic germanium detection system for isotopic identification at the NSC. A second set of sediment and milk samples were analyzed by the Texas Department of Health lab for comparison. The concentrations of environmental samples determined for each quarter are listed below.

Table 6. Environmental Sample Analysis

	MILK	
1999 Quarter	**Sample Location**	**Concentration (uCi/mL)**
1st	TAMU Dairy	< 3.3 E-09
2nd	TAMU Dairy	< 1.9 E-09
3rd	TAMU Dairy	< 5.6 E-09
4th	TAMU Dairy	<5.6 E-09
	SEDIMENT	
1st	NSC creek	4.05 E-07
2nd	NSC creek	1.60 E-06
3rd	NSC creek	3.11 E-07
4th	NSC creek	5.00 E-07

6.2 Site Boundary Dose Rate

The environmental survey program measures the integrated radiation exposures at the exclusion area boundaries. These measurements are made for periods of approximately 91 days, using TLDs. Monthly measurements of direct gamma exposure rate in microrem/h are also made at each of the TLD locations. The dosimeters are provided and processed by Texas Department of Health (TDH), Bureau of Radiation Control, Division of Environmental Programs. One of the background monitor (site # 14) is located at a point 3.84 miles NW of the facility and the other (site # 23) at 0.25 miles SE of facility. Site #23 background monitor was being placed on the third quarter. Total doses are multiplied by our newly determined occupancy factor (1/16) to determine total deep dose to the general public.

To determine internal exposure to individuals outside the site area the EPA's approved code *COMPLY* was used. The exposure calculated via *COMPLY* was 0.3 mrem/yr. This exposure is added to the calculated total deep dose. This total is the dose received by the general public.

Table 7. Site Boundary Dose Rates

Site #	Location	Quarterly Exposure Rate (mrem/91 days)				TLD Dose	Deep Dose (mrem)	Internal Dose (mrem)	Total Dose (mrem)
2	300 ft. W of reactor building, near fence corner	4.0	2.2	1.9	5.0	13	0.8	0.3	1.1
3	250 ft W-SW of reactor building, on SW chain link fence	3.0	5.5	0.0	2.0	10	0.6	0.3	0.9
4	200 ft NW of reactor building, on chain link fence, near butane tank.	9.0	7.7	6.8	10.0	33	2.0	0.3	2.4
5	225 ft NE of reactor building, on fence N of driveway	0.0	0.0	1.0	3.0	4	0.25	0.3	0.55
10	190 ft SE of reactor building, near fence corner	0.0	0.0	0.0	3.0	3	0.18	0.3	0.48
11	300 ft NE of reactor building, near fence corner	0.0	0.0	0.0	2.0	2	0.125	0.3	0.43
18	375 ft NE of reactor building	3.0	2.2	1.9	6.0	13	0.8	0.3	1.1
19	320 ft NE of reactor building	0.0	0.0	1.9	10.0	12	0.75	0.3	1.1
14	3.84 miles NW of facility	0.0	0.0	0.0	0.0	0	0	0.3	0.3
23	0.25 miles SE of facility	—	—	0.0	0.0	0	0	0.3	0.3

7.0 Radioactive Waste Shipments

During 1999, there were no solid waste releases from the NSC for disposal offsite.

8.0 Reactor Safety Board

The Reactor Safety Board (RSB) is responsible to the licensee for providing an independent review and audit of the safety aspects of the NSCR. The RSB meets at least once a year to review audit reports, security and emergency plans, new experiments and modifications to the facility.

Membership (1999)

Chairman/Licensee: Dr. Glen Williams/Dr. B. Don Russell
Texas Engineering Experiment Station

Members:

Dr. Marvin Adams, Professor
Nuclear Engineering Department

Dr. Ted Parish, Professor
Nuclear Engineering Department

Dr. Roger Koppa, Associate Professor,
Industrial Engineering Department

Dr. William Dennis James, Research Chemist
Chemistry Department

Dr. Robert Kenefick, Professor
Physics Department

Dr. Earl Morris, Professor
Veterinary Medicine-Large Animal Clinic

Ex-Officio Members:

Dr. Warren Reece, Director
Nuclear Science Center

Ms. Latha Vasudevan, Radiological Safety Officer
Nuclear Science Center

Mr. Chris Meyer, Director
Environmental Health and Safety

Dr. Alan Waltar, Professor and Head
Nuclear Engineering Department

Mr. Robert Berry, Reactor Supervisor
AGN201, Nuclear Engineering Department