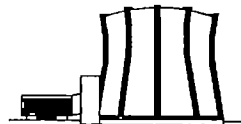


50-128



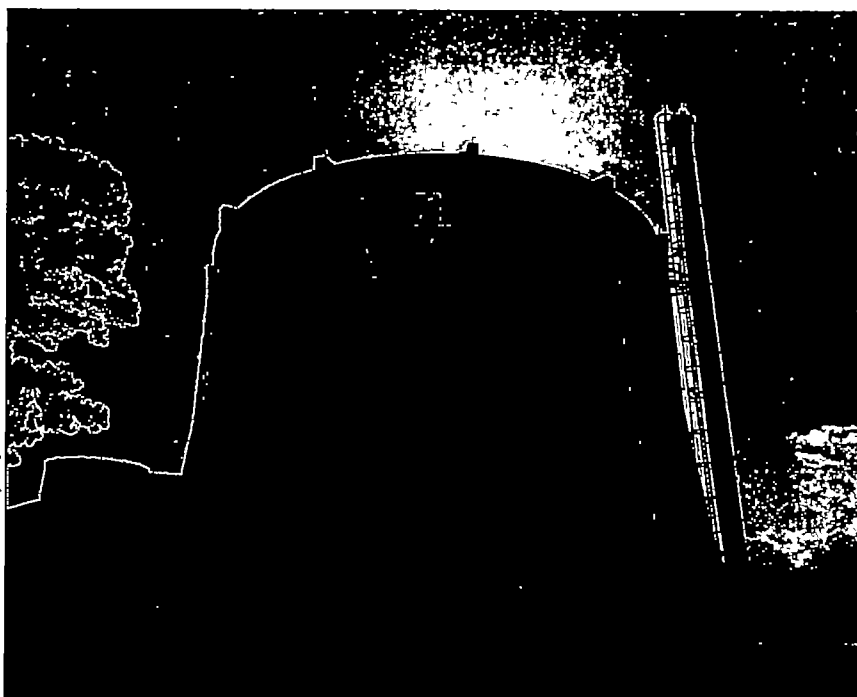
**Texas A&M University System  
Texas Engineering Experiment Station**

Annual Report

2019

# Facility Operating License R-83

Nuclear Science Center  
1095 Nuclear Science Road  
College Station, Texas 77843-3575



Prepared By: Jerry Newhouse, Associate Director;  
Scott Miller, Reactor Operations Manager;  
Donna Rios, Safety Coordinator

ADZO  
NR

# TABLE OF CONTENTS

<b>1. INTRODUCTION</b> .....	<b>1</b>
1.1 NSC STAFF.....	1
<b>2. REACTOR UTILIZATION FOR 2019</b> .....	<b>2</b>
2.1 TAMU ACADEMIC SUPPORT .....	4
2.2 COMMERCIAL ACTIVITY AND EXTERNAL RESEARCH .....	4
<b>3. FACILITY AND PROCEDURE CHANGES</b> .....	<b>5</b>
3.1 FACILITY MODIFICATIONS .....	5
3.2 EXPERIMENT AUTHORIZATION AND MODIFICATION AUTHORIZATION.....	5
<b>4. REACTOR MAINTENANCE AND SURVEILLANCE</b> .....	<b>6</b>
4.1 SCHEDULED MAINTENANCE .....	6
4.2 UNSCHEDULED SHUTDOWNS .....	6
4.3 EMERGENCY PLAN AND REVIEW.....	7
4.4 REACTOR SAFETY BOARD .....	7
4.5 AUDITS .....	7
4.6 NRC INSPECTION RESULTS.....	7
<b>5. HEALTH PHYSICS SURVEILLANCE</b> .....	<b>8</b>
5.1 PERSONNEL MONITORING.....	8
5.2 FACILITY MONITORING .....	8
5.3 PARTICULATE EFFLUENT MONITORING .....	10
5.4 GASEOUS EFFLUENT MONITORING.....	11
5.5 LIQUID EFFLUENT MONITORING.....	12
<b>6. ENVIRONMENTAL MONITORING</b> .....	<b>13</b>
6.1 SITE BOUNDARY DOSE RATE .....	13
<b>7. RADIOACTIVE WASTE SHIPMENTS</b> .....	<b>14</b>
<b>APPENDIX A</b> .....	<b>15</b>
<b>APPENDIX B</b> .....	<b>16</b>

## 1. Introduction

The Texas A&M Engineering Experiment Station 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 is a 1 MW TRIGA research reactor in a large (108,000-gal.) pool. The size of the NSC reactor pool provides great flexibility in the experiments that may be conducted near the reactor. The NSC reactor facility includes five neutron beam ports, a neutron/gamma irradiation cell, hot cells with manipulator arms, and other supporting facilities.

Laboratory facilities include counting laboratories with gas flow proportional detectors and high purity germanium detectors, a pneumatics sample transfer system, and a fast neutron irradiation system.

The NSC reactor design allows for easy loading/unloading of various types of samples. The NSC actively produces a variety of radioisotopes for academic and industry users. The NSC provides neutron activation analysis (NAA) services to many research and academic institutions in the United States. The Nuclear Engineering Department on campus is a major user of the NSC reactor. The NSC is also one of the major attractions on campus. Last year, the NSC hosted 691 visitors including: elementary school, middle school, high school, and college students as well as faculty members, national laboratory scientists, and industrial clients. Through these tours, the NSC taught people with widely varying backgrounds about nuclear science.

This annual report has been prepared 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).

### 1.1 Nuclear Science Center Staff

The staff at the Nuclear Science Center consists of three major groups: Reactor Operations, Radiation Safety, and Engineering. 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. Appendix A shows the Nuclear Science Center Organization Chart.

The Texas A&M Engineering Experiment Station (TEES) of the Texas A&M University System operates the NSC. The Director of the NSC is responsible to the Director of the TEES for the administration and the proper and safe operation of the facility. The NSC Radiation Safety Officer is responsible to the Director of the NSC for matters relating to safety and for maintaining a proper radiation safety program. In addition to the internal structure, the Reactor Safety Board (RSB) advises the Director of the TEES and the Director of the NSC on issues or policy pertaining to reactor safety. Texas A&M Environmental Health and Safety (EHS) provides assistance when

required for emergencies and for special operations as agreed. The Texas A&M University Police Department provides security support on a daily basis and is a key support group in the event of a security incident. The College Station Fire Department and Scott & White Medical Center provide offsite emergency support when required as per agreement.

## 2. Reactor Utilization for 2019

The NSC reactor has been in operation since 1961. The reactor is a 1 MW MTR-converted TRIGA reactor. Core IX is the current core configuration and has been in use since September 2006. The NSC reactor is pulse operational and was pulsed up to 1.60 for nuclear engineering laboratories, staff training, and public tours.

The NSC reactor operated for 1184.9 hours in 2019 with a total integrated power of 69.3 MW-days. There were 285 "Requests for Irradiation" processed at the NSC during the reporting period. The NSC provided services to TAMU departments, other universities, research centers, secondary schools, and industry partners in and outside the state of Texas. The cumulative total energy output since initial criticality of the LEU fuel is 894.1 MW-days. Table 2 shows the reactor utilization summary in 2019 and Figure 2 shows the annual reactor utilization in MW-hrs of operation.

**Table 2: Reactor Utilization Summary in 2019**

Days of Reactor Operation	195
Integrated Power (MW-days)	69.3
Number of Hours at Steady-State	1184.9
Number of Pulses	41
Number of Reactor Irradiations (RFS)	285
Unscheduled Shutdowns	8

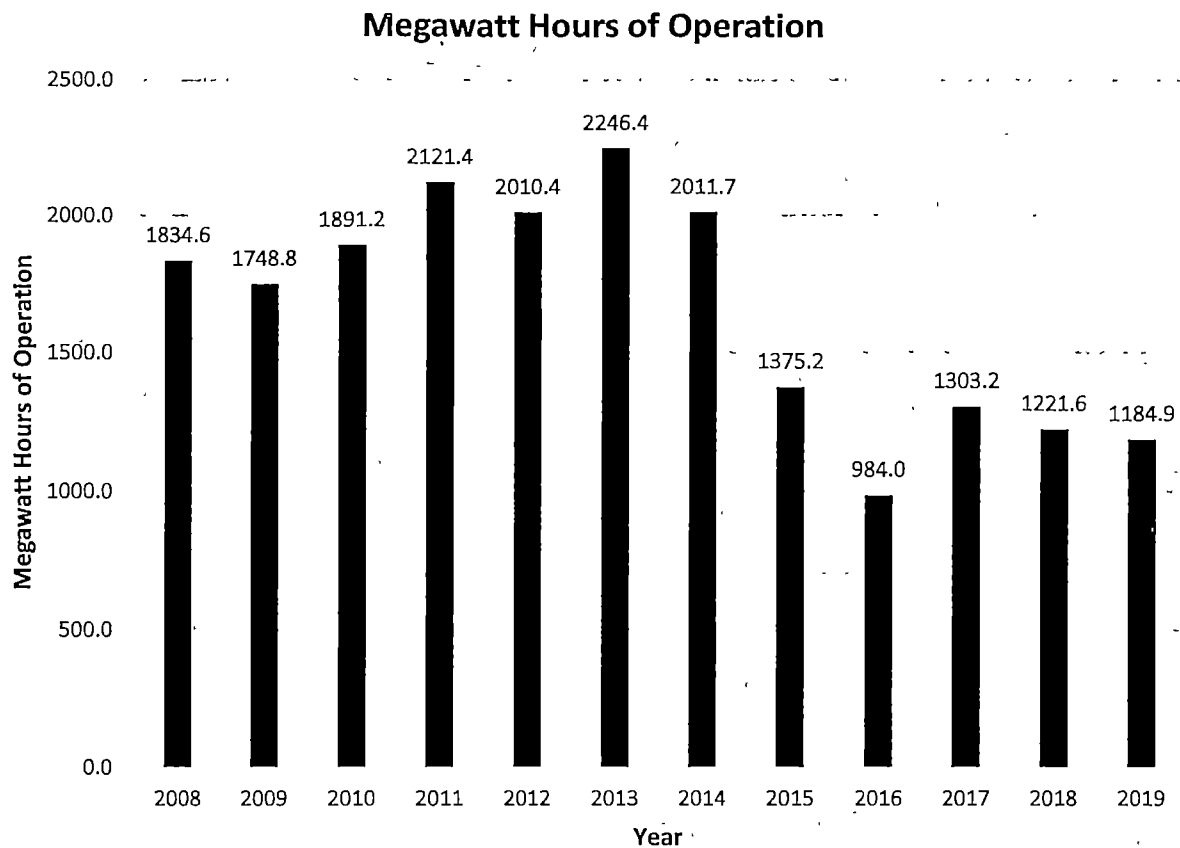


Figure 2. Annual Reactor Utilization in MW-hrs of Operation

## 2.1 TAMU Academic Support Program

Texas A&M University provides funding for the reactor for such academic activities as nuclear engineering laboratories. The wide range of academic users from the university reflects in the NSC's reputation as a multi-disciplinary institution.

## 2.2 Commercial Activity and External Research

The NSC provides services to a variety of users that provide their own funding. The majority of commercial activities focus on production of radioactive tracers for the petroleum and chemical industries. Outside research grants fund a significant amount of the NSC's research. The NSC has many years of experience producing radioisotopes and has developed several customer-specific methods for radioactive sample production and handling. The production of radioisotopes generally involves handling radioactive material with high activities. The NSC staff takes precautions to minimize the exposures during the transfer of radioactive materials to shipping shields.

### **3. Facility and Procedure Changes**

#### **3.1 Facility Modifications**

None.

#### **3.2 Experiment Authorization and Modification Authorization**

There were no new Experiment Authorizations (EA) or Modification Authorizations (MA) in 2019.

## 4. Reactor Maintenance and Surveillance

### 4.1 Scheduled Maintenance

NSC personnel performed regular maintenance on all channels as required by the Technical Specifications. Control rod worth and scram time measurements performed in June 2019 gave the following results. The total rod worth was \$14.908. The most reactive control rod was Shim Safety #4 with a worth of \$4.196. The shutdown margin was \$4.461 and core excess was \$5.182. Scram times on all rods were less than 1.2 seconds. In addition, operators performed calorimetric calibration following each maintenance period, and fuel inspections with no abnormalities noted (as required by the Technical Specification).

### 4.2 Unscheduled Shutdowns

There were eight unscheduled reactor shutdowns during 2019. The cause is detailed below in Table 4-2.

**Table 4-2: Unscheduled Shutdowns**

05/03/19	Directed SCRAM due to loss of signal on FAM 3.
05/08/19	Directed shutdown due to tornado warning in the county.
08/19/19	Directed SCRAM due to heat sensor triggering a fire alarm.
08/22/19	Directed SCRAM due to improper display status on shim safety #1
09/10/19	Automatic SCRAM due to facility power loss.
09/18/19	Manual SCRAM after transient rod dropped due to improper input from fuel temperature thermocouple connection block.
10/28/19	Manual SCRAM after FAMs were inadvertently shut off.
11/07/19	Directed shutdown following magnet failure on SS#2.



### **4.3 Emergency Plan and Review**

The members of RSB reviewed the NSC Security and Emergency Plans.

### **4.4 Reactor Safety Board**

The Reactor Safety Board is responsible for providing an independent review and audit of the safety aspects of the NSC reactor. The Reactor Safety Board met as required in the year 2019.

### **4.5 Audits**

The Reactor Safety Board performed the required audits and inspections as per the Technical Specifications requirement. The results of the audit were shared with the RSB members.

### **4.6 NRC Inspection Results**

Facility inspections were performed by the U.S. Nuclear Regulatory Commission in December 2019.

## 5. Health Physics Surveillance

The purpose of Health Physics surveillance is to ensure safe use of radioactive materials in the Nuclear Science Center's research and service activities and to fulfill the regulatory requirements of the U.S. Nuclear Regulatory Commission and State agencies. The NSC maintains a Health Physics group as an integral part of the organization. It is responsible for radiological as well as chemical and physical safety concerns. The radiation safety team at the TAMU Environmental Health and Safety Department provides additional support to the NSC Health Physics group upon request.

### 5.1 Personnel Monitoring

Personnel Monitoring was provided on a monthly basis to approximately 48 personnel. All measured doses to personnel were below the limits set forth in 10 CFR 20. The highest deep dose equivalent (DDE) recorded was 0.607R 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 2019.

During 2019, 691 visitors toured the Nuclear Science Center. Minimal exposures were measured with pocket ion chambers worn by these visitors and the pocket ion chamber readings of their respective tour guides.

NSC employees who were likely to exceed 10% of their total annual dose wore whole body badges (Luxel dosimeter) and extremity badges (TLD dosimeters) that were provided by Landauer, a NVLAP accredited supplier. Landauer also provides the reports of the doses received. Employees who potentially handle more radioactive materials on a regular basis were provided two extremity badges and were exchanged on a monthly basis.

### 5.2 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. All areas accessible to the general public at the NSC were surveyed for radiation and contamination levels monthly by ion chamber readings and evaluation of smear samples. Areas where contamination is expected are access/egress controlled and are evaluated on shorter intervals as needed. Building monitors and Area monitors are located strategically throughout the reactor facility, providing dose equivalent (mrem) on a monthly basis. Table 5-2 summarizes the annual accumulated dose equivalent (mrem) recorded on the area monitors for the year 2019.

**Table 5-2: Total Dose Equivalent (mrem) Recorded on Area Monitors**

<b>Monitor ID</b>	<b>Location</b>	<b>Accumulated Dose Equivalent (mrem)</b>
BLDG MNTR 1	Upper Research Level Mezzanine	552
BLDG MNTR 2	Lower Research Level Mezzanine	1275 <sup>a</sup>
BLDG MNTR 3	Lower Research Level	12130 <sup>a</sup>
AREA	Control Room	97
AREA	Upper Research Level	247
AREA	Room next to MHA	753 <sup>b</sup>

<sup>a</sup>Radioactive shipments were stored in the LRL area pending transport

<sup>b</sup>Radioactive materials were stored in the temporary locations in MHA.

### 5.3 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  $4.91 \times 10^{-18}$   $\mu\text{Ci}/\text{cc}$ . The total radioactivity released for 2019 was  $3.85 \times 10^{-2}$   $\mu\text{Ci}$ . Table 5-3 summarizes monthly particulate effluent releases during 2019. The most common isotopes noted during particulate effluent releases were Sc-46, Sb-124, and Ir-192.

**Table 5-3: Particulate Effluent Releases**

Quarter	Month	Particulate Activity from channel 1 ( $\mu\text{Ci}$ )	Exhaust Volume (cc)	Additional releases ( $\mu\text{Ci}$ )	Dilution Concentration ( $\mu\text{Ci}/\text{cc}$ )	Total activity released (Ci)
I	January	1.23E-03	9.96E+12	0.00E+00	6.17E-19	1.23E-09
	February	4.28E-03	8.99E+12	0.00E+00	2.38E-18	4.28E-09
	March	<BG	9.96E+12	0.00E+00	0.00E+00	0.00E+00
	<b>Sum:</b>	<b>5.51E-03</b>	<b>9.64E+12</b>	<b>0.00E+00</b>	<b>2.86E-18</b>	<b>5.51E-09</b>
II	April	7.21E-03	9.64E+12	0.00E+00	3.74E-18	7.21E-09
	May	<BG	9.96E+12	0.00E+00	0.00E+00	0.00E+00
	June	<BG	9.64E+12	0.00E+00	0.00E+00	0.00E+00
	<b>Sum:</b>	<b>7.21E-03</b>	<b>9.74E+12</b>	<b>0.00E+00</b>	<b>3.70E-18</b>	<b>7.21E-09</b>
III	July	<BG	9.96E+12	0.00E+00	0.00E+00	0.00E+00
	August	1.10E-03	9.96E+12	0.00E+00	5.51E-19	1.10E-09
	September	<BG	9.64E+12	0.00E+00	0.00E+00	0.00E+00
	<b>Sum:</b>	<b>1.10E-03</b>	<b>9.85E+12</b>	<b>0.00E+00</b>	<b>5.57E-19</b>	<b>1.10E-09</b>
IV	October	<BG	9.96E+12	0.00E+00	0.00E+00	0.00E+00
	November	1.91E-02	9.64E+12	0.00E+00	9.92E-18	1.91E-08
	December	5.56E-03	9.96E+12	0.00E+00	2.79E-18	5.56E-09
	<b>Sum:</b>	<b>2.47E-02</b>	<b>9.85E+12</b>	<b>0.00E+00</b>	<b>1.25E-17</b>	<b>2.47E-08</b>
<b>Summary YTD</b>		<b>3.85E-02</b>	<b>9.77E+12</b>	<b>0.00E+00</b>	<b>4.91E-18</b>	<b>3.85E-08</b>

**notes:**

1. Activity released from the stack: Activity sampled from Ch 1 multiplied by volume of air going through the stack
2. Diluted Concentration equal to: Activity Released/exhaust volume \* 0.005 (Technical Specification 3 5.2, dilution value for release concentration at exclusion boundary)
3. Exhaust Volume equal to: (# days/month)\*(24hrs/day)\*(60min/hr)\*(7875 cfm)/3.53E-5cc)
4. Additional Release equal to: (Individual releases calculated from facility air monitoring data)
5. Total Release equal to: (Activity Released+Additional Releases)\*conversion factor

## 5.4 Gaseous Effluent 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 2019 was approximately 4.67 mCi with an annual average release concentration of  $5.63 \times 10^{-13}$   $\mu\text{Ci}/\text{cc}$ . Table 5-4 summarizes monthly gaseous effluent (Ar-41) releases during 2019.

**Table 5-4: Gaseous Effluent (Ar-41) Releases**

Quarter	Month	Argon-41 Activity from channel 3 ( $\mu\text{Ci}$ )	Exhaust Volume (cc)	Additional Releases (mCi)	Dilution Concentration ( $\mu\text{Ci}/\text{cc}$ )	Total activity released (Ci)
I	January	<BG	9.96E+12	0.00E+00	0.00E+00	0.00E+00
	February	2.06E+02	8.99E+12	0.00E+00	1.15E-13	2.06E-04
	March	5.92E+02	9.96E+12	0.00E+00	2.97E-13	5.92E-04
	Sum:	7.98E+02	9.64E+12	0.00E+00	4.14E-13	7.98E-04
II	April	1.63E+03	9.64E+12	0.00E+00	8.46E-13	1.63E-03
	May	6.56E+01	9.96E+12	0.00E+00	3.30E-14	6.56E-05
	June	1.60E+03	9.64E+12	0.00E+00	8.28E-13	1.60E-03
	Sum:	3.29E+03	9.74E+12	0.00E+00	1.69E-12	3.29E-03
III	July	<BG	9.96E+12	0.00E+00	0.00E+00	0.00E+00
	August	3.58E+01	9.96E+12	0.00E+00	1.80E-14	3.58E-05
	September	1.16E+02	9.64E+12	0.00E+00	6.03E-14	1.16E-04
	Sum:	1.52E+02	9.85E+12	0.00E+00	7.71E-14	1.52E-04
IV	October	7.15E+00	9.96E+12	0.00E+00	3.59E-15	7.15E-06
	November	<BG	9.64E+12	0.00E+00	0.00E+00	0.00E+00
	December	4.19E+02	9.96E+12	0.00E+00	2.10E-13	4.19E-04
	Sum:	4.26E+02	2.96E+13	0.00E+00	7.21E-14	4.26E-04
<b>Summary YTD</b>		<b>4.67E+03</b>	<b>1.47E+13</b>	<b>0.00E+00</b>	<b>5.63E-13</b>	<b>4.67E-03</b>

**notes:**

1. Activity released from the stack: Activity sampled from Ch 3 multiplied by volume of air going through the stack
2. Diluted Concentration equal to: Activity Released/exhaust volume \* 0.005 (Technical Specification 3.5.2, dilution value for release concentration at exclusion boundary)
3. Exhaust Volume equal to: (# days/month)\*(24hrs/day)\*(60min/hr)\*(7875 cfm)/3.53E-5cc
4. Additional Release equal to: (Individual releases calculated from facility air monitoring data)
5. Total Release equal to: (Activity Released+Additional Releases)\*conversion factor

## 5.5 Liquid Effluent Monitoring

Radioactive Liquid effluents are maintained in collection tanks before release from the confines of the Nuclear Science Center. Sample activity concentrations and isotope identifications were determined before each release. The concentration values for each isotope were compared with the effluent concentrations in water (10 CFR 20) and were determined to be in compliance. There were 31 releases in 2019, totaling  $3.66 \times 10^5$  gallons including dilution. The total radioactivity released was 0.970 mCi with an annual average concentration of  $7.00 \times 10^{-7}$   $\mu\text{Ci/cc}$ . The annual dose to the public calculated from liquid effluents is about 0.48 mrem. Summary of the release data are presented in the following Table 5-5. Radioactivity concentrations for each isotope found were below the Effluent Concentration limits specified in 10 CFR 20, Appendix B. The radionuclides identified in the waste stream were Na-22, Na-24, Sc-46, Cr-51, Mn-54, Co-58, Co-60, Zn-65, Sb-122, Sb-124, and K-40.

**Table 5-5: Liquid Effluent Releases**

Quarter	Month	Number of Releases	Volume Released (cc)	Total Radioactivity (Ci)	Average Concentration ( $\mu\text{Ci/cc}$ )
I	January	2	9.2E+07	5.74E-06	1.18E-07
	February	1	4.6E+07	6.05E-06	1.31E-07
	March	2	8.9E+07	5.23E-06	1.18E-07
	<b>Total</b>	<b>5</b>	<b>2.3E+08</b>	<b>1.70E-05</b>	<b>3.67E-07</b>
II	April	4	2.00E+08	3.60E-05	7.45E-07
	May	7	2.59E+08	3.60E-05	1.04E-06
	June	1	6.20E+07	3.96E-06	6.39E-08
	<b>Total</b>	<b>12</b>	<b>5.2E+08</b>	<b>7.59E-05</b>	<b>1.85E-06</b>
III	July	4	1.9E+08	4.89E-05	1.1E-06
	August	5	2.2E+08	3.45E-04	6.92E-06
	September	2	9.5E+07	1.85E-04	3.9E-06
	<b>Total</b>	<b>11</b>	<b>5.1E+08</b>	<b>5.79E-04</b>	<b>1.19E-05</b>
IV	October	2	8.3E+07	2.4E-04	4.9E-06
	November	0	----	----	----
	December	1	4.8E+07	6.2E-05	1.3E-06
	<b>Total</b>	<b>3</b>	<b>1.3E+08</b>	<b>2.98E-04</b>	<b>6.18E-06</b>
<b>Annual Summary</b>	<b>Total</b>	<b>31</b>	<b>1.38E+09</b>	<b>9.70E-04</b>	<b>7.00E-07</b>

## **6. Environmental Monitoring**

In conjunction with representatives from the Texas Department of State Health Services (TDSHS) Radiation Control, a quarterly environmental survey 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.

### **6.1 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  $\mu\text{R/h}$  are also made at each of the TLD locations. The dosimeters were provided and processed by Texas Department of State Health Services, Environmental Monitoring, Division of Regulatory Services, Austin, Texas.

**Table 6-1: Site Boundary TLD Data**

Site #	Location	Quarterly Exposure rates (mrem/91 days)				TLD Dose (total)	Deep Dose=TLD dose*(1/16)
2	300 ft. W of reactor building, near fence corner	4	2	1	4	11	0.6875
3	250 ft W-SW of reactor building, on SW chain link fence	2	1	0	3	6	0.375
4	200 ft NW of reactor building, on chain link fence	5	6	3	7	21	1.3125
5	225 ft NE of reactor building, on fence N of driveway	0	0	0	1	1	0.0625
10	190 ft SE of reactor building, near fence corner	0	0	0	2	2	0.125
11	300 ft NE of reactor building, near fence corner	0	1	0	0	1	0.0625
*14	3.84 miles NW of facility	0	0	0	0	0	0
18	375 ft NE of reactor building	1	2	0	1	4	0.25
19	320 ft NE of reactor building	0	0	0	0	0	0
*23	0.25 miles SE of facility	0	0	0	2	2	0.125
24	Fence line near N wall of BLDG 1307	3	2	1	2	8	0.5

\*Background TLD station

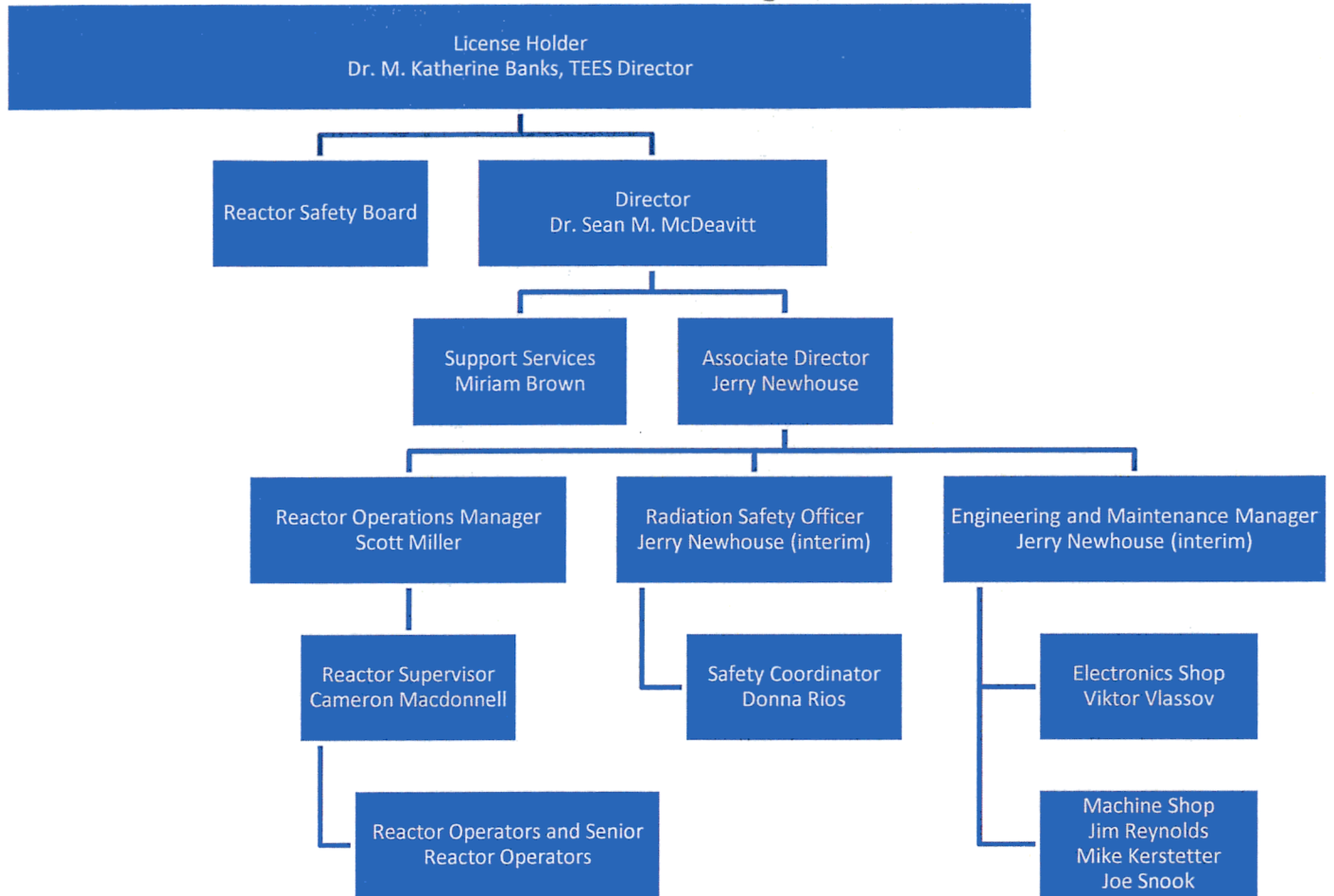
## 7. Radioactive Waste Shipments

In 2019, the NSC conducted no radioactive waste shipments.



### Appendix A

#### Nuclear Science Center Organizational Chart



## **Appendix B**

### Reactor Safety Board Membership (2019)

#### **Chair/Licensee:**

Dr. Kathy Banks, Director  
Texas A&M Engineering Experiment Station

#### **Chair Pro Temp:**

Dr. Charles Folden, Assistant Professor  
Cyclotron Institute

#### **Members:**

Dr. Marvin Adams, Associate Professor  
Nuclear Engineering Department

Dr. Steve Biegalski, Professor  
Mechanical Engineering Department, University of Texas

Dr. John Ford, Associate Professor  
Nuclear Engineering Department

Dr. Teruki Kamon, Professor  
Physics Department

Dr. Bryan Tomlin, Manager  
Center for Chemical Characterization and Analysis

Dr. Karen Vierow, Associate Professor  
Nuclear Engineering Department

#### **Ex-Officio Members:**

Dr. Sean McDeavitt, Director  
Nuclear Science Center

Mr. Jerry Newhouse, RSO  
Nuclear Science Center

Dr. Yassin Hassan, Professor and Head  
Nuclear Engineering Department

Dr. Latha Vasudevan, RSO  
Environmental Health and Safety Department