Department of Mechanical Engineering
THE UNIVERSITY OF TEXAS AT AUSTIN

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March 27, 2007

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington D. C. 20555

Subject: Annual Report for The University of Texas at Austin , Docket 50-602

Dear Sir:

Enclosed is the 2006 Annual Report for the Nuclear Engineering Teaching Laboratory at The University of Texas at Austin. This report is being submitted in accordance with Section 6.6 of the Technical Specifications.

Please contact me at 512-232-5373 if you have any questions.

Sincerely,

Sean O'Kelly
NETL Associate Director

Enclosure: 2006 Annual Report

cc: A. Adams, DRIP/RTR Project Manager
CF#5-30

A020

The University of Texas at Austin

Nuclear Engineering Teaching Laboratory

2006

Annual Report

NRC Docket 50-602

DOE Contract No. DE-AC07-ER03919

EXECUTIVE SUMMARY

The Nuclear Engineering Teaching Laboratory (NETL) facility continues to support the academic and research missions of The University of Texas but has begun to provide these support functions to other institutions. The NETL and NRE programs received an Innovations in Nuclear Infrastructure and Education (INIE) grant from the DOE in June of 2002. The INIE Southwest Consortium is a partnership between the University of Texas, Texas A&M University, the University of New Mexico and the Sandia National Laboratories. The funds from this program have permitted significant upgrades of the experimental facilities and research programs. The environmental research and analysis services performed by the NETL during this past year supported the Sandia National Laboratories, Los Alamos National Laboratory, Oak Ridge National Laboratory, the Canadian government, the University of Texas-Pan American, the University of Texas Medical Branch at Dallas, Idaho State University, the University of Illinois, Texas A&M University and the State of Texas.

FORWARD

The mission of the Nuclear Engineering Teaching Laboratory at The University of Texas at Austin is to:

- **Educate the next generation of leaders in nuclear science and engineering.**
- **Conduct leading research at the forefront of the international nuclear community.**
- **Apply nuclear technology for solving multidisciplinary problems.**
- **Provide service to the citizens of Texas, the U.S., and the international community.**

This objective is achieved by carrying out a well-balanced program of education, research, and service. The NETL research reactor supports hands-on education in reactor physics and nuclear science. In addition, students in non-nuclear fields such as physics, chemistry, and biology use the reactor in laboratory course work. It may also be used in education programs for nuclear power plant personnel, secondary schools students and teachers, and the general public.

The NETL research reactor benefits a wide range of on-campus and off-campus users, including academic, medical, industrial, and government organizations. The principal services offered by our reactor involve material irradiation, trace element detection, material analysis, and radiographic analysis of objects and processes. Such services establish beneficial links to off-campus users, expose faculty and students to multidisiplinary research and commercial applications of nuclear science, and earn revenues to help support Nuclear Engineering activities.

Steven Biegalski
Director
Nuclear Engineering Teaching Laboratory

Chapter 1

1.0 NUCLEAR ENGINEERING TEACHING LABORATORY

1.1 Introduction

Purpose of the Report

The Nuclear Engineering Teaching Laboratory (NETL) at The University of Texas at Austin prepares an annual report of program activities to comply with requirements of the nuclear reactor license and the Department of Energy's fuel assistance program. Information in this report provides an introduction to the education, research, and service programs of the NETL. A TRIGA nuclear reactor is the major experimental facility at the Laboratory. The reactor operates at power levels up to 1000 kilowatts or with pulse reactivity insertions up to 2.2% $\Delta k/k$.

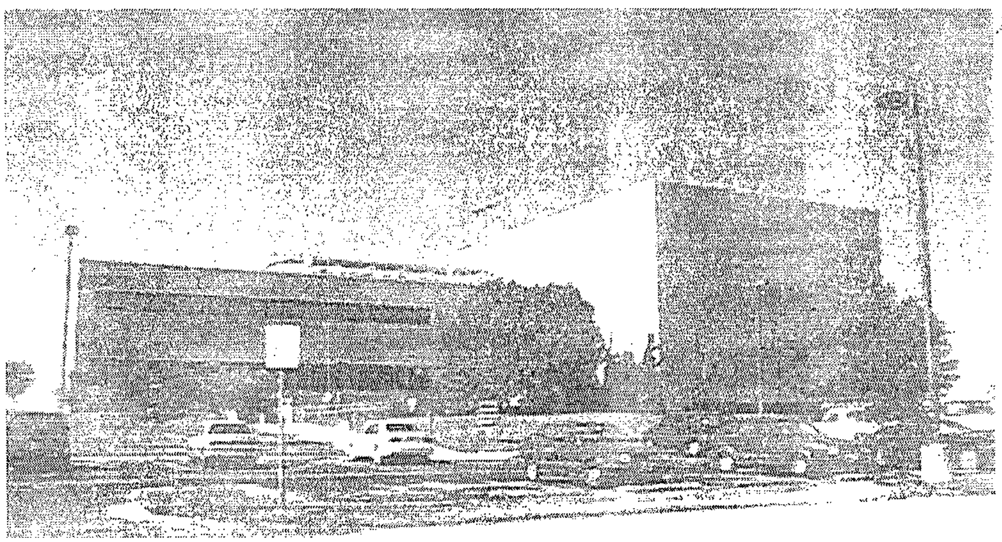

Figure 1-1 NETL - Nuclear Engineering Teaching Laboratory

The annual report satisfys requirements of the University Fuel Assistance Program, U.S. Department of Energy (DOE) [contract number DE-AC07-ER03919, Amendment A015; C85-110742 Task Order 2, Mod. 1], and the licensing agency, the U.S. Nuclear Regulatory Commission (NRC) [docket number 50-602]. This annual report covers the period from January 1, 2006 to December 31, 2006.

Availability of the Facility

The NETL facility serves a multipurpose role. The use of NETL by faculty, staff, and students in the College of Engineering is the Laboratory's primary function. In addition, the development and application of nuclear methods are done to assist researchers from other universities, industry, and government. NETL provides services to industry, government and other laboratories for the testing and evaluation of materials. Public education through tours and demonstrations is also a routine function of the laboratory operation.

Operating Regulations

Licensing of activities at NETL involve both Federal and State agencies. The nuclear reactor is subject to the terms and specifications of Nuclear Regulatory Commission (NRC) License R-129, a class 104c research reactor license. Another NRC license, SNM-180, for special nuclear material, provides for the use of a subcritical assembly with neutron sources. Both licenses are responsibilities of the NETL. For general use of radioisotopes the university maintains a broad license with the State of Texas, L00485. Functions of the broad license are the responsibility of the University Office of Environmental Health and Safety.

NETL History

Development of the nuclear engineering program was an effort of both physics and engineering faculty during the late 1950's and early 1960's. The program became part of the Mechanical Engineering Department where it remains to this day. The program installed, operated, and dismantled a TRIGA nuclear reactor at a site on the main campus in the engineering building, Taylor Hall. Initial criticality for the first UT reactor was August 1963 with the final operation in April 1988. Power at startup was 10 kilowatts (1963) with one power upgrade to 250 kilowatts (1968). The total burnup during a 25 year period from 1963 to 1988 was 26.1 megawatt-days. Pulse capability of the reactor was 1.4% $\Delta k/k$ with a total of 476 pulses during the operating history. Dismantling and decommissioning of the facility were completed in December 1992.

Planning for a new facility, which led to the shutdown of the campus facility, began in October 1983, with construction commencing in December 1986 and continuing until May 1989. The final license was issued in January 1992, and initial criticality occurred on March 12, 1992.

The new facility, including support laboratories, administrative offices, and the reactor is the central location for all NETL activities.

Land use in the area of the NETL site began as an industrial site during the 1940's. Following the 1950's, lease agreements between the University and the Federal government led to the creation of the Balcones Research Center. In the 1990's, the University became owner of the site, and in 1994 the site name was changed to the J.J. Pickle Research Campus to honor retired U.S. Congressman James "Jake" Pickle.

1.2 NETL Building

J.J. Pickle Research Campus

The J.J. Pickle Research Campus (PRC) is a multidiscipline research campus with a site area of 1.87 square kilometers. Areas of the site consist of two approximately equal east and west tracts of land. An area of about 9000 square meters on the east tract is the location of the NETL building. Sixteen separate research units and at least five other academic research programs, including the NETL facility, have research efforts with locations at the research campus. Adjacent to the NETL site is the Center for Research in Water Resources and Bureau of Economic Geology, which are examples of the diverse research activities on the campus. A Commons Building provides cafeteria service, recreation areas, meeting rooms, and conference facilities. Access to the NETL site is shown in Figure 1-2.

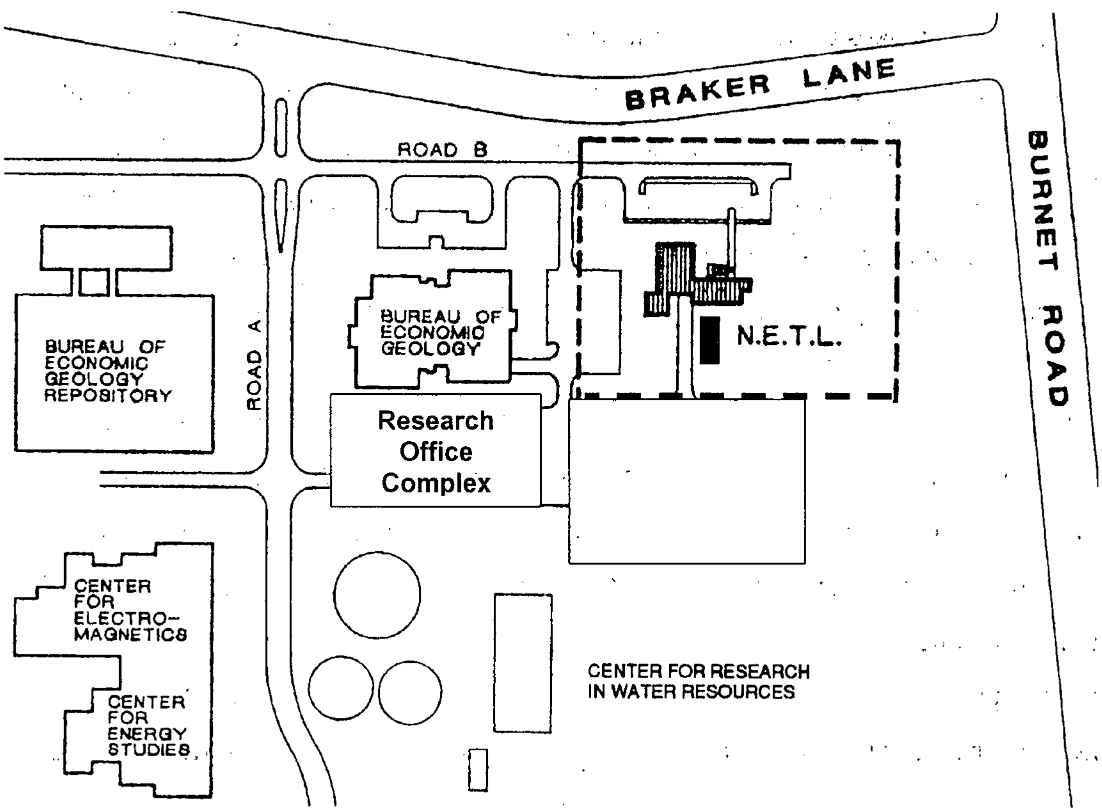

Figure 1-2 NETL Site - J.J. Pickle Research Campus

NETL Building Description

The NETL building is a 1950 sq meter (21,000 sq ft), facility with laboratory and office spaces. Building areas consist of two primary laboratories of 330 sq m (3600 sq ft) and 80 sq m (900 sq ft), eight support laboratories (217 sq m, 2340 sq ft), and six supplemental areas (130 sq m, 1430 sq ft). Conference and office space is allocated to 12 rooms totaling 244 sq m (2570 sq ft). One of the primary laboratories contains the TRIGA reactor pool, biological shield structure, and the neutron beam experiment areas. A second primary laboratory consists of 1.3 meter (4.25 ft) thick walls for use as a general purpose radiation experiment facility. Other areas of the building include support shops, instrument laboratories, measurement laboratories, and material handling laboratories.

Laboratories, Equipment

The NETL facility makes available several types of radiation facilities and an array of radiation detection equipment. In addition to the reactor, facilities include a subcritical assembly, a gamma irradiator, various radioisotope sources, and several radiation producing machines.

The gamma irradiator is a multicurie cobalt-60 source with a design activity of 10,000 curies. The gamma irradiator is in permanent storage and is not currently available for use. The irradiator is expected to be shipped for disposal in 2007. Radioisotopes are available in millicurie quantities for calibration of radiation detection equipment.

Neutron sources of plutonium-beryllium and californium-252 are available. A subcritical assembly of 20% enriched uranium in a polyethylene moderated cylinder provides an experimental device for laboratory demonstrations of neutron multiplication and neutron flux measurements. A full critical loading of fuel from the Manhattan College Zero Power Reactor is currently available for subcritical experiments.

Laboratories provide locations to setup radiation experiments, test instrumentation, prepare materials for irradiation, process radioactive samples and experiment with radiochemical reactions.

1.3 UT-TRIGA MARK II Research Reactor

The TRIGA Mark II nuclear reactor at the Nuclear Engineering Teaching Laboratory of The University of Texas at Austin is an above-ground, fixed-core research reactor. The nuclear core, containing uranium fuel, is located at the bottom of an 8.2 meter deep water-filled tank surrounded by a concrete shield structure. The highly purified water in the tank serves as the reactor coolant, neutron moderator, and a transparent radiation shield. Visual and physical access to the core is possible at all times. The TRIGA Mark II reactor is a versatile and inherently safe research reactor conceived and developed by General Atomics to meet the requirements of education and research. The UT-TRIGA research reactor provides sufficient power and neutron flux for comprehensive and productive work in many fields including physics, chemistry, engineering, medicine, and metallurgy. The word TRIGA stands for Training, Research, Isotope production, General Atomics.

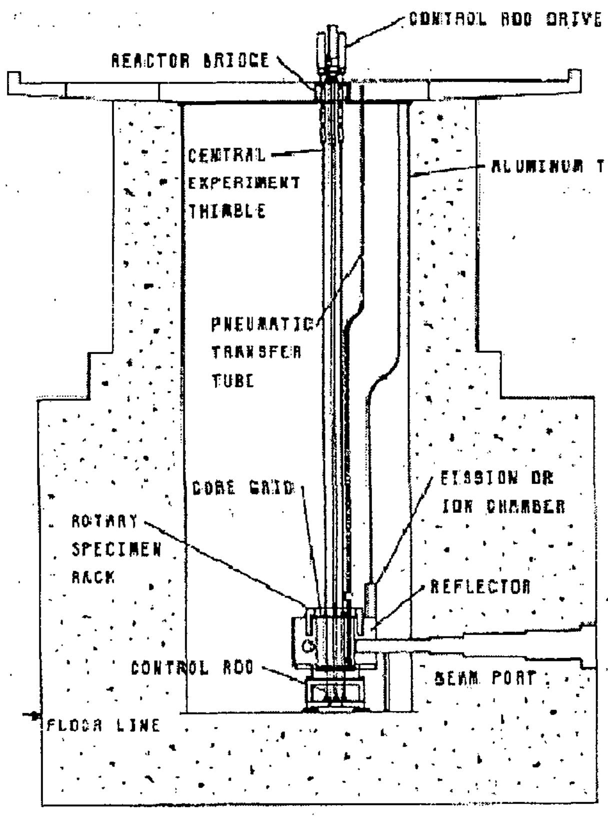

Figure 1-3, Reactor Tank and Biological Shield

Reactor Description

Reactor Operation. The UT-TRIGA research reactor can operate continuously at nominal powers up to 1 MW, or in the pulsing mode where typical peak powers of 1500 MW can be achieved for durations of about 10 msec. The UT-TRIGA with its new digital control system provides a unique facility for performing reactor physics experiments as well as reactor operator training. The pulsing operation is particularly useful in the study of reactor kinetics and control. Neutrons produced in the reactor core can be used in a wide variety of research applications including nuclear reaction studies, neutron scattering experiments, and nuclear analytical and irradiation services.

Special neutron facilities include a rotary specimen rack, which is located in the reactor graphite reflector, a pneumatically operated "rabbit" transfer system, which penetrates the reactor core, and a central thimble, which allows samples to be inserted into the peak flux region of the core. Cylindrical voids in the concrete shield structure, called neutron beam ports, allow neutrons to stream out away from the core. Experiments may be done inside the beam ports or outside the concrete shield in the neutron beams.

Nuclear Core. The reactor core is an assembly of about 100 fuel elements surrounded by an annular graphite neutron reflector. Each element consists of a fuel region capped at top and bottom with a graphite section, all contained within a thin-walled stainless steel tube. The fuel region is a metallic alloy of low-enriched uranium evenly distributed in zirconium hydride (UZrH). The physical properties of the TRIGA fuel provide an inherently safe operation. Rapid power transients to high powers are automatically suppressed without using mechanical control; the reactor quickly returns to normal power levels. Pulse operation, which is a normal mode of operation, is a practical demonstration of this inherent safety feature.

Reactor Reflector. The aluminum-canned graphite neutron reflector surrounding the reactor was flooded in 2000 by the NETL staff to correct pressurization problems. The reflector was replaced in 2004 with slight modification.

Reactor Control. The instrumentation for the UT-TRIGA research reactor is contained in a compact microprocessor-driven control system. This advanced system provides for flexible and efficient operation with precise power and flux control. It also allows permanent retention of all pertinent data. The power level of the UT-TRIGA is controlled by four control rods. Three of these rods, one regulating and two shim, are sealed stainless steel tubes containing powdered boron carbide followed by UZrH. As these rods are withdrawn, boron (a neutron absorber) leaves the core and UZrH (fuel) enters the core, increasing power. The fourth control rod, the transient rod, is a solid cylinder of borated graphite followed by air, clad in aluminum, and operated by pneumatic pressure to permit pulse operation. The sudden ejection of the transient rod produces an immediate burst of power.

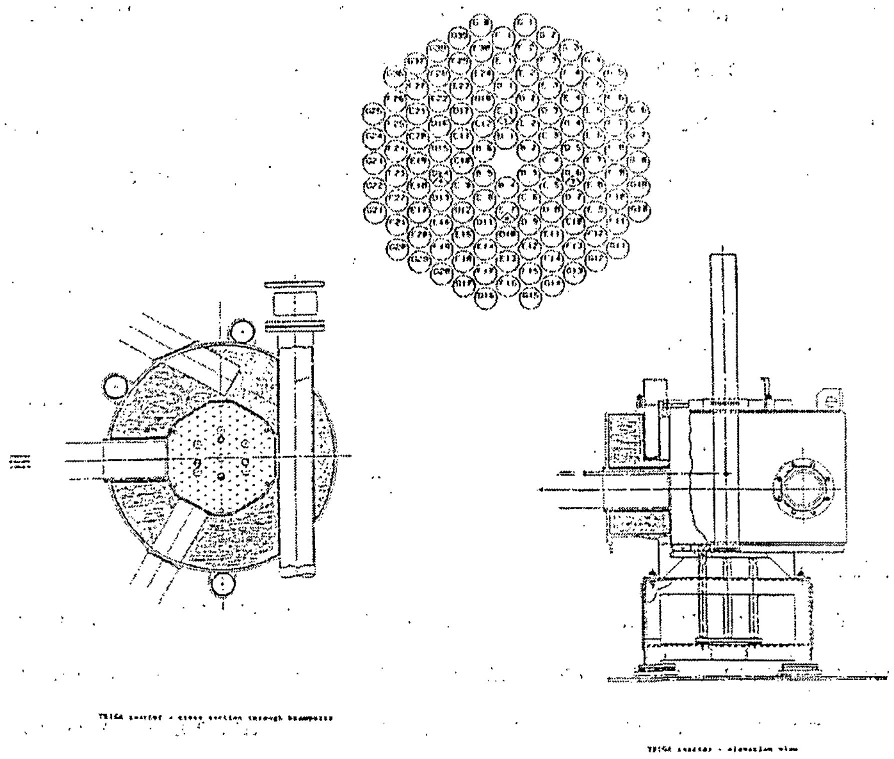

Figure 1-4 TRIGA Reactor Detail

Experiment Facilities

The experimental and irradiation facilities of the TRIGA Mark II reactor are extensive and versatile. Experimental tubes can easily be installed in the core region to provide facilities for high-level irradiations or small in-core experiments. Areas outside the core and reflector are available for large experiment equipment or facilities.

The reactor is equipped with a central thimble for access to the point of maximum flux in the core. The central thimble consists of an aluminum tube that fits through the center hole of the top and bottom grid plates. Experiments with the central thimble include irradiation of small samples and the exposure of materials to a collimated beam of neutrons or gamma rays.

A rotary multiple-position specimen rack located in a well in the top of the graphite reflector provides for batch production of radioisotopes and for the activation and irradiation of multiple samples. When rotated, all forty positions in the rack are exposed to neutron fluxes of the same intensity. Samples are loaded from the top of the reactor through a tube into the rotary rack using a specimen lifting device. A rack design feature provides pneumatic pressure for insertion and removal of samples from the sample rack positions.

A pneumatic transfer system permits applications with short-lived radioisotopes. The in-core terminus of the system is normally located in the outer ring of fuel element positions, a region of high neutron flux. The sample capsule (rabbit) is conveyed to a sender-receiver station via pressure differences in the tubing system. An optional transfer box permits the sample to be sent and received from one to three different sender-receiver stations.

Special cadmium-lined facilities have been constructed that utilize an internal area of the core created by removing three fuel elements.

Beam Port Facilities

Five neutron beam ports penetrate the concrete biological shield and reactor water tank at core level. These beam ports were designed with different characteristics to accommodate a wide variety of experiments. Specimens may be placed inside a beam port or outside the beam port in a neutron beam from the beam port. When a beam port is not in use, special shielding reduces the radiation levels outside the concrete biological shield to safe values. This shielding consists of an inner shield plug, outer shield plug, lead-filled shutter, and circular steel cover plate.

Beam Port (BP) #1 is connected to BP #5, end to end, to form a through beam port. The through beam port penetrates the graphite reflector tangential to the reactor core, as seen in Figure 1-6. This configuration allows introduction of specimens adjacent to the reactor core to gain access to a high neutron flux, allows access from either side of the concrete biological shield, and can provide beams of thermal neutrons with relatively low fast-neutron and gamma-ray contamination.

Beam Port #2 is a tangential beam port, terminating at the outer edge of the reflector. However, a void in the graphite reflector extends the effective source of neutrons into the reflector to provide a thermal neutron beam with minimum fast-neutron and gamma-ray backgrounds. The beam port was recently configured to provide neutron depth profiling applications and potential thermal prompt neutron capabilities.

Beam Port #3 is a radial beam port. The beam port pierces the graphite reflector and terminates at the inner edge of the reflector. This beam port permits access to a position adjacent to the reactor core, and can provide a neutron beam with relatively high fast-neutron and gamma-ray fluxes. Beam Port #3 contains the Texas Cold Neutron Source Facility.

Beam Port #4 is a radial beam port which also terminates at the outer edge of the reflector. A void in the graphite reflector extends the effective source of neutrons to the reactor core. This configuration is useful for neutron-beam experiments which require neutron energies higher than thermal energies. Beam Port #4 was configured in 2005 to provide student laboratories.

A neutron beam coming from a beam port may be modified by using collimators, moderators and neutron filters. Collimators are used to limit beam size and beam divergence. Moderators are used to change the energy of neutron beams (e.g., cold moderator). Filters allow neutrons in selected energy intervals to pass through while attenuating neutrons with other energies.

Table 1-1
Physical Dimensions of Standard Beam Ports

Beam Port	Port Diameter	
BP#1, BP#2, BP#4		
At Core:	6 in.	15.24 cm
At Exit:	8 in.	20.32 cm
BP #3, BP#5		
At Core:	6 in.	15.24 cm
	8 in.	20.32 cm
	10 in.	25.40 cm
At Exit:	16 in.	40.64 cm

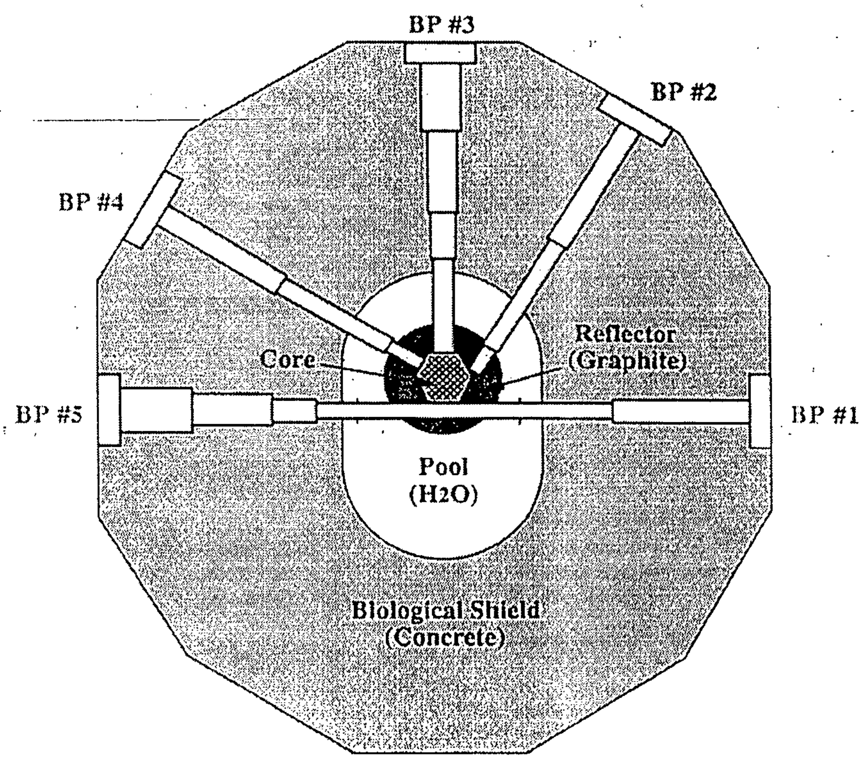

Figure 1-5 Beam Ports

1.4 Nuclear Engineering Academic Program

The Nuclear Engineering Program (NE) at The University of Texas at Austin is located within the Mechanical Engineering Department. The Program's undergraduate degree is the Bachelor of Science in Mechanical Engineering, Nuclear Engineering Option. It is best described as a major in Mechanical Engineering with a minor in Nuclear Engineering. As such, all Mechanical Engineering degree requirements must be met.

The Program's graduate degrees are completely autonomous; they are Master of Science in Engineering (Concentration in Nuclear Engineering) and Doctor of Philosophy (Concentration in Nuclear Engineering). Course requirements for these degrees and the qualifying examination for the Ph.D. are separate and distinct from other areas of Mechanical Engineering. A Dissertation Proposal and Defense of Dissertation are also required for the Ph.D. degree and are acted on by a NE dissertation committee.

Of the five undergraduate Nuclear Engineering courses and the dozen graduate Nuclear Engineering courses, five courses make extensive use of the reactor facility. Table 1-3 lists the courses that use the reactor and its experiment facilities.

Table 1-3
Nuclear Engineering Courses

<u>Undergraduate</u>

ME 361F Instrumentation and Methods
ME 361G Reactor Operations and Control
ME 177K Nuclear and Radiation Engineering Concepts

<u>Graduate</u>

ME 388R.3 Kinetics and Dynamics of Nuclear Systems
ME 389R.1 Nuclear Engineering Laboratory
ME 389R.2 Nuclear Analytical Measurement Techniques
ME 397M Radioactive Waste Management
ME 337D Radiation and Radiation Protection

In addition to these formal classes the NETL often provides short, one day short courses or tours for Texas agencies, high schools and the Boy Scouts of America. The NETL has participated in the IAEA Fellowship programs for over five years. Several Fellows and Visiting Scientists spend 3-6 months at the NETL per year.

1.5 NETL Divisions

The Nuclear Engineering Teaching Laboratory operates as a unit of the Department of Mechanical Engineering at The University of Texas. Figure 1-8 shows the responsibility line organization of the Nuclear Engineering Teaching Laboratory. The staff includes the Health Physics and Reactor Operations to support the Experimenter and Users groups and to insure compliance with all licensed activities.

The Operation and Maintenance Division (OMD) is responsible for the safe and effective operations of the TRIGA nuclear reactor. Activities of OMD include neutron and gamma irradiation service, operator/engineering training courses, and teaching reactor short courses.

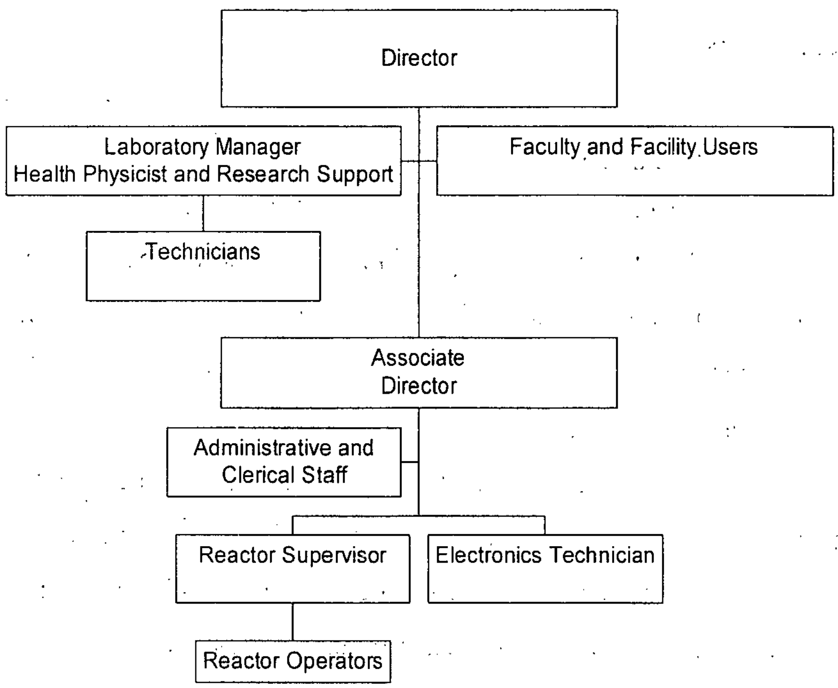

Figure 1-6 NETL Staff Organization

Reactor Operations and Maintenance

The role of these individuals is the routine maintenance and safe operation of the TRIGA Mark II Research Reactor. With the assistance of the NETL licensed operators, Health Physicists and Electronics Technician this division performs most of the work necessary to meet the Technical Specifications of the reactor license. Personnel implement modifications to reactor systems and furnish design assistance for new experiment systems. The reactor operators may operate standard reactor experiment facilities.

Services provided to other divisions at the laboratory include assistance in the areas of initial experiment design, fabrication, and setup. Maintenance, repair support, and inventory control of computer, electronic, and mechanical equipment is also provided. Building systems maintenance is also coordinated by the OMD. Other activities include scheduling and coordination of facility tours.

Laboratory and Research Activities

The principal objectives of the Laboratory research staff involve support of the research and educational missions of the university at large. Elemental measurements using instrumental neutron activation analysis provide nuclear analytical support for individual projects ranging from student project support for classes to measurements for faculty research projects. Project support is in the areas of engineering, chemistry, physics, geology, biology, zoology, and other areas. Research project support includes elemental measurements for routine environmental and innovative research projects. In the area of education, the division, with available state-of-the-art equipment, helps stimulate the interest of students to consider studies in the areas of science and engineering. Education in the irradiation and measurement of radioactivity is presented to college, high school and other student groups in class demonstrations or on a one-on-one basis. The neutron activation analysis technique is made available to different state agencies to assist with quality control of sample measurements. Analysis of samples for the presence of various elements and measurements of environmental effects assists detection of toxic elements.

Radiation measurement systems available include several high purity germanium detectors with relative efficiencies ranging from 20 to 40%. The detectors are coupled to several Canberra and ORTEC PC-based systems. Two of the detectors are equipped with an automatic sample changer for full-time (i.e., 24 hrs a day) utilization of the counting equipment. Two detectors operate as a Compton Gamma Ray Suppression System that provides improved low background measurements. A PC based acquisition and analysis system supports the analysis of Compton Suppression spectra and short half-life nuclear reaction.

The group also manages the use of the five beam ports. Experiments at the beam ports may be permanent systems which function for periods in excess of one or two years or temporary systems. Temporary systems function once or for a few months, and generally require removal and replacement as part of the setup and shutdown process. The reactor bay contains floor space for each of the beam ports. Available beam paths range from 6 meters (20 ft) to 12 meters (40 ft). The objectives of the research function are to apply nuclear methods at the forefront of modern technology and to investigate fundamental issues related to nuclear physics and condensed matter. Another mission of the division is to obtain new, funded research programs to promote the capabilities of the neutron beam projects division for academic, government and industrial organizations and/or groups.

The Laboratory Manager is responsible for coordinating all phases of a project, beginning with the proposal and design, proceeding to the fabrication and testing, and concluding with the operation, evaluation and dismantlement. Projects available at NETL are the Texas Cold Neutron Source, Neutron Depth Profiling, Neutron Guide and Focusing System, Prompt Gamma Activation Analysis, Neutron Radiography and Texas Intense Positron Source.

The Laboratory Management group is also responsible for radiation safety and protection of personnel at the NETL as well as the protection of the general public. The laws mandated by Federal and State government agencies are enforced at the facility through various measures. Health physics procedures have been developed that are facility-specific to ensure that all operations comply with the regulations. Periodic monitoring for radiation and contamination assures that the use of the reactor and radioactive nuclides is conducted safely with no hazard to personnel outside of the facility. Personnel exposures are always maintained ALARA ("as low as is reasonably achievable"). This practice is consistent with the mission of the NETL. Collateral duties of the Health Physics group include the inventory and monitoring of hazardous materials, and environmental health.

The Laboratory and Health Physics group consists of one full time Health Physicist/Nuclear Laboratory Manager with part-time student support. The Health Physicist is functionally responsible to the Management of the NETL and the Department Chairman, but maintains a reporting relationship to the University Radiation Safety Office. This arrangement allows the Health Physicist to operate independent of NETL operations constraints to insure that safety is not compromised. One or more part-time Undergraduate Research Assistant (URA) may assist as Health Physics Technicians. The URA reports to the Health Physicist and assists with technical tasks including periodic surveys, equipment maintenance, equipment calibration, and record keeping.

The Laboratory Safety Group provides radiation monitoring, personnel exposure monitoring, and educational activities. Personnel for whom permanent dosimeters are required must attend an eight hour course given by the Health Physicist. This course covers basic radiation principles including general safety practices, and facility-specific procedures and rules. Each trainee is given a guided tour of the facility to familiarize him with emergency equipment and to reinforce safety/emergency procedures. The group supports University educational activities through assistance to student experimenters in their projects by demonstration of the proper radiation work techniques and controls. The Health Physics group participates in emergency planning between NETL and the City of Austin to provide basic response requirements and conducts off-site radiation safety training to emergency response personnel such as the Hazardous Materials Division of the Fire Department, and Emergency Medical Services crews.

Chapter 2

2.0 ANNUAL PROGRESS REPORT

2.1 Faculty, Staff, and Students

Organization. The University administrative structure overseeing the NETL program is presented in Figure 2-1. A description follows, including titles and names of personnel, of the administration and committees that set policy important to NETL.

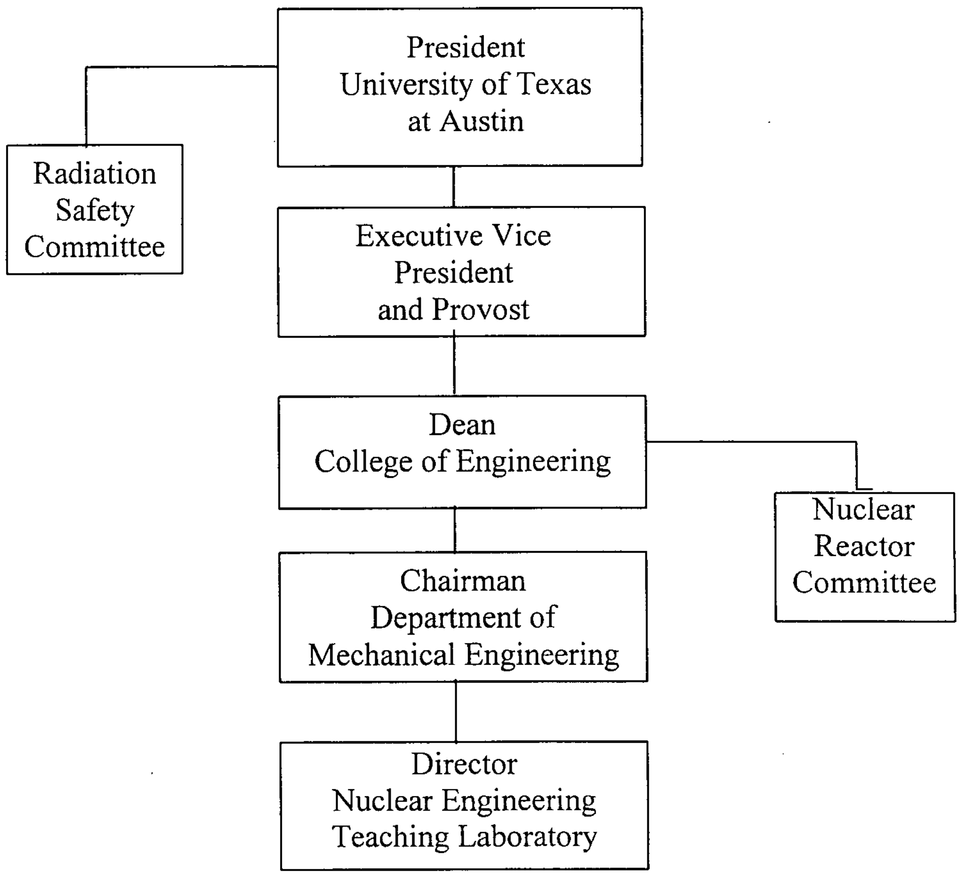

Figure 2-1 - University Administrative Structure over NETL

Administration. The University of Texas at Austin is one campus of 15 campuses of the University of Texas System. As the flagship campus, UT Austin consists of 16 separate colleges and schools. The College of Engineering consists of six engineering departments with separate degree programs. NETL is one of several education and research functions within the college.

Table 2-1 and Table 2-2 list The University of Texas System Board of Regents which is the governing organization and the pertinent administrative officials of The University of Texas at Austin.

Table 2-1
The University of Texas System
Board of Regents for 2005

Chairman	James R. Huffines
Vice Chairman	Rita C. Clements
Vice Chairman	Woody L. Hunt
Vice Chairman	Cyndi T. Krier
Executive Secretary	Francie A. Frederick
UT System Chancellor	M. G. Yudof

Table 2-2
The University of Texas at Austin
Administration

President	William Powers, Jr.
Executive Vice President and Provost ad interim	Steven W. Leslie
Dean of College of Engineering	Benjamin Streetman
Chairman of Department of Mechanical Engineering	Joseph J. Beaman

Radiation Safety Committee. The Radiation Safety Committee convenes to review radiological safety practices at the University during each academic term. The committee composition is shown in Table 2-3. Committee general responsibilities are review of activities of University research programs that utilize radiation source materials.

Table 2-3
2005 Radiation Safety Committee

Chair	J.M. Sanchez
Member	G. Hoffmann
Member	S.A. Monti
Member	J. Robertus
Member	B.G. Sanders
Member	D. J. O'Kelly
Ex officio member	S. Pennington
Ex officio member	E. Janssen

Nuclear Reactor Committee. The Nuclear Reactor Committee convenes to review the activities related to facility operation during each quarter of the calendar year. The committee composition is shown in Table 2-4. Committee general responsibilities are review of reactor operation and associated activities.

Table 2-4
Nuclear Reactor Committee

Chairman	H. M. Liljestrand
Member	S. Biegalski
Member	J. Cortez
Member	L. Katz
Member	S. Landsberger
Member	S. Pennington
Ex officio member	J. Beaman
Ex officio member	R. J. Charbeneau
Ex officio member	D. J. O'Kelly
Ex officio member	M. Krause
Ex officio member	D. S. O'Kelly

Table 2-5
NETL Personnel

NETL Facility Staff	
Director	S. Biegalski
Associate Director	D. S. O'Kelly
Reactor Supervisor	M.G. Krause
Laboratory and Safety Manager	D. J O'Kelly
Research Associate (Positron)	B. Hurst
Research Associate (NAA/Rad Effects)	J. Braisted
Electronics Technician/Reactor Operator	L. Welch
Reactor Operators	S. Johnson
	W. Wilson
	W. Wharton
Health Physics Technician	D. Tillman
Administrative Associate	D. Judson
NRE Faculty	
S. Biegalski	
D.E. Klein	
E. Schneider	
S. Landsberger	

Funding. NETL funding is provided by state appropriations, research grants, and service activities. Research funding supplements the base budget provided by the State and is obtained mostly through the process of competitive project proposals. Funds from service activities supplement the base funds to allow the facility to provide quality data acquisition and analysis capabilities. Both sources of supplemental funds, research projects and service activities, contribute to the education and research environment for students.

Innovations in Nuclear Infrastructure and Education (INIE). The NETL received a significant grant in 2002 in a partnership with Texas A&M University, The University of New Mexico and Sandia National Laboratories. This five-year grant will enable the facilities to acquire advanced experimental equipment and provide shared resources within the so-called Southwest Consortium.

Education and Training Activities

Tours and special projects are available to promote public awareness of nuclear energy issues. Tours of the NETL facility are routine activities of NETL staff and students. A typical tour is a general presentation for high school and civic organizations. Other tours given special consideration are demonstrations for interest groups such as physics, chemistry and science groups.

Visitor groups were given access to the facility during the reporting period but in reduced numbers due to security changes implemented since 2001. The total includes tour groups, official visitors, and facility maintenance personnel. The number of tours has decreased over the past several years due to security checks and access restrictions. Tours for 15 groups with an average 20 persons/group were taken through the facility during the reporting period. The NETL typically hosts three international visitors on IAEA (International Atomic Energy Agency) Fellowships a year.

2.3 Research Acitivities

Beam Port 2 Area Neutron Depth Profiling and Prompt Gamma Activation System

Beam Port 2 is a tangential beam and this results in a "softer" energy neutron beam because the beam is resulting only from scattered reactor neutrons. The thermal neutron energies have been optimized by installing a sapphire neutron energy filter in the beam. Current projects in development include a reconstruction of the previous neutron depth profiling system and a thermal prompt gamma activation analysis system as an installed co-experiment sharing the neutron beam.

Texas Cold Neutron Source

The Texas Cold Neutron Source (TCNS) is located in one of the radial beam ports (BP #3) and consists of a cold source system and a neutron guide system. The facility was originally constructed using Texas Advance Research Program funding but later improvements were funded by the Department of Energy or using internal NETL sources.

The cold source system includes a cooled moderator, a heat pipe, a cryogenic refrigerator, a vacuum jacket, and connecting lines. Eighty milliliters of mesitylene moderator is maintained by the cold source system at ~36 K in a chamber within the reactor graphite reflector. Mesitylene, 1,3,5-trimethylbenzene, was selected for the cold moderator because it has been shown to be an effective and safe cold moderator. The moderator chamber for the mesitylene is a 7.5 cm diameter right-circular cylinder 2.0 cm thick. The neon heat pipe (properly called thermosyphon) is a 3-m long aluminum tube which is used for cooling the moderator chamber. The heat pipe contains neon as the working fluid that evaporates at the moderator chamber and condenses at the cold head.

Cold neutrons coming from the moderator chamber are transported by a 2-m-long neutron guide inside the beam port and a 4-m-long neutron guide (two 2-m sections) outside the beam port. Both the internal neutron guide and the external neutron guide are curved with a radius of curvature equal to 300 m. To block line-of-sight radiation streaming in the guides, the cross-sectional area of the guides is separated into three channels by 1-mm-thick vertical walls. All reflecting surfaces are coated with Ni-58.

The TCNS system provides a low background subthermal neutron beam for neutron reaction and scattering research. Installation and testing of the external curved neutron guides, the shielding structure, neutron focusing and a Prompt Gamma Activation Analysis facility are completed. The only other operating reactor cold neutron source in the United States is at the

National Institute of Standards and Technology and uses liquid hydrogen. At least four major centers for cold neutron research exist in Europe, with another two in Japan.

The TCNS was upgraded in 2004 with a larger cryorefrigerator, cold head and instrumentation system. The larger refrigerator (22 watts from 4 watts) cools the thermosyphon system faster and produce a more rapid cooldown and better thermal control at higher reactor powers. The automatic control system (shown below) will provide alarms and automatic shutdowns if normal parameters are exceeded.

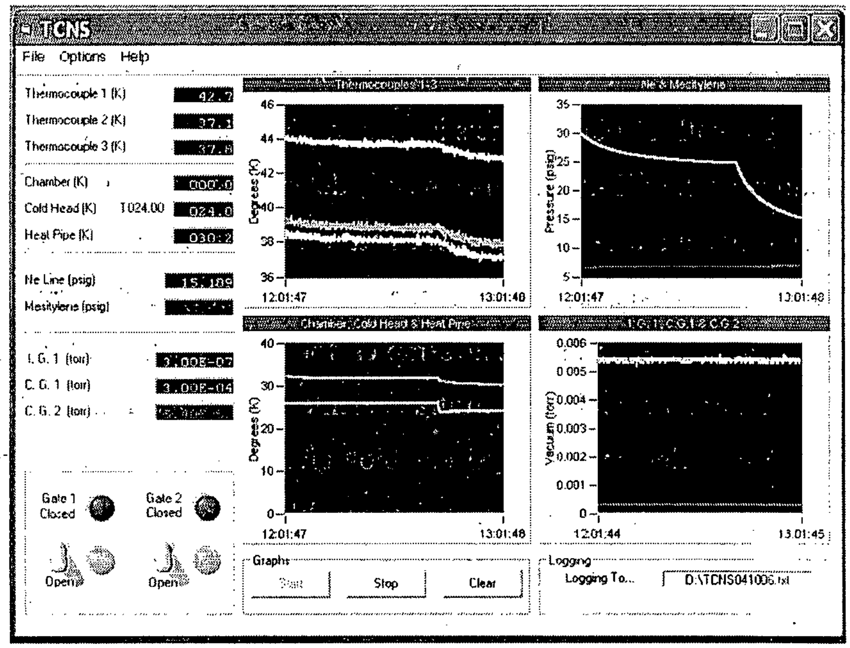

Figure 2-2 TCNS Control and Instrumentation Console

<u>Prompt Gamma Activation Analysis Facility</u>

The UT-PGAA facility utilizes the focused cold-neutron beam from the Texas Cold Neutron Source. The PGAA sample is located at the focal point of the converging guide focusing system. The use of a guided focused cold-neutron beam provides a higher capture reaction rate and a lower background at the sample-detector area as compared to other facilities using filtered thermal neutron beams.

The UT-PGAA facility has been designed taking into account the advantage of the low background. The following criteria have been used during the design: a) The structure and shielding materials for the UT-PGAA facility were chosen to minimize the background contribution for elements to be detected in the samples to be studied. b) The sample handling system was designed to be versatile to permit the study of a wide range of samples with quick and reproducible sample positioning with a minimum of material close to the samples. The shielding was improved this reporting year to reduce the hydrogen capture gamma ray background.

A 25% efficient n-type gamma-ray detector in a configuration with an offset-port dewar was purchased to be used at the UT-PGAA facility in the early 1990's. The detector was selected in order to incorporate a Compton suppression system at a later date. Vacuum failures required repeated repairs to this detector. Thus, a new 66% p-type detector was purchased as a replacement. This system could be configured for Compton suppression if required. A gamma-spectrum analysis system with 16,000 channels is used for data acquisition and processing.

The applications of the UT-PGAA includes: i) determination of B and Gd concentration in biological samples which are used for Neutron Capture Therapy studies, ii) determination of H and B impurity levels in metals, alloys, and semiconductor, iii) multielemental analysis of geological, archeological, and environmental samples for determination of major components such as Al, S, K, Ca, Ti, and Fe, and minor or trace elements such as H, B, V, Mn, Co, Cd, Nd, Sm, and Gd, and iv) multielemental analysis of biological samples for the major and minor elements H, C, N, Na, P, S, Cl, and K, and trace elements like B and Cd.

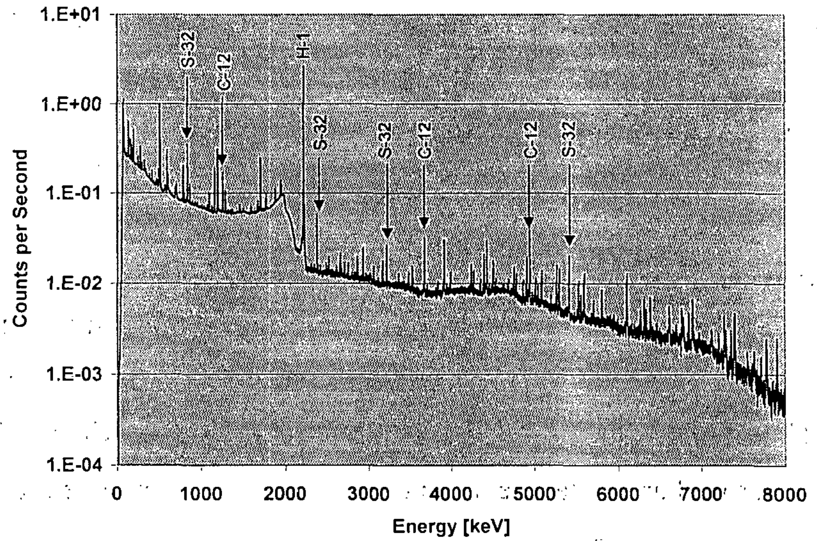

Figure 2-3 PGAA Spectra of Carbon Composite Flywheel

Neutron Radiography Facility

The Neutron Radiography Facility at Beam Port 5 had not been significantly modified prior to 2003. That year, the NETL began to use the existing video-con radiography camera, upgraded the image capture boards and PC image analysis software and purchased a much improved neutron imaging system from NOVA Scientific based on Micro-Channel Plate technology. A cryogenically cooled CCD camera system was installed in 2006 and paired with a 64-bit software package for image reconstruction and manipulation. The system is still under initial testing but resolutions are on the order of 30- 50 microns.

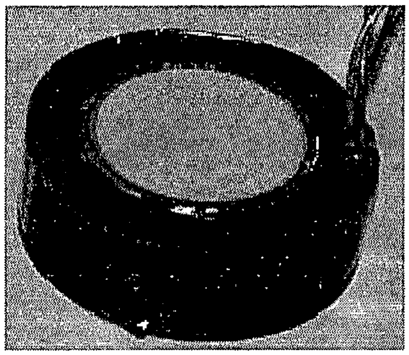

Figure 2-4 MCP Neutron Imaging Detector (NOVA Scientific)

Texas Intense Positron Source

A reactor-based slow positron beam facility is being fabricated at the Nuclear Engineering Teaching Laboratory (NETL). The facility (Texas Intense Positron Source) will be one of a few reactor-based slow positron beams in the world when completed. The Texas Intense Positron Source consists of a copper source, a source transport system, a combined positron moderator/remoderator assembly, a positron beam line and a sample chamber. High energy positrons from the source will be slowed down to a few eV by a tungsten foil moderator that also acts as a remoderator to reduce the beam size to enable beam transport to a target for experimentation. The beam will be electrostatically guided and will deliver about 10^8 positrons/sec in the energy range of 0 - 50 keV.

Reactor-based positron beams utilizing a copper source have been implemented at Delft University of Technology, The Netherlands. There are several differences between TIPS and these reactor based positron beams. The source/moderator array of the Delft positron beam is located inside one of the neutron beam ports of their reactor and the positron beam is transported out of the reactor and then remoderated before it enters into an experimental chamber.

Based on general experience on reactor based positron sources, we have decided that the moderator/remoderator assembly and the positron beam optics should be entirely outside the reactor biological shield. A source transport system will be placed in a 4 meter aluminum system for low activation that will be inserted into one of the neutron beam ports of the NETL 1-MW TRIGA Mark II research reactor. The transport system will be used to move the source to the irradiation location and out of the biological shield. The source will be moved away from the neutron beam line to an ultra high vacuum (at around 10^{-10} torr) chamber, where the moderator assembly is located. The transporter, load-lock transfer sytem and ultra high vacuum systems will be separated by gate valves.

The copper source of TIPS will be irradiated across from the core in the graphite reflector, in the middle section of the through port (BP1-BP5). The isotope ^{64}Cu formed by neutron capture in ^{63}Cu (69 % in natural copper) has a half life of 12.7 hours, and the branching ratio for b $^{+}$ emission is 19 %. Our current source design consists of copper electroplated thinly onto a carbon backing. This source minimizes the unnecessary activation products because the positrons produced are relatively near the surface of the copper and may be ejected for moderation and beam focus.

Preliminary designs and construction of the source transport system are completed. The source transport system will use carbon fiber cord to move a sample carriage out near the reactor and back with minimal activation of transport components. The positron source may be transferred with remote tools into the system Load-Lock device.

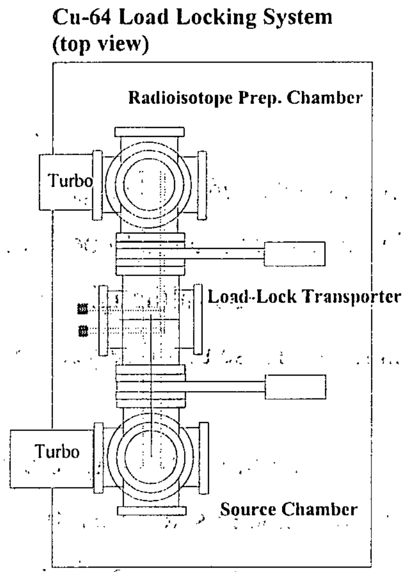

Figure 2-5 TIPS Load-Lock Source Transfer System

The Load-Lock will maintain the primary source chamber at ultra-high vacuum while permitting source transfer at atmospheric pressures.

The design and construction of the copper source, moderator assembly, and the positron beam optics are completed and testing of these components are currently in progress. The high-intensity low-energy positron beam of TIPS will be applied to defect characterization of metals, semiconductors, and polymers. The first planned experimental use will be to evaluate new low density, high k insulators for the semiconductor industry and industrial coatings.

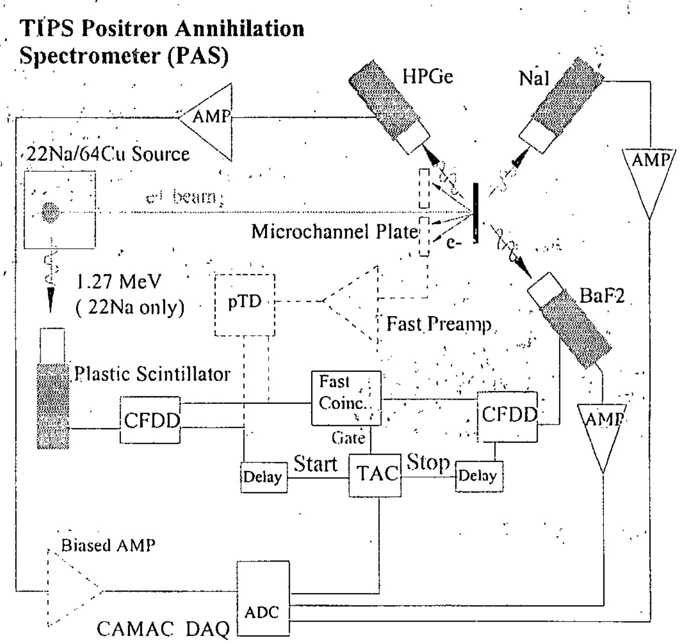

Figure 2-6 TIPS Positron Detection System

Other Projects at the NETL

Neutrino Mass Experiment

The UT Physics Department has obtained an NSF grant to investigate the theoretical mass of the neutrino. The neutrino is classically considered to be a massless particle but some theories dispute this and leave the potential for a mass (although very small). The NETL has a large shielded room that is being refurbished to house this five-year experiment.

Radiochemistry Laboratory

The Department of Energy provided initial funding to equip and develop a graduate-level radiochemistry laboratory to encourage students to enter this field and replace retiring radio chemists in the DOE laboratories. Dr. Sheldon Landsberger and Dr. Donna O'Kelly have prepared several laboratories and several students are now working on projects directly sponsored by Los Alamos National Laboratory and Sandia National Laboratories. The laboratory consist of state-of-the-art Alpha Spectroscopy Systems, Liquid Scintillation Counting System and several High Resolution Gamma Counting Systems.

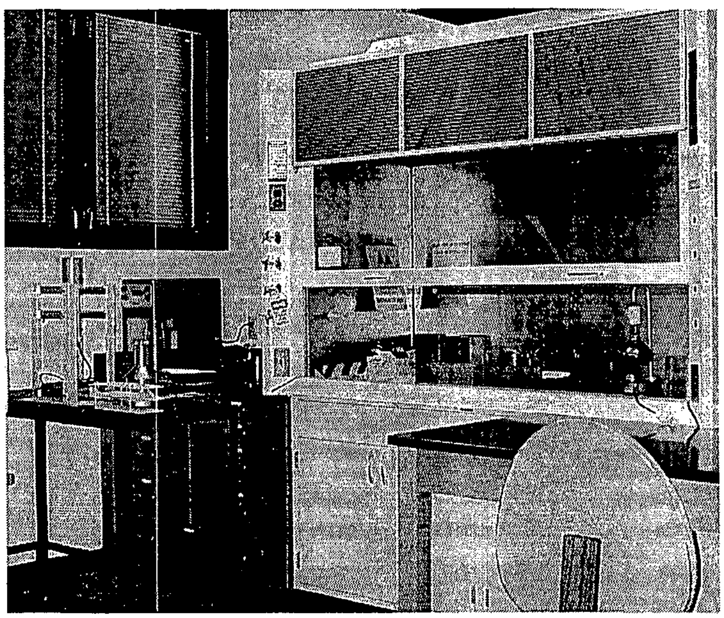

Figure 2-7, Room 3.106 Radiochemistry Laboratory

Chapter 3

3.0 FACILITY OPERATING SUMMARIES

3.1 Operating Experience

The UT-TRIGA reactor operated for 15 days in 2006. The reactor produced a total energy output of 741.4 MW-hrs during this period. This represents the second highest utilization of the reactor since initial criticality. The burnup per year in the fourteen years of operation is shown in Figure 3-1. Several experiments required 50% power or less so the burnup is less then what it would have been if the reactor were operating at full power. This year, three full months were operated in a subcritical condition to perform experiments as an accelerator driven subcritical system (ADSS). Observing the graph below indicates that the average reactor operating schedule in the last 5 years (6 month shutdown in 2000 and 5 month shutdown in 2004) is substantially increased from the early years of operation.

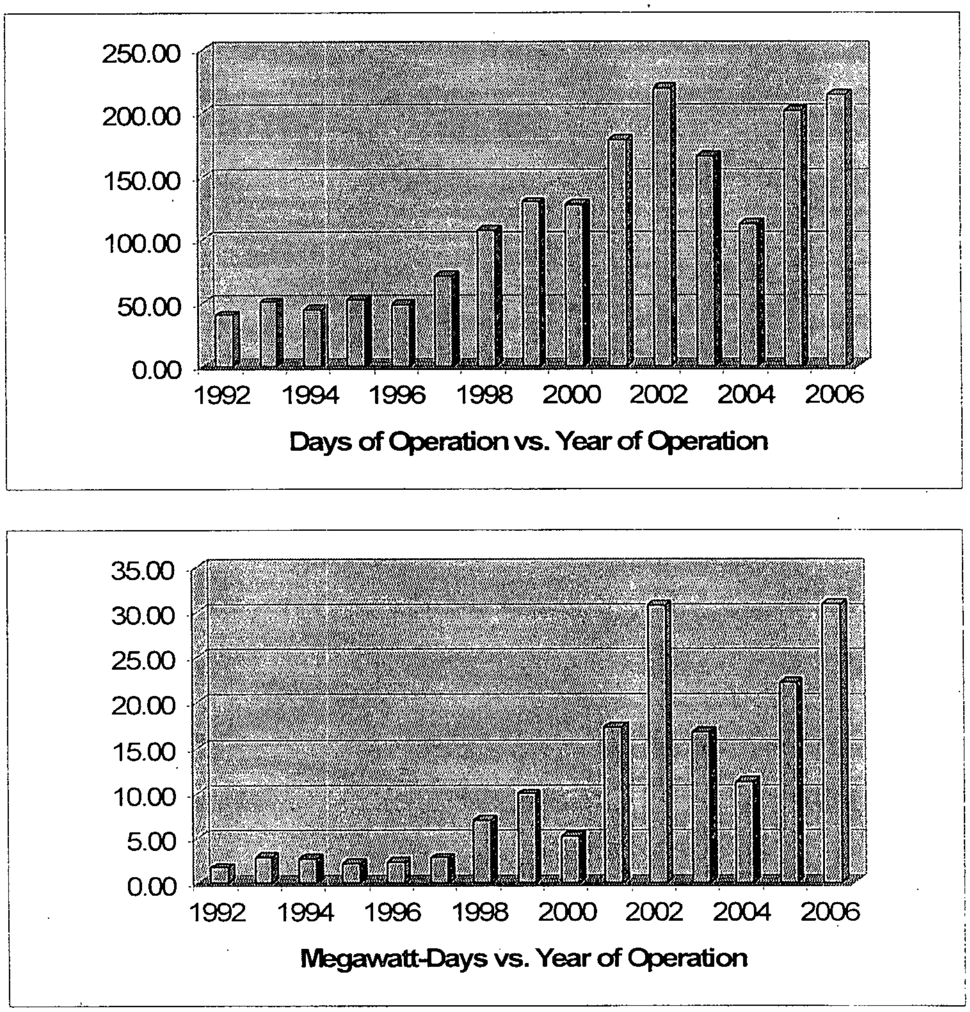

Figure 3-1 History of Reactor Operations

3.2 Reactor Shutdowns

The reactor safety system classifies protective action trips as one of three types, a limiting safety system (LSSS) trip, a limiting condition for operation (LCO) trip or a trip of the SCRAM manual switch. In the event the switch is used for a normal reactor shutdown, the operation is not considered a protective action shutdown. The following definitions in Table 3-1 classify the types of protective actions recorded.

Table 3-1
Protective Action Definitions

Protective Action	Description
Safety System Setting LSSS	Setpoint corresponds to detection of limiting safety system setting. Examples: fuel temperature percent power
Condition for Operation LCO - (analog detection)	Hardware action detects inoperable conditions within a safety channel or the instrument control and safety system. Examples: pool water level detector high voltage external circuit trips
Condition for Operation LCO - (digital detection)	Software action detects inoperable conditions within a program function of the instrument control and safety system. Examples: watchdog timers program database errors
Manual Switch (protective action)	Operator emergency shutdown
Manual Switch (intentional operation)	Operator routine shutdown

Non-Scheduled Scrams for 2006 Calendar Year

Date: 2/16/06 Time: 11:03

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that all control rods were withdrawn and the Linac was at 170 Hz. The scram log states that the reactor was sub-critical and fuel temperature 1 indicated 21°C.

Date: 4/11/06 Time: 16:58

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate power had been steady at 950 kW for over 8 hours when the reactor scrammed on fuel temperature 1 high. The scram log states that there were no temperature or power fluctuations.

Date: 4/26/06 Time: 11:08

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that the reactor had been at 950 kW for approximately 2 hours when the reactor scrammed on fuel temperature 1 hi. Records indicate that no abnormal fuel temperatures were noticed.

Date: 5/23/06 Time: 08:52

Scram Type: Percent Power 2

Notes: Reactor scram due to operator error. Operations records indicate that the operator was increasing reactor power from 50 Watts to 950 kW. Near 950 kW the operator began attempting to bank the control rods when the reactor scrammed on percent power 2. Most likely, during the banking process the operator withdrew a control rod too much, inserting positive reactivity faster than the regulating rod could insert negative reactivity. This caused the power level to temporarily jump over the percent power 2 scram set-point of 105%, and thus caused the reactor to scram.

Date: 06/12/06 Time: 15:27

Scram Type: Percent Power 2 and NM Percent

Notes: Operations logs indicate that the operator was attempting to square wave from 50 Watts to 500 kW when the reactor scrammed on both the NP and the NM. In the scram log the operator suggests he may have inserted too much reactivity (around 95 cents).

Date: 06/22/06 Time: 10:51

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that the reactor had been at 950 kW for approximately 2 hours when the reactor scrammed on fuel temperature 1 hi. Records indicate that no abnormal fuel temperatures were noticed.

Date: 06/22/06 Time: 12:00

Scram Type: Manual Scram

Notes: Operations records indicate that, while at 950 kW, the rack holding the fuel temperature limit modules was pulled from the cabinet. It is presumed that pulling the shelf from the cabinet caused the reactor to scram.

Date: 07/19/06 Time: 11:19

Scram Type: Percent Power 2

Notes: Reactor scram due to operator error.

Date: 07/27/06 Time: 10:03

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate reactor power had been at 950 kW for less than 10 minutes when the reactor scrammed on fuel temperature 1. Operations logs also state that the fuel temperature circuits were tested, and appeared to be normal.

Date: 07/27/06 Time: 10:49

Scram Type: NM Percent

Notes: Reactor scram due to operator error. Operations logs indicate that reactor power had just reached 950 kW when the reactor scrammed on NM percent hi. It is presumed that because power had just reached 950 kW the operator was attempting to bank the control rods and caused the reactor to scram.

Date: 08/04/06 Time: 1212

Scram Type: Database Timeout

Notes: The reactor had been at 950 kW for 3 hours when the reactor scrammed on a database timeout.

Date: 08/10/06 Time: 15:38

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate the reactor had been running at various powers throughout the day when it scrammed on fuel temperature 1. The logs state that further investigation revealed that fuel temperatures 1 and 2 were 263°C and 291°C respectively.

Date: 08/15/06 Time: 16:41

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for less than 10 minutes when the reactor scrammed on fuel temperature 1.

Date: 08/31/06 Time: 12:47

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for a little over 3 hours when the reactor scrammed on fuel temperature 1.

Date: 09/05/06 Time: 16:47

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for about 5 hours when the reactor scrammed on fuel temperature 1.

Date: 09/20/06 Time: 13:15

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for approximately 4 hours when the reactor scrammed on fuel temperature 1.

Date: 10/30/06 Time: 12:57

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 100 kW for about 4 hours when the reactor scrammed on fuel temperature 1.

Date: 11/03/06 Time: 14:58

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for about 6 hours when the reactor scrammed on fuel temperature 1.

Date: 11/08/06 Time: 10:23

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for approximately 1 hour when the reactor scrammed on fuel temperature 1.

Date: 11/27/06 Time: 15:16

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had just reached 950 kW when the reactor scrammed on fuel temperature 1.

Date: 12/14/06 Time: 15:36

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for 7½ hours when the reactor scrammed on fuel temperature 1.

Date: 12/15/06 Time: 12:36

Scram Type: Fuel Temperature 1

Notes: Intermittent fuel temperature scram. Operations logs indicate that reactor power had been at 950 kW for 3½ hours when the reactor scrammed on fuel temperature 1.

3.3 Utilization

Utilization was skewed during the first part of 2006 due to a project requiring the reactor operate in a subcritical condition for accelerator-driven experiments. This represented operational time with no reactor operations. Four of the five beam ports had active experiment programs this year but an experiment was designed and tested in the BP4 that is likely to be installed in the future. The NETL staff continues to perform activation and analysis services as a public service and in support of the overall UT mission. Neutron activation analysis accounted for much of the reactor utilization time with teaching labs and beam port research projects making up the remainder. The Prompt Gamma Analysis System was in use for much of the year for student projects and a project under the DOE Nuclear Engineering Education and Research (NEER) program.

3.4 Routine Scheduled Maintenance

All surveillances and scheduled maintenance were completed during the reporting year. All results met or exceeded the limits of the Technical Specifications.

3.5 Facility Changes and Corrective Maintenance

No facility changes requiring a 10 CFR 50.59 review were performed.

3.6 Laboratory Inspections

Inspections of laboratory operations are conducted by university and licensing agency personnel. Two committees, a Radiation Safety Committee and a Reactor Oversight Committee, review operations of the NETL facility. The Reactor Oversight Committee convened at the times listed in Table 3-6.

Table 3-6
Committee Meetings

Reactor Oversight Committee

First Quarter	March 31, 2006
Second Quarter	None
Third Quarter	November 2, 2006
Fourth Quarter	No meeting

Inspections by licensing agencies include federal license activities by the U. S. Nuclear Regulatory Commission (NRC), Nuclear Reactor Regulation Branch (NRR), and state license activities by the Texas Department of Safety and Health Services (DSHS). NRC and DSHS inspections were held at the times presented in Table 3-7. An NRC inspection was performed the week of October 30, 2006. The inspection included reactor operations, license compliance and emergency planning. No violations were noted.

Table 3-7
Dates of License Inspections

License	Dates
R-129	Oct 30 – Nov 2, 2006
SNM-180	None
L00485(48)	None

Routine inspections by the Office of Environmental Health and Safety (OEHS) for compliance with university safety rules and procedures are conducted at varying intervals throughout the year. In response to safety concerns at other sites on the main campus, several additional OEHS inspections have been made. Inspections cover fire, chemical, and radiological hazards. No significant safety problems were found at NETL, which reflects favorably on the positive safety culture for all hazard classes at the NETL.

3.7 Radiation Exposures

A radiation protection program for the NETL facility provides monitoring for personnel radiation exposure, surveys of radiation areas and contamination areas, and measurements of radioactive effluents. Radiation exposures for personnel, building work areas and areas of the NETL site are shown in the following tables. Site area measurements include exterior points adjacent to the building and exterior points away from the building.

Table 3-8 summarizes NETL personnel dose exposure data for the calendar year. In general, personnel exposures for 2006 were in line and less than 10% of the allowed 5000 mrem. Figure 3-3 locates the building internal and external dosimetry sites. Dots locate fixed monitoring points within the building. Numbers identify the immediate site area radiation measurement points exterior to the building. These measurements do not indicate any measurable dose from work within the NETL building. Table 3-9 and Table 3-10 summarize doses recorded in facility work areas and the site areas. Table 3-11 contains a list of the basic requirements and frequencies of measurements.

Additional measurement data is available from the State of Texas Department of Health. The state agency records environmental radiological exposures at five sites in the vicinity of the research reactor site. Samples are also taken for analysis of soil, vegetation, and sanitary waste effluents.

Table 3-8

Personnel exposures for Year 2006

- Personnel exposures for 2006 were less than 10% of the federally allowed maximum of 5000 mrem. Additionally, personnel whole body exposures were also less than 10% of the NETL local limit of 1000 mrem.
- The highest exposures for 2006 were 62 mrem whole body and 710 mrem extremity.

Personnel Group	#	Average Annual Dose (mrem)			Greatest Individual Dose (mrem)			Total Person mrem per Group (mrem) (1)		
		Whole Body (DDE)	Lens of Eye (LDE)	Extremity (SDE)	Whole Body (DDE)	Lens of Eye (LDE)	Extremity (SDE)	Whole Body (DDE)	Lens of Eye (LDE)	Extremity (SDE)
Facility Personnel (Landauer)	16	20.9	21.1	164	62	63	710	313	316	2460
Facility Personnel (PD)	37	2		-	-	-	-	74	-	-
Visitors (PD)	516	0.14	-	N/A	0	N/A	N/A	73	N/A	N/A

Table 3-9

TOTAL DOSE EQUIVALENT RECORDED ON AREA DOSIMETERS LOCATED WITHIN THE NETL FACILITY 2006				
Reactor Facility Location	**Monitor ID**	**Total Dose (1,2) β,γ,x Deep (3)**	**Eye (4)**	**Shallow (5)**
Reactor Bay, North Wall	00277	54	65	230
Reactor Bay, East Wall	00278	38	46	226
Reactor Bay, West Wall	00279	47489	50080	52556
Water Treatment Room	00280	29273	30159	31570
Area, Room 1.102	00281	14*	14*	16*
Sample Processing, Room 3.102	00173	15*	15*	57*
Gamma Spectroscopy Lab, Room 3.112	00174	12*	13*	18*
Radiation Experiment Lab, Room 3.106	00175	13*	14*	14*
Reception Area, Room 2.102	00176	13*	13*	13*
Office, Room 3.104	00222	13*	13*	18*

1) The total recorded dose equivalent values reported in mrem do not include natural background contribution and reflect the summation of the results of 12 monthly beta, x-, and gammy ray or neutron dosimeters for each location. A total dose equivalent of "M" indicates that each of the dosimeters during the period was below the vendor's minimum measurable quantity of 1 mrem for x and gamma rays, 10 mrem for energetic betas, 20 mrem for fast neutrons, and 10 mrem for thermal neutron. "N/A" indicates that there was no neutron monitor in that location.
2) These dose equivalent values do not represent radiation exposure through an exterior wall directly into an unrestricted area.
3) Deep indicates Deep Dose Equivalent and applies to external whole-body exposure and is the dose equivalent at a tissue depth of 1 cm.
4) Eye indicates Eye Dose Equivalent and applies to external exposure of the lens at a depth of 0.3 cm.
5) Shallow indicates Shallow Dose Equivalent and applies to external exposure of the skin or an extremity, and is taken as the dose equivalent at a tissue depth of 0.007 cm averaged over an area of 1 cm^2.
* No control subtracted in January 2006. Control would subtract ~13 mrem.

Figure 3-3 Environmental TLD Locations

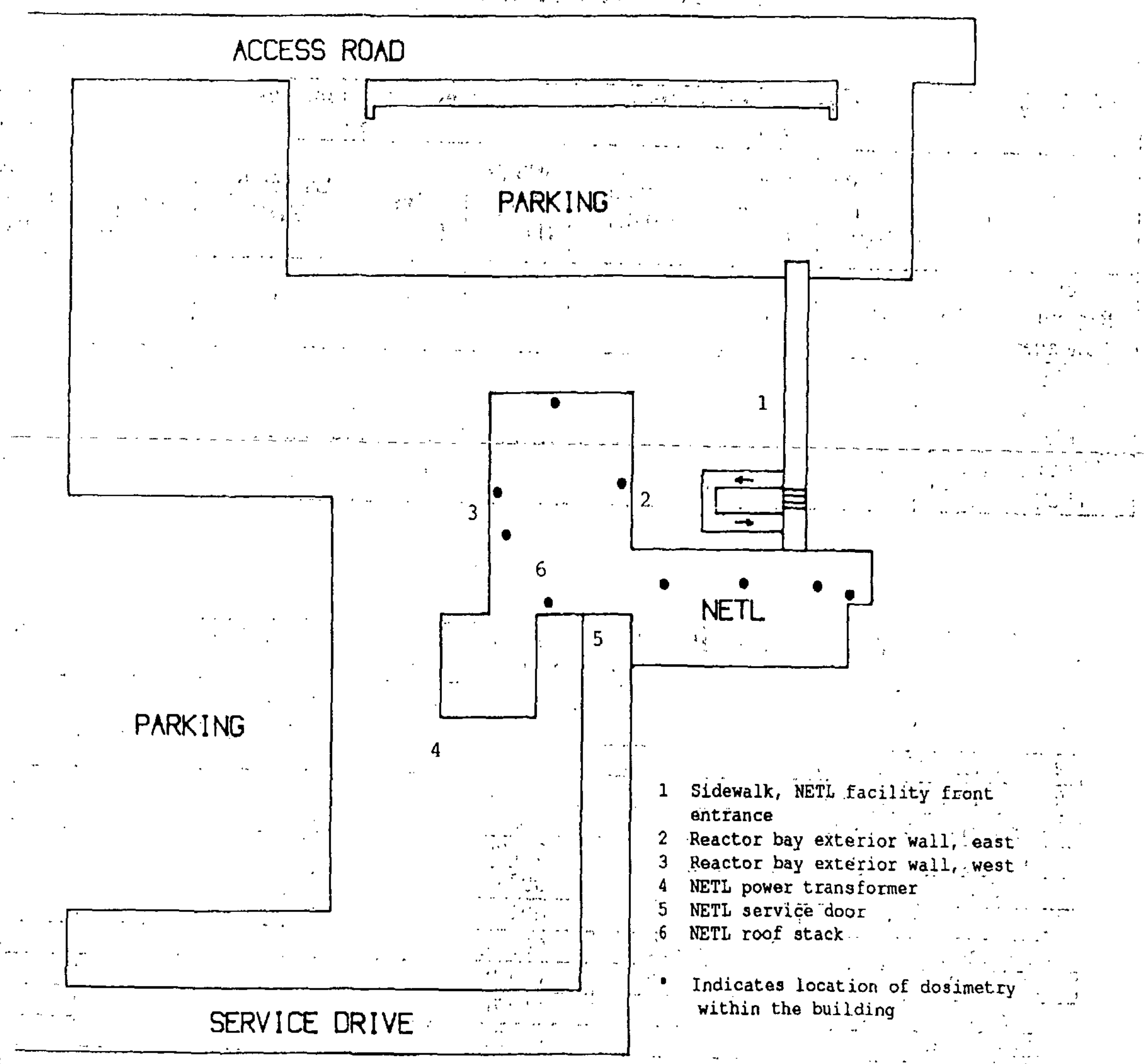

Table 3-10

TOTAL DOSE EQUIVALENT RECORDED ON TLD ENVIRONMENTAL MONITORS AROUND THE NETL REACTOR FACILITY 2006		
Monitor ID	Reactor Facility Location	Total Recorded Dose Equivalent (1) (mrem)
00156	Sidewalk, NETL Front Entrance	M
00157	NETL Power Transformer	M
00158	NETL Roof Stack	M
00159	Reactor bay exterior wall, East	M
00160	Reactor bay exterior wall, West	60
00161	NETL Service Door	M

1) The total recorded dose equivalent values reported in mrem do not include natural background contribution and reflect the summation of the results of 12 monthly beta, x-, and gammy ray or neutron dosimeters for each location. A total dose equivalent of "M" indicates that each of the dosimeters during the period was below the vendor's minimum measurable quantity of 1 mrem for x and gamma rays, 10 mrem for energetic betas, 20 mrem for fast neutrons, and 10 mrem for thermal neutron. "N/A" indicates that there was no neutron monitor in that location.

Table 3-11
Radiation Protection Program
Requirements and Frequencies

Frequency	Radiation Protection Requirement
Weekly	Gamma survey of all Restricted Areas. Swipe survey of all Restricted Areas. Swipe survey of Radioactive Materials Areas. Response check of the continuous air monitor. Response checks of the area radiation monitors. Neutron survey of the reactor bay (during reactor operation).
Monthly	Gamma, neutron and swipe surveys of exterior walls and roof. Exchange personnel dosimeters and interior area monitoring dosimeters. Review dosimetry reports. Response check emergency locker portable radiation measuring equipment. Review Radiation Work Permits. Response check of the argon monitor. Response check hand and foot monitor. Conduct background checks of low background alpha/beta counting system. Collect and analyze TRIGA primary water.
As Required	Process and record solid wastes and liquid effluent discharges. Prepare and record radioactive material shipments. Survey and record incoming radioactive materials. Perform and record special radiation surveys. Issue radiation work permits and provide health physics coverage for maintenance operations. Conduct orientations and training.
Quarterly	Exchange TLD environmental monitors. Gamma and swipe surveys of all non restricted areas. Swipe survey of building exterior areas. Calibrate area monitors in neutron generator room. Perform Chi-square test, and determine HV plateaus and detection efficiencies on the low background alpha/beta counting system.
Semi-Annual	Inventory emergency locker. Calibrate portable radiation monitoring instruments. Calibrate continuous air monitor, argon monitor, and area radiation monitors. Calibrate personnel pocket dosimeters. Leak test and inventory sealed sources.
Annual	Conduct ALARA Committee meeting. Conduct personnel refresher training. Calibrate emergency locker portable radiation detection equipment

1.8 Radiation Surveys

Radiation surveys of NETL work areas are shown in Table 3-12. Surveys with portable instruments and measurements of radioactive contamination are routine. Supplemental measurements are also made any time unusual conditions occur. Values in the table represent the result of routine measurements. Environmental monitoring at sample sites exterior to the building are generally done at random times or as a case by case evaluation.

Table 3-12

Annual Summary of Radiation and Contamination Levels within the NETL Reactor Facility 2006

Accessible Location:	Area Radiation Levels (mrem/hr)		Contamination Levels (dpm/11 cm^2)	
	Avg. (1)	Max. (1)	Avg	Max
TRIGA Reactor Bay				
Reactor Bay North	BKG	BKG	MDA	MDA
Reactor Bay South	BKG	BKG	MDA	MDA
Reactor Bay East	BKG	BKG	MDA	MDA
Reactor Bay West	5	20	MDA	MDA
Reactor Pool Deck (3rd Floor)	BKG	BKG	MDA	MDA
NETL Facility				
NAA Sample Processing (Rm 3.102)	BKG	BKG	MDA	MDA
NAA Sample Counting (Rm 3.112)	BKG	BKG	MDA	MDA
Health Physics Laboratory	<0.1	2	MDA	MDA
NAA Lab (Rm. 3.106)	BKG	BKG	MDA	MDA

3.9 Radioactive Effluents, Radioactive Waste

Radioactive effluents are releases to the air and to the sanitary sewer system. The most significant effluent is an airborne radionuclide, argon-41. Two other airborne radionuclides, nitrogen-16 and oxygen-19, decay rapidly and do not contribute to effluent releases. Argon-41, with a half-life of 109 minutes is the only airborne radionuclide emitted by the facility. A summary of the argon-41 releases are shown in Table 3-13. Total quantity of Ar-41 released in 2006 was 3.95% of the T.S. allowance. This is based on a conservative dilution factor. Evaluation of the radioactive gaseous effluent by the COMPLY code indicates the NETL is in compliance with dose limits to the public with a calculated effective dose equivalent of 4.8 mrem/yr at the conservative receptor point.

Table 3-13

Monthly Summary of Argon-41 Effluent Releases 2006 (1)			
Discharge Date, 2006	**Total Quantity ^{41}Ar Released (μCi)**	**Average Concentration of ^{41}Ar at Point of Release**	**Percentage of ^{41}Ar Released relative to Tech Spec.**
January	1.75E3	1.74E-10	0.0087
February	8.70E0	8.64E-13	0.000043
March	9.15E2	9.07E-11	0.0045
April	8.80E5	8.73E-8	4.37
May	7.48E5	7.42E-8	3.71
June	9.66E5	9.58E-8	4.79
July	5.20E5	5.16E-8	2.58
August	1.93E6	1.91E-7	9.55
September	1.01E6	9.97E-8	4.99
October	1.35E6	1.34E-7	6.71
November	1.10E6	1.09E-7	5.45
December	1.07E6	1.06E-7	5.29
ANNUAL VALUE	**9.56E6**	**7.91E-8**	**3.95**

1) Point of release is roof exhaust stack. Concentration includes dilution factor of 0.2 for mixing with main exhaust.
2) Technical Specification limit for continuous release is 2.00E-6 μCi/cm^3.

Large liquid releases to the sanitary sewer are done from waste hold up tanks at irregular intervals. To date, no releases have been made. The liquid radioactive waste tanks allow for segregation of liquids for decay of the activity. Liquids may also be processed on-site to concentrate the radionuclides into other forms prior to disposal. Small quantities of liquid scintillation cocktail or dilute concentrations may be disposed directly to the sanitary sewer if below the limits of 10 CFR 20. One gross spillage of stored reactor pool water with the reactor bay was evaluated and found to have concentrations much less than levels permitted for release and no contamination was found so the material were treated as non-contaminated. There were no solid waste transfers off the NETL R-129 License in 2006.

Table 3-14

Monthly Summary of Solid Waste Transfers for Disposal and Liquid Effluent Releases to the Sanitary Sewer from the NETL Facility 2006			
Discharge/Disposal Date	Volume Released (cm^3)	Total Activity (μCi)	Total Activity Released (μCi)
January	0	NONE	No Releases
February	0	NONE	No Releases
March	0	NONE	No Releases
April	0	NONE	No Releases
May	0	NONE	No Releases
June	0	NONE	No Releases
July	0	NONE	No Releases
August	0	NONE	No Releases
September	0	NONE	No Releases
October	0	NONE	No Releases
November	0	NONE	No Releases
December	0	NONE	No Releases