Department of Mechanical Engineering

THE UNIVERSITY OF TEXAS AT AUSTIN

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March 31, 2003

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

Subject: NETL 2002 Annual Report

Reference: Facility License R-129 (Amend. 4), Docket 50-602

Sirs:

Attached is the 2002 Annual Report of the Nuclear Engineering Teaching Laboratory at The University of Texas at Austin. This report meets the requirements of R-129 Technical Specifications, Section 6.6.1 with additional material as background information.

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

Sincerely,

Sean O'Kelly
NETL Associate Director

Attachment: 2002 Annual Report (50-602)

cc: A. Adams, Project Manager

A020

The University of Texas at Austin

Nuclear Engineering Teaching Laboratory

2002

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 U.S. Army, Los Alamos National Laboratory, the State of Vermont, the Canadian government, the National Oceanic and Atmospheric Administration 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.

Sheldon Landsberger
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. 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 1100 kilowatts or with pulse reactivity insertions up to 2.2% $\Delta k/k$.

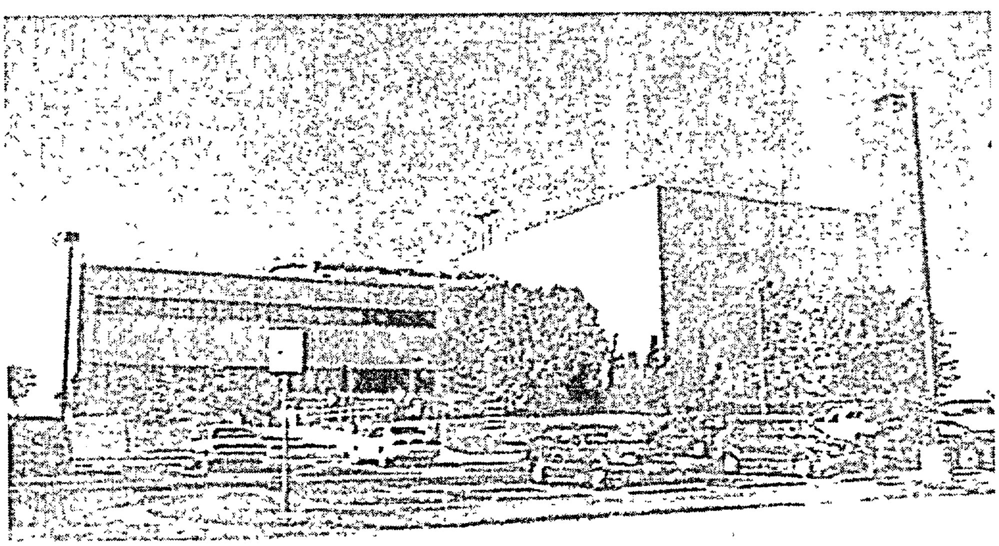

Figure 1-1 NETL - Nuclear Engineering Teaching Laboratory

The annual reports also satisfy 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, 2002 to December 31, 2002.

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.

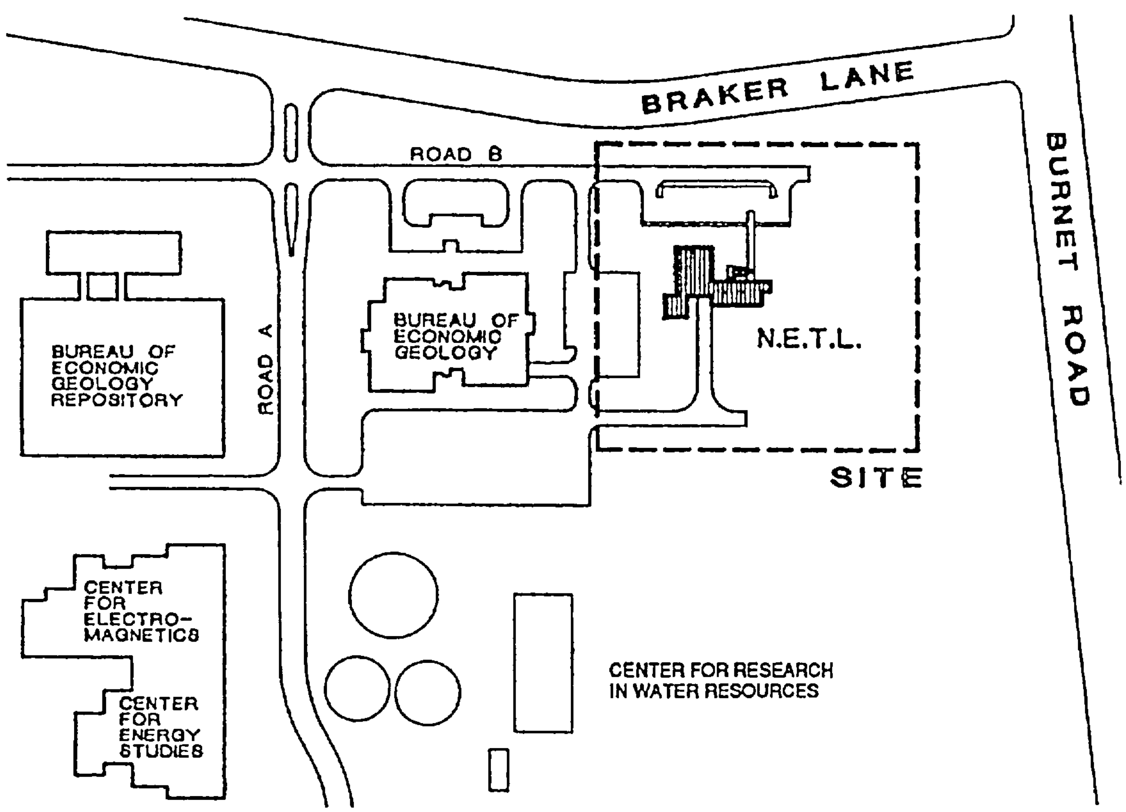

Figure 1-2 NETL Site - J.J. Pickle Research Campus

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. 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.

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.

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 90 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 is expected to be replaced within five years.

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.

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. Beam Port #2 is out of commission due to Reflector flooding.

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 is out of commission due to Reflector flooding.

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

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

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

Graduate
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 staff organization of the Nuclear Engineering Teaching Laboratory. The staff includes the Health Physics and the 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.

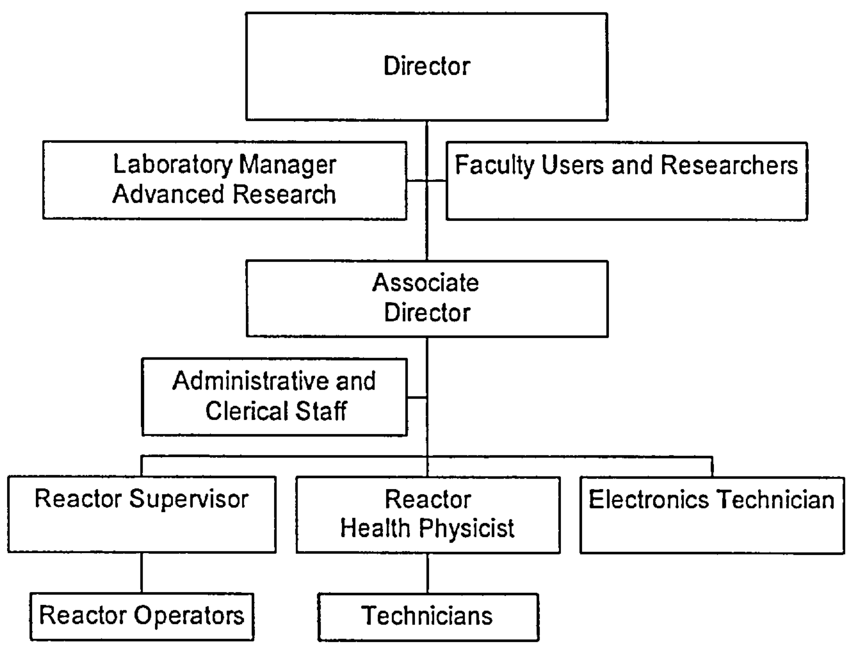

Figure 1-8 NETL Staff Organization

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. Ppersonnel 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. One detector operates in a Compton Gamma Ray Suppression System that provides improved low background measurements. APC 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 and Texas Intense Positron Source.

Health Physics

The Health Physics (HP) group is 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 Health Physics group consists of one full time Health Physicist with part-time student support. The Health Physicist is functionally responsible to the Management of the NETL, 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. A part-time Undergraduate Research Assistant (URA) may assist the Health Physicist. The URA reports to the Health Physicist and assists with technical tasks including periodic surveys, equipment maintenance, equipment calibration, and record keeping.

The Health Physics 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.

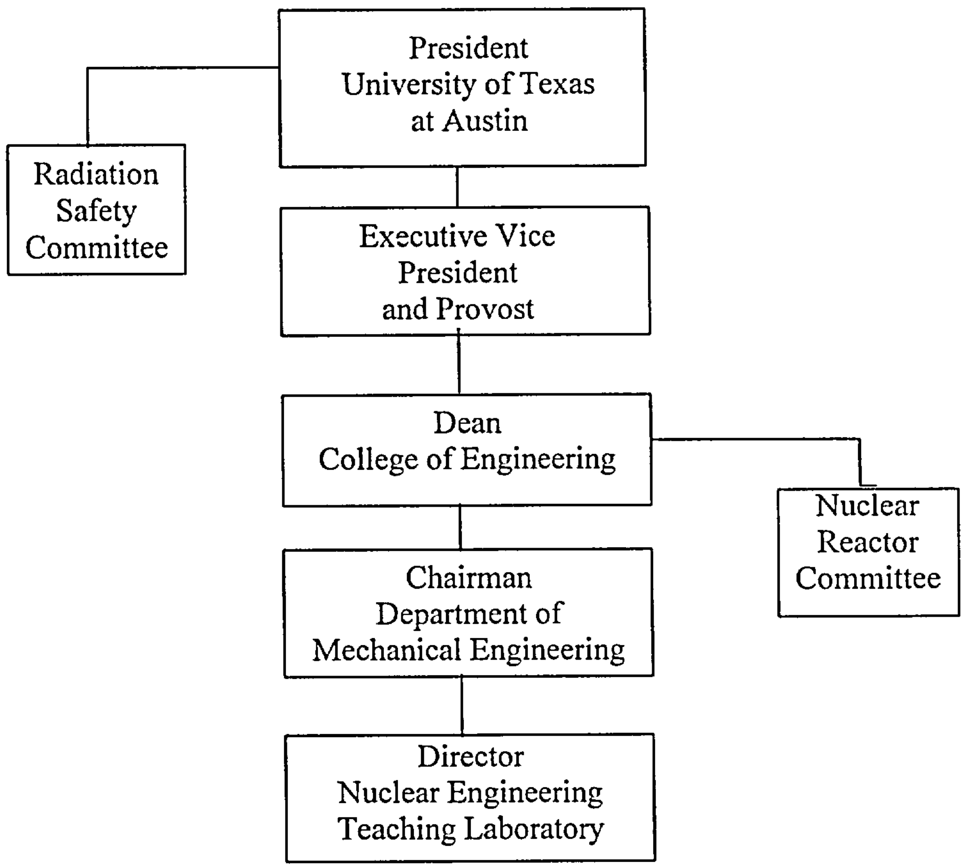

Figure 2-1 - University Administrative Structure over NETL

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 2002

Chairman	A. Sanchez
Vice Chairman	W. Hunt
Vice Chairman	R.C. Clements
Vice Chairman	C. Miller
Executive Secretary	F. A. Frederick
UT System Chancellor	R.D. Burck

Table 2-2
The University of Texas at Austin
Administration

President	Larry R. Faulkner
Executive Vice President and Provost ad interim	Sheldon Ekland-Olson
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
2002 Radiation Safety Committee

Chair	J.M. Sanchez
Member	G. Hoffmann
Member	S.A. Monti
Member	J. Robertus
Member	B.G. Sanders
Member	W. Charlton
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	K. Ball
Member	W. Charlton
Member	R.T. Johns
Member	H. M. Liljestrand
Member	W. Charlton
Member	S. Landsberger
Member	S. Pennington
Student Member	D. Dorsey
Ex officio member	J. Beaman
Ex officio member	R. J. Charbeneau
Ex officio member	W. Kitchen
Ex officio member	M. Krause
Ex officio member	D. S. O'Kelly

Table 2-5
NETL Personnel

<u>NETL FTE Facility Staff</u>

Director	R. Charbeneau (Jan-May),S.Landsberger
Associate Director	D. S. O'Kelly
Reactor Supervisor	M.G. Krause
Research Laboratory Manager	D. J O'Kelly
Health Physicist	W. A. Kitchen
Electronics Technician	L. Welch
Administrative Associate	J.L. Wiley

<u>NRE Faculty</u>

S. Biegalski W. Charlton
D.E. Klein
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.

NETL/NRE Research 2002

1. Developed time-integrated proliferation resistance methodology for nuclear fuel cycles (DOE)
2. Measurements of (in collaboration with LANSCE at LANL) spallation product yields and cross sections for materials of interest to the DOE/NE AAA program (DOE)
3. Determine the effects of internal country monitoring on the illicit trafficking of nuclear materials through the newly independent states (namely Russia, Ukraine, Belarus, Kazakhstan, Armenia, and Georgia) (LANL)
4. Developed proliferation resistance metrics for ATW technology options (Burns and Roe, PANTEX)
5. Nuclear archaeology study in support of treaty verifications (LANL)
6. Development of stochastic network models to study nuclear smuggling routes in Russia for the U.S. DOE Second Line of Defense (SLD) project (managed through DOE/NN-50/Office of Security Affairs)
7. Hosted the 13th International Training Course on Implementation of State Systems of Accounting for and Control of Nuclear Materials (SSAC). Performed in collaboration with the U.S. State Department and the International Atomic Energy Agency. (IAEA/LANL)
8. Radiation shielding testing of advanced tungsten composite materials to reduce environmental hazards of lead shielding (Ecomass Technologies)
9. Radiation shielding tests and modeling of composite gloves for handling transuranic materials (LANL)
10. Trace impurities and iodine background levels in groundwater (Illinois Geological Survey)
11. Neutron Activation Analysis (NAA) of travertine and anthracite from Civil War-era ships for nautical archaeology.
12. NAA of plant materials to determine Arsenics and Antimony pollution levels on U.S/Mexico border (UT El Paso)
13. Irradiation and damage studies of advanced high temperature superconductors (U of Florida)
14. Heavy-metal particulate pollution levels over Russian smelters (NOAA)

15. Particulate atmospheric pollution levels over Finland (U of Alaska/NOAA)

16. Prompt gamma activation analysis of carbon composite flywheels (NASA/UT)

17. Radiation damage modeling of integrated chip packaging materials (Texas A&M/Texas Instruments)

18. NAA of human blood serum for identification of biological cancer markers (MD Anderson Hospital)

19. NAA of air filters for monitoring environmental atmospheric pollution to maintain compliance with EPA and Clean Air Act (State of Vermont)

2.2 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.

A total of 1411 visitors were given access to the facility during the reporting period. The total includes tour groups, official visitors, and facility maintenance personnel. Tours for 16 groups with an average 20 persons/group were taken through the facility during the reporting period. This is a significant increase in the number of tours for education.

Presentations by NETL staff, including demonstrations with laboratory equipment, were given to several high school organizations. These presentations were done as part of school wide programs sponsored by the high schools. This year the NETL Associate Director provided hands-on activities for the local Boy Scouts of American as part of the NETL/UT outreach program. 30 Scouts received Atomic Energy merit badges from this activity.

2.3 Research Acitivities

Neutron Depth Profiling

The University of Texas (UT) NDP instrument utilizes thermal neutrons from the tangential beam port (BP#2) of the reactor. The NDP technique is not normally available to the research community due to the limited number of appropriate neutron sources.

Neutron depth profiling is an isotope specific nondestructive technique used to measure the near-surface depth distributions of several technologically important elements in various substrates. NDP is based on neutron induced reactions to determine concentration versus depth profiles. Because of the potential for materials research, particularly for semiconductor research, the UT-NDP facility has been developed and is available for scientific measurements.

The UT-NDP facility consists of a collimated thermal neutron beam, a target chamber, a beam catcher, and necessary data acquisition and process electronics. A collimator system was designed to achieve a high quality thermal neutron beam with good intensity and minimum contamination of neutrons above thermal energies.

A target vacuum chamber for NDP was constructed from 40.6 cm diameter aluminum tubing. The chamber can accommodate several small samples or a single large sample with a diameter up to 30 cm. The other degrees of freedom for an NDP measurement, location of charged particle detector and angle between sample and neutron beam, are set with the top cover of the chamber removed.

Depth profiles of various borophosphosilicate glass from Intel Corporation and Advanced Micro Devices, Inc. have been measured. Measurements were repeated at the National Institute of Standards and Technology (NIST) NDP facility using the same samples. The NETL results showed good agreement with the NIST depth profiles.

Boron-10 implanted silicon wafers from Advanced Micro Devices have been used for NDP measurements for the comparison of reported implant dose and profile. Also several measurements of Helium-3 implanted in stainless steel samples were carried out in order to examine helium behavior on metals and alloys.

Other possible applications of the UT-NDP facility include study of nitrogen in metals as it affects wear resistance, hardness, and corrosion.

Texas Cold Neutron Source

A cold neutron source has been designed, constructed, and tested by NETL personnel. 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 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 sources in the United States are at Brookhaven National Laboratory, the National Institute of Standards and Technology, and Cornell University. At least four major centers for cold neutron research exist in Europe, with another two in Japan.

Prompt Gamma Activation Analysis Facility

A Prompt Gamma Activation Analysis (PGAA) facility has been designed, constructed, and tested. 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.

A 25% efficient gamma-ray detector in a configuration with an offset-port dewar was purchased to be used at the UT-PGAA facility. The detector was selected in order to incorporate a Compton suppression system at a later date. A gamma-spectrum analysis system with 16,000 channels is used for data acquisition and processing.

The applications of the UT-PGAA will include: 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.

Neutron Radiography

A collimator design is being developed for beam port #5 of the TRIGA reactor. The collimator will provide neutrons for imaging various objects for analysis by neutron radiography. An image intensifier, display and acquisition system and analysis software are being acquired. The system will provide standard neutron radiography and provide for research into neutron tomography.

Texas Intense Positron Source

A reactor-based slow positron beam facility is being fabricated at the Nuclear Engineering Teaching Laboratory (NETL). This is a joint effort between UT-Austin and UT-Arlington researchers. 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 solid Kr 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 Brookhaven National Laboratory (BNL) and 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. For the BNL positron beam, a 200 mg copper pellet is irradiated in the High Flux Beam Reactor (8.3×10^{14} n/cm^{2}sec) and then transported to their positron beam facility at a different location where the copper is evaporated onto a source holder. The BNL positron beam uses solid Kr to moderate the fast positrons while at Delft a tungsten moderator is applied. The TIPS will have a joint moderator/remoderator stage using solid Kr, an approach that is similar in concept to that suggested for a magnetically guided positron beam. A major advantage is that our moderator/remoderator stage is operated in a magnetic field free environment such that electric fields can be established to increase its overall efficiency.

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 long vacuum jacket that will be inserted into one of the neutron beam ports of the NETL 1-MW TRIGA Mark II research reactor. The vacuum jacket will be evacuated to high vacuum and will have a rectangular section to allow for some shielding materials inside the beam port. 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/remoderator assembly is located. The high vacuum and ultra high vacuum systems will be separated by a gate valve.

The copper source of TIPS will be irradiated across from the core in the graphite reflector, in the middle section of the through port. 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 400 copper cylinders with 1 cm height and 0.5 cm diameter mounted on a 10x10 cm^2 copper plate forming a square lattice. The source activity will be around 100 Ci of which 14 Ci or more is available for positron beam production. The combined efficiency of the moderator/remoderator assembly is approximately 10^{-3} and, therefore, TIPS should deliver about 10^8 positrons/sec at the sample chamber.

Preliminary designs and construction of the source transport system and the vacuum jacket are completed. The designs and construction of the copper source, moderator/remoderator 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.

2.4 Publications, Reports, and Papers

Reports, publications, and presentations on research done at NETL are produced each year by NETL personnel. The following list documents research done by NETL faculty, staff, and students during the reporting period.

Publications

1. Landsberger,S. and K. Schmidt, "Distance Learning Opportunities for University-Industry Partnering", Conference on Nuclear Training and Education", August, Orlando, 2002.
2. Basunia, M., S. Landsberger, P. Hopke, T. Yli-Tuomi, J. Paatero and Y. Viisanen "Trace Elements in Historical Finnish Arctic Aerosols as Determined by Neutron Activation Analysis" Trans ANS, 87, 461-463 (2002).
3. Landsberger, S., T. J. Bellandi, and W. Kitchen, "Health Physics Practices in a Neutron Activation Analysis Laboratory", Trans ANS, 87, 389-390, (2002).
4. Landsberger, S. and S. Basunia, "An Evaluation of Epithermal Neutron Activation Analysis for Arctic Aerosols", Trans ANS, 455-456, (2002).
5. Landsberger, S., D. O'Kelly and L. Katz, "Development of a PhD Radiochemistry Program at the University of Texas at Austin", Trans ANS, 259-260, (2002).
6. Landsberger, S. and D. O'Kelly", Salient Gamma Ray Spectra Features of Compton Suppression Neutron Activation Analysis", Trans ANS, 439-441 (2002).

Oral Presentations

1. 1. Yli-Tuomi, T., L. Venditte, P.K. Hopke, M. S. Basunia, S. Landsberger, Y. Viisanen, and J. Paatero" Stepping Back in Time: Analysis of Arctic Aerosols Collected From Northern Finland Between 1964 and 1978", International Aerosol Conference, Charlotte, NC, October, 2002.
2. 2. Charlton, W. S., D. J. Dorsey and S. Landsberger "Cold Neutron Prompt Gamma Ray Activation Analysis at the University of Texas at Austin", First Research Co-ordination Meeting of the Co-ordinated Research Project on "New Applications of Prompt Gamma Neutron Activation Analysis", Budapest, Hungary, December 9-13, 2002.

Invited Lectures

Bi-National Workshop in Air Quality Management and Planning, International Atomic Energy Agency, Ghana, Africa, "A Series of Lectures on Source-Receptor Modeling" given to various staff scientists and government employees, September, 2002.

Workshops

O'Kelly, D.S., "Reactor Facility Licensing and Operations Workshop" prepared for Lawrence Livermore National Laboratory and Moroccan Center for Nuclear Science and Technology (CENSTEN), Rabat Morocco, June 2002.

Chapter 3

3.0 FACILITY OPERATING SUMMARIES

3.1 Operating Experience

The UT-TRIGA reactor operated for 220 days in 2002. The reactor produced a total energy output of 738 MW-hrs during this period. The burnup per year in the ten 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.

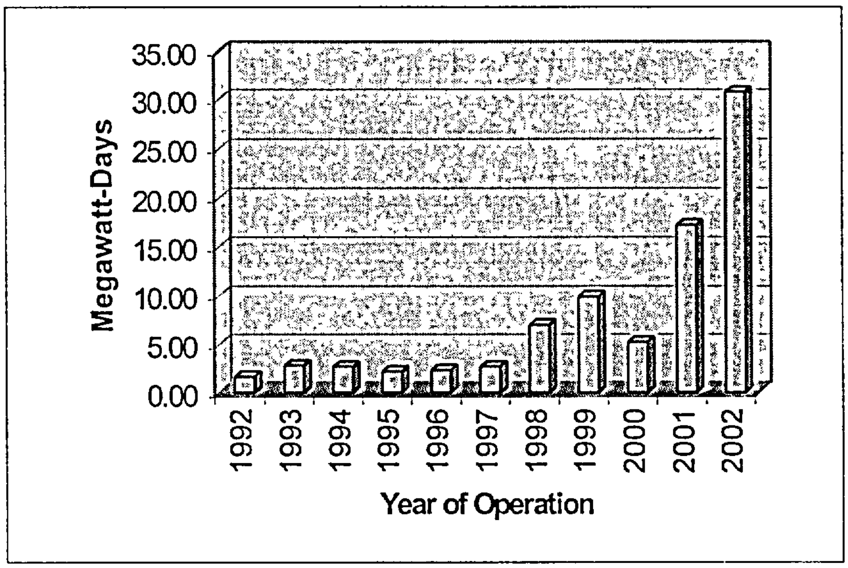

Figure 3-1 History of Reactor Operations

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

There were 19 safety system protective unscheduled shutdowns in 2002. Nine of these were considered watchdog or timeout scrams when an operator tried replacing another operator already logged into the system or when the operator tried printing a status window with the printer in a non-functioning mode. One scram was caused by operator error while operating too close to a high power scram setpoint and six others were attributed to noise spikes.

SCRM Fuel Temp 1		
1) 1/30/02	1158	@500kW – Spurious spike.
2) 12/19/02	1620	@950kW – Reviewed History File and found FT1 at 365. Suspect TC failure intermittent open caused SCRAM.
SCRM PPWR HI		
1) 2/7/02	1409	NM1000 Power HI SCRAM – Power fluctuation; In history mode, power fluctuates between 94% and 99% and then jumps to 108%.
2) 6/25/02	1203	NM1000 Power HI SCRAM – @ 1 MW auto, Power fluctuation; Statistical fluctuations of digital system to 108%.
3) 6/25/02	1253	NM1000 Power HI SCRAM – @ 1 MW auto, Power fluctuation; Statistical fluctuations of digital system to 108%.
SCRM %P2		
1) 6/25/02	1310	At 1 MW; Operator was banking rods at the time of SCRAM in auto mode. No levels > 102%.
MANUAL SCRAM		
1) 7/31/02	0850	Reactor SCRAM due to operator error – @ 500 kW.
Other		
1) 4/15/02	1356	Building AC power fluctuation – saw lights blink several times, which was also seen in other buildings.
2) 6/25/02	1504	Building AC power fluctuation – Loss of magnet voltage caused rods to drop; Control system remained operational and drove rods down manually.
3) 7/3/02	1131	Reactor SCRAM due to operator error.

Scram log for digital systems:

(Control System Console Watchdog Timeout)

1) 1/30/02	1714	CSC W/D when operator tried logging in to replace current operator @ 500 kW.
2) 2/13/02	1533	CSC W/D when operator tried logging in to replace current operator @ 950 kW.
3) 2/27/02	1013	CSC W/D when operator tried logging in to replace current operator @ 500 kW.
4) 3/13/02	1236	CSC W/D when operator tried logging in to replace current operator @ 500 kW.
5) 3/19/02	1206	CSC W/D when operator tried logging in to replace current operator @ 500 kW.

(Data Acquisition and Control System Watchdog Timeout)

1) 3/27/02	0901	DAC W/D Timeout @ 500 kW.
2) 3/27/02	0936	DAC W/D Timeout while pressing the print window command when printer had a paper jam @ 500 kW.
3) 3/27/02	1004	DAC W/D Timeout while pressing the print window command when printer had a paper jam @ 500 kW. Also received CSC WD TO.
4) 4/1/02	1501	DAC W/D Timeout while pressing the print window command when printer was out of paper @ 500 kW.

3.3 Utilization

There was a significant increase in the number of sample irradiated and hours of operation during the reporting period compared to previous years of NETL operations. One reactor operator upgraded his license to a senior reactor operator status. 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 two student projects.

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

Digital Console Upgrade

The original software for the TRIGA digital console instrumentation and control system (ICS) was developed in the mid-1980s. The ICS program runs under a proprietary (and no longer supported) UNIX operating system (OS) developed by Action Instruments called IC-DOS. The current NETL ICS operates on two IBM 7532 Rack-Mounted Industrial PCs. The IBM 7532 PC is an Intel 80286 machine and replacements for many of the hardware components have become difficult to obtain. Recently, Sorrento Electronics has ported the original General Atomic (GA) ICS code to run under a widely used and well-documented OS, QNX. The change in OS and updated software permits an upgrade of the ICS to operate on Intel Pentium-class IBM machines. This software and hardware upgrade was completed in early December 2001. The upgrade has been formally accepted by NETL but a few minor software "bugs" remain. Functionally, the system has passed all safety and control checks and thus provides the same level of safety as the previous Console system. The General Atomics vendors traveled to Austin three times in 2002 to perform onsite evaluation and corrective programming. The final version was "locked" in October of 2002 because the remaining software bugs were not reproducible and did not affect reactor safety or operations. One such fault was the Accumulated Operator Time. Occasionally, the program would miscalculate the values or Megawatt hours of operations. This function is a useful tool to determine total fuel burnup and the vendor will continue to troubleshoot this with the Operations staff.

Briefly, the ICS utilizes two separate computers to monitor and control the NETL reactor (see attached Figure). The Control System Computer (CSC) is located in the Control Room and The Data Acquisition and Control (DAC) computer is located in the Reactor Bay adjacent to the pool. These two systems provide outputs to control rod movement and process information from the various inputs (rod position, reactor power, etc) for operator information and control. Additionally, the ICS provides protective action (Scram) and interlocks for reactor safety. Several protective actions, such as the "Watchdog" timers, are unique to the microprocessor controlled ICS. The Watchdog circuits comprise a system where each computer checks for normal internal processing and the operation of the other computer. The essential changes to the ICS system are as follows

1. Functionally the same software package with the same operator interface at the console. 32-bit QNX operating system is fully supported, industry standard with broad user base.

2. Replaces previous proprietary network adapters with standard 3Com Ethernet network adapters. System uses standard Ethernet network hub.

3. Version control software (PVCS) has been incorporated into the program.

4. Replaced Intel X286 machine with Pentium machines (600 MHz clock speed) to extend effective hardware lifetime.

5. Software was restructured and optimized using standard C and UNIX functions.

The ICS upgrade was previously installed and is in operation at the following US research reactors:

1. AFRRI TRIGA Facility, Bethesda MD
2. DOW TRIGA, Midland, MI
3. USGS TRIGA, Denver, CO

Personal communications with Reactor Supervisors at each facility confirm the software and equipment have been essentially debugged and are operating reliably. It was noted that a few (non-protective) routines appeared slower but this is attributed to a change in software timing loops such that their speed is processor independent. In general, operators have seen noticeably fewer network failures and watchdog circuit timeouts (a weekly occurrence at some facilities). Loose wiring terminals caused several system failures during installation but the equipment was installed and operational within 5 to 10 days (with the exception of the Beta test site, AFRRI).

System testing at NETL verified the software logic, the network communication and the reactor instrumentation controls are identical to the ICS previously installed. Minor changes to remove obsolete and unnecessary functions or the modification of existing subroutines based on operator experiences was permitted if it do not change the essential operator interface.

The UT-TRIGA testing program was adapted from the original GA TRIGA CSC/DAC Checkout and Test Plan (4/87) and the approved software upgrade test programs from the USGS and AFFRI facilities. The ICS Acceptance Test verified operation in all reactor operating modes (Steady State, Scram, Pulse and Square Wave). The retests included testing the performance of the NETL Procedure MAIN 1 (Interlock and Scram Features), MAIN 2 (Calibration and Function Checks of the ICS-Instrument System), MAIN 3 (Calibration and Function Checks of the ICS-Support System) and MAIN 4 (Calibration and Function Checks of the ICS-Radiation Monitor System). The ICS upgrade replaced the redundant network system with a single network system. Redundancy is less of an issue with the current reliable Ethernet systems. The majority of facilities using the older software had already converted to a single network system. The current system and the upgraded network are not connected to the Internet or the NETL LAN and will not be vulnerable to external effects.

The Digital ICS operation and possible accident conditions (reactivity insertion) are considered in the UT-TRIGA Safety Analysis Report and Reactor Facility License. The original software and hardware complies with the American Nuclear Society Standard Criteria for the Rector

Safety Systems of Research Reactors (ANSI/ANS 15.15). The software upgrade will increase the reliability and maintainability of the ICS and extend the operational console lifetime.

DAC Power Supply

The power supply of the new, industrial grade computer failed on October 18. A temporary power supply was installed and the computer was verified operational. Failure analysis determined the failure was possibly a manufacturing problem but the unit was noted to trip off and reset after cooling off. It is hypothesized the power supply (standard 300W, single fan) was under powered for the older GA boards and overheated. The failed power supply was replaced with a unit with a higher power rating (500W) and dual cooling fans.

NM-1000 Wide Range Channel Microprocessor

Operators received a computerwarning "NM Com Fail" with a Halt lamp lit on 9/23/02. The problem was traced to the MB80 Microboard Computer. A spare board was available and swapped in to continue operations. It was determined the Z80 microprocessor had failed. Replacement IC-Chips were obtained for future spare parts.

Fuel Loading

Reactor excess reactivity was below $0.50 by the third quarter of 2002. Additional fuel elements were requested from DOE and fresh fuel was received form Illinois in November. Seven elements, including one TC element, of standard TRIGA fuel were received and fully inspected. Two fresh elements were previously stored at the NETL. Eight standard fuel elements were added to the reactor and the reactor was calibrated. The additional elements provided approximately $1.30 of excess reactivity.

3.6 Laboratory Inspections

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

Table 3-6
Committee Meetings

Nuclear Reactor Committee	
First Quarter	No meeting
Second Quarter	April 4, 2002
Third Quarter	September 6, 2002
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 Health (TDH) Bureau of Radiation Control (BRC). NRC and TDH inspections were held at the times presented in Table 3-7.

Table 3-7
Dates of License Inspections

License	Dates
R-129	None (postponed to early 2003)
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. Safety concerns included such items as storage of combustibles, compressed gases, and fire extinguisher access.

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. 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

Annual Summary of Personnel Radiation Doses Received Within the NETL Facility for 2002

Personnel Group	Average Annual Dose (mrem)(1)(6)			Greatest Individual Dose (mrem)(1)(6)			Total Person mrem per Group (1)(6)		
	Whole Body DDE(2)	Lens of Eye LDE(3)	Extremities SDE(4)	Whole Body DDE(2)	Lens of Eye LDE(3)	Extremities SDE(4)	Whole Body DDE(2)	Lens of Eye LDE(3)	Extremitie s SDE(4)
Facility Operating and Research Personnel	23.11	23.33	135.11	56	46	790	208	210	1216
Students	3.71	3 79	7.21	24	18	16	52	53	101
Visitors PD's (5)	0	N/A	N/A	0	N/A	N/A	0	N/A	N/A

(1) "M" indicates that each of the beta-gamma or neutron dosimeters during the reporting period was less than the vendor's minimum measurable quantity of 10 mrem for x and gamma rays and thermal neutrons, 40 mrem for energetic betas, and 20 mrem for fast neutrons. "N/A" indicates that there was no extremity monitoring conducted or required for the group

(2), (3), (4) Deep, Eye, and Shallow Dose Equivalents (DDE, LDE, and SDE respectively) DDE applies to external whole-body exposure and is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2) LDE applies to the external exposure of the eye lens and is taken as the dose equivalent at a tissue depth of 0 3 cm (300mg/cm^2) SDE applies to skin or extremity exposure, and is the dose equivalent at a tissue depth of 0 007 cm (7mg/cm^2) averaged over an area of 1 cm.

(5) PD's are pocket ion chambers issued to persons who enter radioactive materials / restricted areas for periods of short duration, i e , a few hours or days.

(6) Exposures were obtained from Daily Dosimeter Log sheets for DDE, and vendor dosimeter reports for LDE and SDE

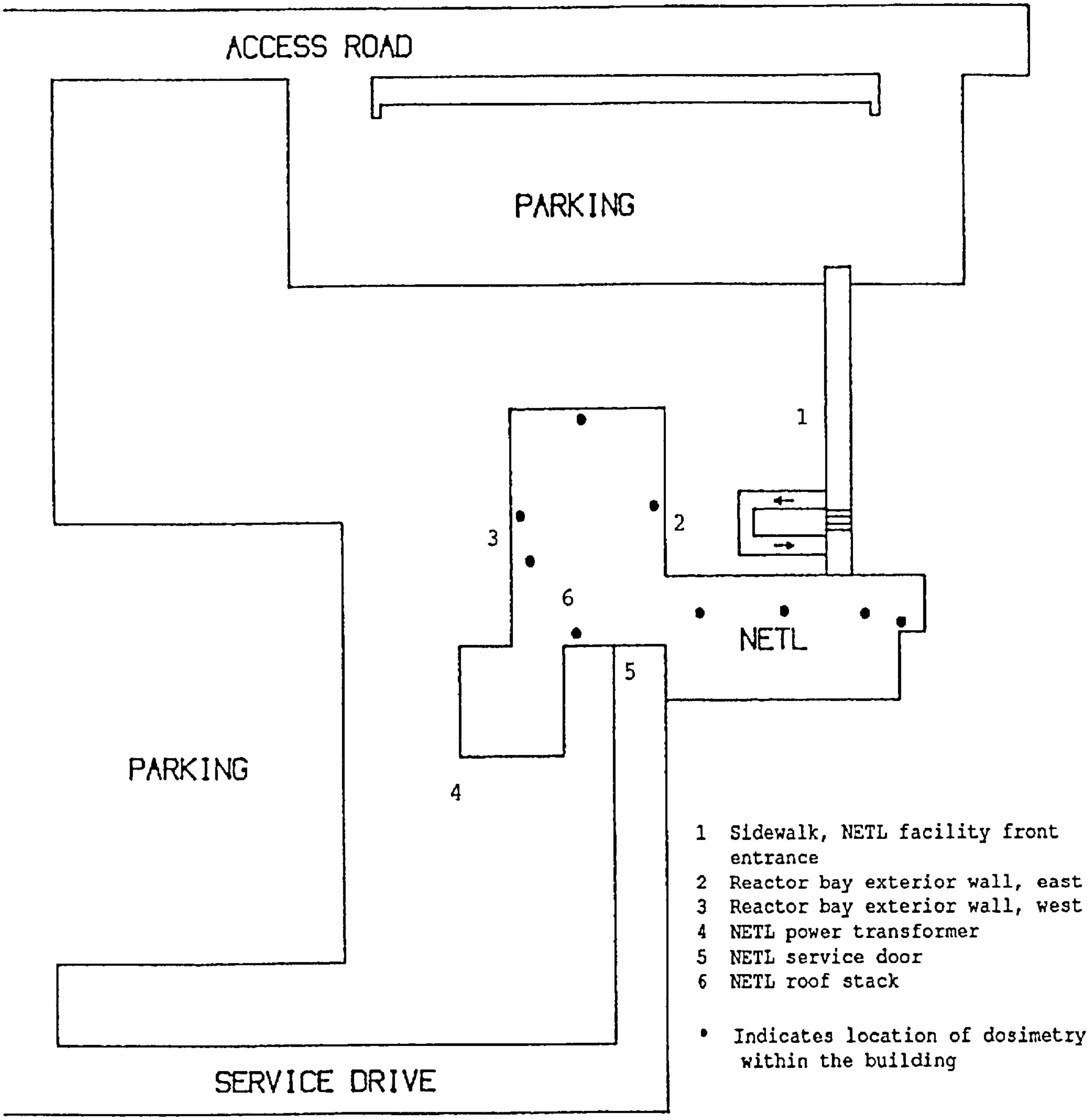

Figure 3-3 Environmental TLD Locations

Table 3-9

Total Dose Equivalent Recorded on Area Dosimeters Located WithIn the NETL Facility 2002				
Location in Reactor Facility	Monitor ID	Total Dose (1,2) b,g,x Deep (3)	(mrem) n	Shallow (4)
Reactor Bay, North Wall	00277	145	147	143
Reactor Bay, East Wall	00278	10	10	9
Reactor Bay, West Wall	00279	651	650	629
Water Treatment Room	00280	24801	24679	23997
Shield Area, Room 1.102	00281	M	1	1
Sample Processing, Room 3.102	00173	4	4	4
Gamma Spectroscopy Lab, 3.112	00174	45	44	44
Radiation Experiment Lab, 3.106	00175	M	M	M
Reception Area, 2.102	00176	M	M	M
Office, Room 3.104	00222	4	4	4

(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 gamma 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 measureable quantity of 10 mrem for x and gamma rays, 40 mrem for energetic betas, 20 mrem for fast neutrons, and 10 mrem for thermal neutron "N/A" indicates that there was no neutron monitor at 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, which applies to external whole-body exposure and is the dose equivalent at a tissue depth of 1 cm

(4) 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 square cm

Table 3-10

Total Dose Equivalent Recorded on TLD Environmental Monitors Around the NETL Reactor Facility 2002

Monitor I.D	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	M
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 gamma 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 measureable quantity of 10 mrem for x and gamma rays, 40 mrem for energetic betas, 20 mrem for fast neutrons, and 10 mrem for thermal neutron

(2) X or gamma ray exposure May be followed by an 'H' for energies greater than 250 keV effective or 'L' for energies less than 100 keV effective

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

3.8 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 2002

Accessible Location		Area Radiation Levels (mrem/hr)		Contamination Levels (dpm/11sq cm)	
		Avg.(1)	Max. (1)	Avg.	Max.
TRIGA Reactor Bay:					
Reactor Bay North		0.1	15	MDA	MDA
Reactor Bay South		<0.05	40 (3)	MDA	MDA
Reactor Bay East		<0.05	1	MDA	MDA
Reactor Bay West		3	10	MDA	MDA
Reactor Pool Deck (3rd Floor)		<0.05	10	MDA	MDA
NETL Facility:					
NAA Sample Processing (Rm 3.102)		0.1	10	MDA	MDA
NAA Sample Counting (Rm 3.112)		<0.05	0.1	MDA	MDA
Health Physics Laboratory		<0.05	0.5	MDA	MDA
NAA Laboratory (Rm 3.106)		<0.05	0.1	MDA	MDA

(1)Measurements made with Victoreen 450B and/or Bicron Microrem portables survey meters in areas readily accessible to personnel

(2)MDA for the G-5000 low level alpha-beta radiation counting system is 2 49 dpm/100cm^2 beta, and 58 dpm/100cm^2 alpha Calculation of MDA based on NCRP Report #58

(3)Water Treatment room at Ion exchanger