COLLEGE OF ENGINEERING
THE UNIVERSITY OF TEXAS AT AUSTIN

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August 19, 2013

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 2012 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,

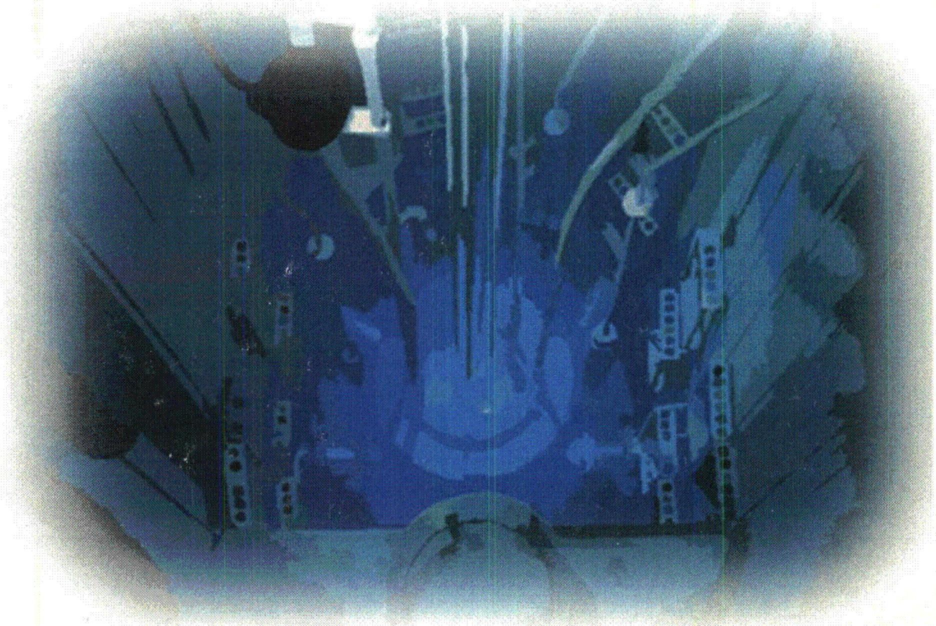
P. M. Whaley
NETL Associate Director

Enclosure: 2012 Annual Report

A020
NRR

The University of Texas at Austin

Nuclear Engineering Teaching Laboratory



2012 Annual Report

NRC Docket 50-602

DOE Contract No. DE-AC07-ER03919

Department of Mechanical Engineering
THE UNIVERSITY OF TEXAS AT AUSTIN
Nuclear Engineering Teaching Laboratory • Austin, Texas 78758
512-232-5370 • FAX 512-471-4589 • http//www.me.utexas.edu/~netl/net.html

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. The NETL is also 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 multidisciplinary research and commercial applications of nuclear science, and generate resources to help support Nuclear Engineering activities.

Steven Biegalski, Ph.D., P.E.
Director, Nuclear Engineering Teaching Laboratory

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EXECUTIVE SUMMARY

The Nuclear Engineering Teaching Laboratory (NETL) facility supports the academic and research missions of The University of Texas, and has begun to provide these support functions to other institutions. The environmental research and analysis services performed by the NETL during the past year have been used to support the Sandia National Laboratories, Los Alamos National Laboratory, Oak Ridge National Laboratory, the Canadian government, the National Oceanic and Atmospheric Administration, the University of Illinois, Texas A&M University and the State of Texas.

1.0 NUCLEAR ENGINEERING TEACHING LABORATORY ANNUAL REPORT

The Nuclear Engineering Laboratory Annual Report covers the period from January through December 2010. The report includes descriptions of the organization, NETL facilities, the reactor, experiment and research facilities and summaries of operations and radiological impact.

1.1 General

The NETL facility serves a multipurpose role, with the primary function as a "user facility" for faculty, staff, and students of the Cockrell School of Engineering. The NETL supports development and application of nuclear methods for researchers from other universities, government organizations and industry. The NETL provides nuclear analytic services to researchers, industry, and other laboratories for characterization, testing and evaluation of materials. The NETL provides public education through tours and demonstrations.

Figure 1-1, NETL - Nuclear Engineering Teaching Laboratory

Activities at NETL are regulated by Federal and State agencies. The nuclear reactor is subject to the terms and specifications of Nuclear Regulatory Commission (NRC) License R-129, a class 104 research reactor license. A second NRC license for special nuclear materials, SNM-180, authorizes possession of a subcritical assembly, neutron sources, and various equipment. The NETL is responsible for administration and management of both licenses. Activities at the University using radioisotopes are conducted under a State of Texas license, L00485. Functions of the broad license are the responsibility of the University Office of Environmental Health and Safety.

1.2 Purpose of this Report

This report meets requirements of the reactor Technical Specifications and the Department of Energy Fuels Assistance program, and provides an overview of the education, research, and service programs of the NETL for the calendar year 2010.

1.2.1 TRIGA II Reactor Technical Specifications

The NETL TRIGA II reactor Technical Specifications (section 6.6.1) requires submission of an annual report to the Nuclear Regulatory Commission. Table 1.1 correlates specified requirements to the report.

Table 1.1, TRIGA Mark II Technical Specification and the Annual Report

Specification	Section
A narrative summary of reactor operating experience including the energy produced by the reactor or the hours the reactor was critical, or both.	5.0, 6.1, 6.3
The unscheduled shutdowns & corrective action taken to preclude recurrence	6.2
Major preventive & corrective maintenance operations with safety significance	6.4
Major changes in the reactor facility and procedures, tabulation of new tests or experiments, or both, significantly different from those performed previously, including conclusions that no unreviewed safety questions were involved	6.6
A summary of radioactive effluents (nature & amount) released or discharged to the environs beyond effective control of the university as determined at or before the point of such release or discharge, including to the extent practicable an estimate of individual radionuclides present in the effluent or a statement that the estimated average release after dilution or diffusion is less than 25% of the concentration allowed or recommended	7.2
A summary of exposures received by facility personnel and visitors where such exposures are greater than 25% of that allowed or recommended.	7.3
A summarized result of environmental surveys performed outside the facility	7.4

1.2.2 The Department of Energy Fuels Assistance Program

The DOE University Fuels Assistance program (DE-AC07-05ID14517, subcontract 00078206, 08/01/2008-08/31/2013) supports the facility for utilization of the reactor in a program of education and training of students in nuclear science and engineering, and for faculty and student research. The contract requires an annual progress report in conjunction with submittal of a Material Balance Report and Physical Inventory Listing report. Specific technical details of the report (listed in Table 2.2) are sent under separate cover to the DOE with this Annual Report.

Table 2.2, DOE Reactor Fuel Assistance Report Requirements

Fuel usage (grams Uranium 235 & number of fuel elements)
Inventory of unirradiated fuel elements in storage
Inventory of fuel elements in core
Inventory of useable irradiated fuel elements outside of core
Projected 5-year fuel needs
Current inventory of other nuclear material items with DOE-ID project identifier (i.e., "J")
Point of contact for nuclear material accountability

2.0 ORGANIZATION AND ADMINSTRATION

The University of Texas System (UTS) was established by the Texas Constitution in 1876, and currently consists of nine academic universities and six health institutions. The UTS mission is to provide high-quality educational opportunities for the enhancement of the human resources of Texas, the nation, and the world through intellectual and personal growth.

The Board of Regents is the governing body for the UTS. It is composed of members appointed by the Governor and confirmed by the Senate. Terms are of six years each and staggered, with the terms of three members expiring on February 1 of odd-numbered years. Current members of the current Board of Regents are listed in Table 2.1.

Table 2.1

The University of Texas Board for 2011
Wm. Eugene Powell, Chairman
Paul L. Foster, Vice Chairman
R. Steven Hicks, Vice Chairman
Francie A. Frederick, General Counsel to the Board of Regents
Nash M. Horne, Student Regent
Ernest Aliseda
Alexis Cranberg
Wallace Hall, Jr.
Jeffrey D. Hildebrand
Brenda Pejovich

http://www.utsystem.edu/bor/currentRegents.htm, 07/31/2013

The chief executive officer of the UTS is the Chancellor. The Chancellor has direct line responsibility for all aspects of UTS operations, and reports to and is responsible to the Board of Regents. The current Chancellor and Staff are listed in Table 2.2.

Table 2.2

University of Texas System Chancellor's Office
Francisco G. Cigarroa, *MD, Chancellor*
Pedro Reyes, PhD, *Executive Vice Chancellor for Academic Affairs*
Scott C. Kelley, PhD, *Executive Vice Chancellor for Business Affairs*
Kenneth I. Shine, MD, *Executive Vice Chancellor for Health*
Randa S. Safady, *Vice Chancellor for External Relations*
Dan Sharphorn, *Vice Chancellor and General Counsel ad interim*
Stephanie A. Bond Huie, *Vice Chancellor for Strategic Initiatives ad interim*
Barry McBee, JD, *Vice Chancellor for Governmental Relations*
Francie A. Frederick, JD, *General Counsel to the Board of Regents*

http://www.utsystem.edu/sites/utsfiles/assets/general-files/OrgChart.pdf, 07/31/2013

UT Austin is the flagship campus of the UTS. The facility operating license for the TRIGA Mark II at the NETL is issued to the University of Texas at Austin. Figure 2-1 reflects the organizational structure for 4 levels of line management of the NETL reactor, as identified in the Technical Specifications, as well as oversight functions. Other NETL resources (in addition to line management positions) include staff with specialized functions, and faculty and facility users. NETL support is through a combination of State allocation, research programs, and remuneration for service.

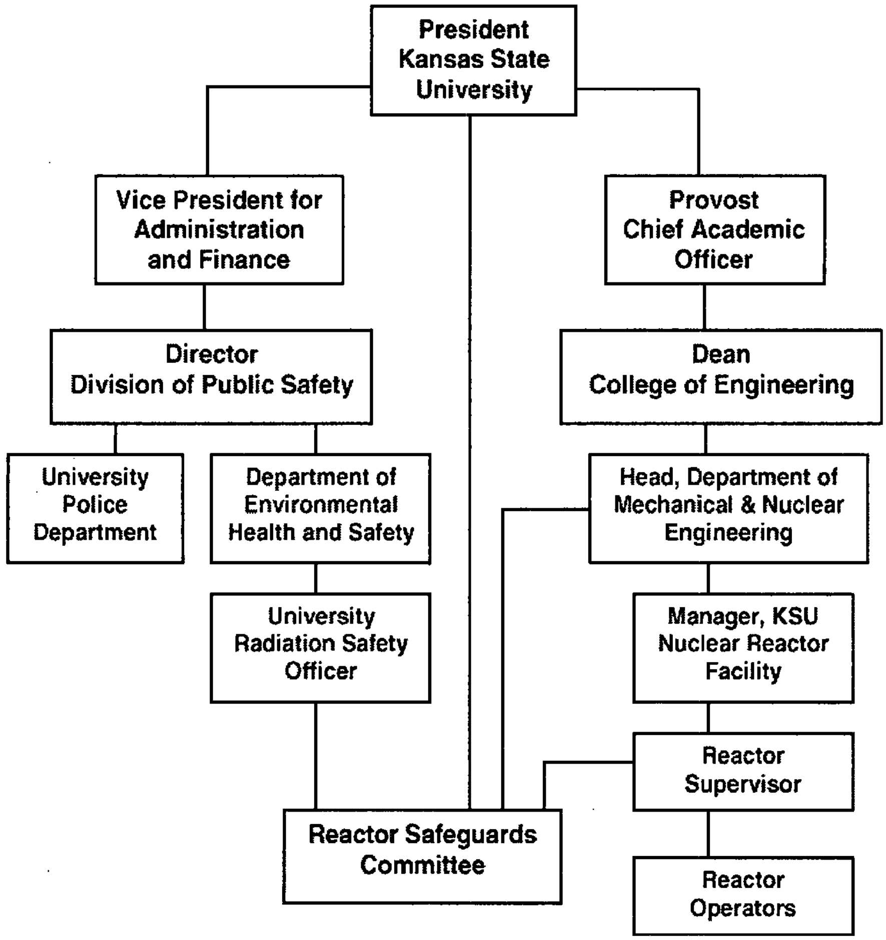


Figure 2-1, Organizational Structure for the University of Texas at Ausitn TRIGA Reactor

2.1 Level 1 Personnel

Level 1 represents the central administrative functions of the University and the Cockrell School of Engineering. The University of Texas at Austin is composed of 16 separate colleges and schools; the Cockrell School of Engineering manages eight departments with individual degree programs. The Nuclear Engineering Teaching Laboratory (NETL) is one of several education and research functions within the School. Current Level 1 personnel are reported in Table 2.3.

2.1.1 President, University of Texas at Austin

The President is the individual vested by the University of Texas system with responsibility for the University of Texas at Austin.

2.1.2 Executive Vice president and Provost (Provost)

Research and educational programs are administered through the Office of the Executive Vice President and Provost. Separate officers assist with the administration of research activities and academic affairs with specific management functions delegated to the Dean of the Cockrell School of Engineering and the Chairman of the Mechanical Engineering Department.

2.1.3 Dean of the Cockrell School of Engineering

The Dean of the Cockrell School of Engineering reports to the Provost. The School consists of 8 departments and undergraduate degree programs and 12 graduate degree programs.

2.1.4 Department of Mechanical Engineering Chairman

The Chairman reports to the Dean of the Cockrell School of Engineering. The Department manages 8 areas of study, including Nuclear and Radiation Engineering.

Table 2.3

The University of Texas at Austin Administration (Level 1)
William Powers Jr., JD, President
Steven W. Leslie, PhD, Executive Vice President and Provost
Gregory L. Fenves, PhD, Dean, Cockrell School of Engineering
Jayathi Murthy, Chair of Department of Mechanical Engineering

2.2 Level 2 Personnel

The Nuclear Engineering Teaching Laboratory operates as a unit of the Department of Mechanical Engineering at The University of Texas. Level 2 personnel are those with direct responsibilities for administration and management of resources for the facility, including the Chair of the Mechanical Engineering Department, the NETL Director and Associate Director. Oversight roles are provided at Level 2 by the Radiation Safety Committee, the Radiation Safety Officer and the Nuclear Reactor Committee. The current complement of Level 2 personnel is reported along with the NETL facility staff and the Nuclear and Radiation Engineering program faculty in Table 2.4.

Table 2.4

Facility Staff & NRE Faculty

NETL Facility Staff		NRE Faculty
Director	S. Biegalski	S. Biegalski
Associate Director	P. M. Whaley	S. Landsberger
Reactor Supervisor	M. Krause	E. Schneider
Health Physicist & Lab manager	T. Tipping	M. Deinhert
Administrative Associate	D. Judson	
Electronics Technician/ Reactor Operator	L. Welch	
	E. Herrara	
	N. Mohammed	
	A. Davis	
	J. Navar	
	U. Chatterjee	
Health Physics Technician	J. Sims	

2.2.1 Director, Nuclear Engineering Teaching Laboratory (NETL Director)

Nuclear Engineering Teaching Laboratory programs are directed by an engineering faculty member with academic responsibilities in nuclear engineering and research related to nuclear applications. The Director is a member of the Cockrell School of Engineering, and the Department of Mechanical Engineering.

2.2.2 Associate Director

The Associate Director is responsible for safe and effective conduct of operations and maintenance of the TRIGA nuclear reactor. Other activities performed by the Associate Director and staff include neutron and gamma irradiation service, operator/engineering training courses, and teaching reactor short courses. In addition to Level 3 staff, an Administrative Assistant and an Electronics Technician report to the Associate Director. Many staff functions overlap, with significant cooperation required.

2.2.4 Safety Oversight

Safety oversight is provided for radiation protection and facility safety functions. A University of Texas Radiation Safety Committee is responsible programmatically for coordination, training and oversight of the University radiation protection program, with management of the program through a Radiation Safety Officer. Current personnel on the Radiation Safety Committee are listed on Table 2.5.

Nuclear reactor facility safety oversight is the responsibility of a Nuclear Reactor Committee; a request has been made to the Nuclear Regulatory Commission to change the name "Nuclear Reactor Committee" to "Reactor Oversight Committee" to better describe the committee function for the University and avoid confusion with other NRC organizations. "Reactor Oversight Committee" will be used in this report pending approval. Current personnel on the Reactor Oversight Committee are listed on Table 2.6.

Radiation Safety Committee. The Radiation Safety Committee reports to the President and has the broad responsibility for policies and practices regarding the license, purchase, shipment, use, monitoring, disposal and transfer of radioisotopes or sources of ionizing radiation at The University of Texas at Austin. The Committee meets at least three times each calendar year. The Committee is consulted by the Office of Environmental Health and Safety concerning any unusual or exceptional action that affects the administration of the Radiation Safety Program.

Table 2.5

Radiation Safety Committee 2012-2013
Gerald W. Hoffmann, Ph.D., *Chair,* Department of Physics
Juan M. Sanchez, Ph.D., *Vice Chair,* Vice President for Research
Neal Armstrong, Ph.D., Vice Provost
Kevin Dalby, Ph.D., College of Pharmacy
W. Scott Pennington, *ex-officio,* Office of Environmental Health & Safety
Jon D. Robertus, Ph.D., Department of Chemistry & Biochemistry
Bob G. Sanders, Ph.D., School of Biological Sciences
Peter Schneider, Director, Office of Environmental Health & Safety
Tracy Tipping, Nuclear Engineering Teaching Laboratory

http://www.utexas.edu/research/resources/committees#rsc, 07/31/2013

Radiation Safety Officer. A Radiation Safety Officer holds delegated authority of the Radiation Safety Committee in the daily implementation of policies and practices regarding the safe use of radioisotopes and sources of radiation as determined by the Radiation Safety Committee. Radiation Safety Officer responsibilities are outlined in *The University of Texas at Austin Radiation Safety Manual*. The Radiation Safety Officer has an ancillary function reporting to the NETL Director as required on matters of radiological protection. The Radiation Safety Program is administered through the University Office of Environmental Health and Safety.

A NETL Health Physicist (Level 3) manages daily radiological protection functions at the NETL, and reports to the Radiation Safety Officer as well as the Associate Director. This arrangement assures independence of the Health Physicist through the Radiation Safety Officer while maintaining close interaction with NETL line management.

Reactor Oversight Committee (ROC). The Reactor Oversight Committee (formerly known as the Nuclear Reactor Committee) evaluates, reviews, and approves facility standards for safe operation of the nuclear reactor and associated facilities. The ROC meets at least semiannually. The ROC provides reports to the Dean on matters as necessary throughout the year and submits a final report of activities no later than the end of the spring semester. The ROC makes recommendations to the NETL Director for enhancing the safety of nuclear reactor operations. Specific requirements in the Technical Specifications are incorporated in the committee charter, including an audit of present and planned operations. The ROC is chaired by a professor in the Cockrell School of Engineering. ROC Membership varies, consisting of ex-officio and appointed positions. The Dean appoints at least three members to the Committee that represent a broad spectrum of expertise appropriate to reactor technology, including personnel external to the School.

Table 2.6

Reactor Oversight Committee 2011-2012
Erich Schneider (ME), Chair
Howard Liljestrand (CAEE)
Lynn Katz (CAEE)
Steven Biegalski (ME)
Lawrence R. Jacobi (External Representative)
Jodi Jenkins (External Representative)
Jayathi Murthy, ex-officio (ME)
Michael Krause, ex-officio (NETL)
Tracy Tipping, ex-officio (NETL)
Mike Whaley, ex-officio (NETL)
John G. Ekerdt, ex-officio
Scott Pennington, other (Radiation Safety Officer)

http://www.engr.utexas.edu/faculty/committees/225-roc, 07/31/2013

2.3 Level 3 Personnel

Level 3 personnel are responsible for managing daily activities at the NETL. The Reactor Supervisor and Health Physicist are Level 3. The current Reactor Supervisor and Health Physicist are listed on Table 2.4.

2.3.1 Reactor Supervisor

The Reactor Supervisor function is incorporated in a Reactor Manager position, responsible for daily operations, maintenance, scheduling, and training. The Reactor Manager is responsible for the maintenance and daily operations of the reactor, including coordination and performance of activities to meet the Technical Specifications of the reactor license. The Reactor Manager plans and coordinates emergency exercises with first responders and other local support (Austin Fire Department, Austin/Travis County EMS, area hospitals, etc.).

The Reactor Manager, assisted by Level 4 personnel and other NETL staff, implements modifications to reactor systems and furnishes design assistance for new experiment systems. The Reactor Manager assists initial experiment design, fabrication, and setup. The Reactor Manager provides maintenance, repair support, and inventory control of computer, electronic, and mechanical equipment. The Administrative Assistant and Reactor Manager schedule and coordinate facility tours, and support coordination of building maintenance.

2.2.1 Health Physicist

The Health Physicist function is incorporated into a Laboratory Manager position, responsible for radiological protection (Health Physics), safe and effective utilization of the facility (Lab Management), and research support. Each of these three functions is described below. The Laboratory Manager is functionally responsible to the NETL Associate Director, but maintains a strong reporting relationship to the University Radiation Safety Officer and is a member of the Radiation Safety Committee. This arrangement allows the Health Physicist to operate independent of NETL operational constraints in consideration of radiation safety.

Health Physics. NETL is a radiological facility operating in the State of Texas under a facility operating license issued by the Nuclear Regulatory Commission (NRC). Radioactive material and activities associated with operation of the reactor are regulated by the NRC, and the uses of radioactive materials at the NETL not associated with the reactor are regulated by the Texas Department of State Health Services (TDSHS) Radiation Control Program. The NETL Health Physicist ensures operations comply with these requirements, and that personnel exposures are maintained ALARA ("as low as is reasonably achievable"). One or more part-time Undergraduate Research Assistant (URA) may assist as Health Physics Technicians.

Lab Management. The lab management function is responsible for implementation of occupational safety and health programs at the NETL. The Laboratory Manager supports University educational activities through assistance to student experimenters in their projects by demonstration of the proper radiation work techniques and controls. The Laboratory Manager participates in emergency planning for 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.

Research Support. The mission of The University of Texas at Austin is to achieve excellence in the interrelated areas of undergraduate education, graduate education, research and public service. The Laboratory Manager and research staff supports the research and educational missions of the university at large, as well as development or support of other initiatives.

The Laboratory Manager is responsible for coordinating all phases of a project, including proposal and design, fabrication and testing, operation, evaluation, and removal/dismantlement. Researchers are generally focused on accomplishing very specific goals, and the research support function ensures the NETL facilities are utilized in a safe efficient manner to produce quality data. The Laboratory Manager obtains new, funded research programs to promote the capabilities of the neutron beam projects division for academic, government and industrial organizations and/or groups.

The NETL provides unique facilities for nuclear analytic techniques, including but not limited to elemental analysis (instrumental neutron activation analysis, prompt gamma analysis), measurements of physical characteristics (neutron depth profiling, neutron radiography) and experimental techniques investigating fundamental issues related to nuclear physics and condensed matter. Nuclear analytical techniques support individual projects ranging from class assignments to measurements for faculty research.

The Laboratory Manager manages the use of the five beam ports with the Texas Cold Neutron Source, Neutron Depth Profiling, Neutron Guide and Focusing System, Prompt Gamma Activation Analysis Neutron Radiography and Texas Intense Positron Source. Projects are supported in engineering, chemistry, physics, geology, biology, zoology, and other areas. Research project support includes elemental measurements for routine environmental and innovative research projects. The neutron activation analysis technique is made available to different state agencies to assist with quality control of sample measurements.

2.4 Level 4 Personnel

Reactor Operators and Senior Reactor Operators (RO/SRO) operate and maintain the reactor and associated facilities. An RO/SRO may operate standard reactor experiment facilities as directed by the Reactor Supervisor.

2.5 Other Facility Staff

In addition to the line management positions defined in Figure 2-1, NETL staff includes an Administrative Assistant, and Electronics Technician, and variously one or more Undergraduate Research Assistants assigned either non-licensed maintenance support (generally but not necessarily in training for Reactor Operator licensure) or to support the Laboratory Manager as Health Physics Technicians and/or research support.

2.6 Faculty and Facility Users

The complement of faculty and facility users at the NETL is extremely variable. Functionally faculty and facility users are associated with the NETL in the capacity of academic utilization, other educational efforts, or research & service. A description of these activities follows.

2.6.1 Academic Utilization

The NETL is integrated in the Nuclear and Radiation Engineering program (NRE) of Mechanical Engineering (ME). The ME faculty complement directly supporting the nuclear education program is listed in Table 2.7. Successful participation in the undergraduate program results in a Bachelor of Science in Mechanical Engineering, Nuclear Engineering certification; the degree is essentially a major in Mechanical Engineering with a minor in Nuclear Engineering. All Mechanical Engineering degree requirements must be met with an additional set of specific nuclear engineering courses successfully completed.

Table 2.7

University of Texas Nuclear and Radiation Engineering program Faculty
Dr. Sheldon Landsberger, Nuclear and Radiation Engineering Professor
Dr. Steven Biegalski, Nuclear and Radiation Engineering Associate Professor
Dr. Erich Schneider, Nuclear and Radiation Engineering Assistant Professor
Dr. Ofodike A. Ezekoye, Thermal Fluids Systems Professor
Dr. Kendra M. Foltz-Biegalski, Nuclear and Radiation Engineering Research Engineer
Dr. Elmira Popova, Operations Research Associate Professor
Dr.Mark Deinert, Nuclear and Radiation Engineering, Thermal Fluid Systems, Assistant Professor
Dr.Mitch Pryor, Robotics Research Group Research Associate

Of the five undergraduate Nuclear Engineering courses and the dozen graduate Nuclear Engineering courses, five courses make extensive use of the reactor facility. Table 2.8 lists the courses currently in the UT course catalog, many of which use the reactor and its experiment facilities.

Table 2.8, Nuclear Engineering Courses

Undergraduate

ME 136N, 236N: Concepts in Nuclear and Radiological Engineering	
ME 337C: Introduction to Nuclear Power Systems	
ME337F: Nuclear Environmental Protection	
ME 337G: Nuclear Safety and Security[1]	
ME 361E: Nuclear Operations and Reactor Engineering	
ME 361F: Radiation and Radiation protection Laboratory	
Graduate	
ME 388C: Nuclear Power Engineering	
ME 388D: Nuclear Reactor Theory I[1]	
ME 388F: Computational Methods in Radiation Transport[1]	
ME 388G: Nuclear Radiation Shielding[1]	
ME 388H: Nuclear Safety and Security[1]	
ME 388J: Neutron Interactions and their Applications in Nuclear Science and Engineering[1]	
ME 388M: Mathematical Methods for Nuclear and Radiation Engineers[1]	
ME 388N: Design of Nuclear Systems I[1]	
ME 388P: Applied Nuclear Physics[1]	
ME 388S: Modern Trends in Nuclear and Radiation Engineering[1]	
ME 389C: Nuclear Environmental Protection	
NE 389F: The Nuclear Fuel Cycle[1]	
ME 390F: Nuclear Analysis Techniques	
ME 390G: Nuclear Engineering Laboratory	
ME390T: Nuclear- and Radio-Chemistry	

NOTE[1], Academic courses with minimal or no use of the reactor facilities

The NRE 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 required for the Ph.D. degree and acted on by a NRE dissertation committee.

2.6.2 Other Education Efforts

The NETL has participated in the IAEA Fellowship programs for the past decade. Several Fellows and Visiting Scientists spend 3-6 months at the NETL per year.

The Nuclear Engineering Teaching Lab also extends its facilities to two Historically Black Colleges or Universities (HBCUs). Both Hutson-Tillotson University in Austin and Florida Memorial University in Miami Gardens, Florida have participated in this these educational efforts.

In addition to formal classes, the NETL routinely provides short courses or tours for Texas agencies, high schools and pre-college groups such as the Boy Scouts of America. Tours and special projects are available to promote public awareness of nuclear energy issues. 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.

2.6.3 Research & Service

A more comprehensive description of the nuclear analytic techniques and facilities available at the NETL is provided in section 5. Personnel support for these activities includes faculty, graduate and undergraduate research assistants, and NETL staff.

2.7 NETL Support

NETL funding is provided by state appropriations, research grants, and fees accrued from service activities. Research funding supplements the base budget provided by the State and is generally obtained through competitive research and program awards. Funds from service activities supplement base funding to allow the facility to provide quality data acquisition and analysis capabilities. Both sources of supplemental funds (competitive awards and service work) are important to the education and research environment for students. The U.S. Nuclear Regulatory Commission supported development of the Summer Nuclear Engineering Institute, and supports continuation of the program.

3.0 FACILITY DESCRIPTION

3.1 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 currently resides. The program installed and operated the first UT TRIGA nuclear reactor in Taylor Hall on the main campus. Initial criticality for the first UT reactor was August 1963. Power at startup was 10 kilowatts with a power upgrade to 250 kilowatts in 1968. Total burnup during the 25 year period from 1963 to final operation in April 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.

In October 1983, planning was initiated for the NETL to replace the original UT TRIGA installation. Construction was initiated December 1986 and completed in May 1989. The NETL facility operating license was issued in January 1992, with initial criticality on March 12, 1992. Dismantling and decommissioning of the first UT TRIGA reactor facility was completed in December 1992.

3.2 NETL SITE, J.J. Pickle Research Campus

Land development in the area of the current NETL installation 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. The University became owner of the site in the 190's, and in 1994 the site name was changed to the J.J. Pickle Research Campus (PRC) in honor of retired U.S. Congressman James "Jake" Pickle.

The PRC is a multidiscipline research campus on 1.87 square kilometers. The site consists of two approximately equal areas, east and west. 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 conduct research at locations on the PRC. Adjacent to the NETL site are the Center for Research in Water Resources, the Bureau of Economic Geology, and the Research Office Complex, illustrating the diverse research activities on the campus. A

Commons Building provides cafeteria service, recreation areas, meeting rooms, and conference facilities.

3.3 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 neutron beam experiment area. 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 shops, instrument & measurement laboratories, and material handling facilities.

The NETL Annex was installed in 2005, a 24 by 60 foot modular class room building adjacent to the NETL building. The building provides classroom space and offices for graduate students working at the NETL.

4.0 UT-TRIGA MARK II RESEARCH REACTOR

TRIGA is an acronym for Training, Research, Isotope production, General Atomics. The TRIGA Mark II reactor is a versatile and inherently safe research reactor conceived and developed by General Atomics to meet education and research requirements. The UT-TRIGA reactor provides sufficient power and neutron flux for comprehensive and productive work in many fields including physics, chemistry, engineering, medicine, and metallurgy

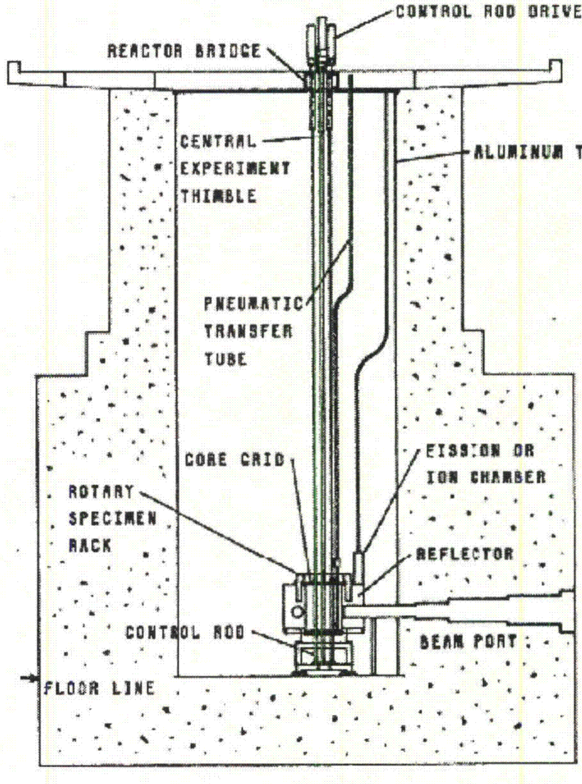


Figure 4-1, UT TRIGA Mark II Nuclear Research Reactor

The NETL UT-TRIGA reactor is an above-ground, fixed-core research reactor. The reactor core is located at the bottom of an 8.2 meter deep water-filled tank surrounded by a concrete shield structure. The water serves as a coolant, neutron moderator, and transparent radiation shield. The reactor core is surrounded by a reflector, a 1 foot thick graphite cylinder. The reactor is controlled by manipulating cylindrical "control rods" containing boron.

4.1 Reactor Core.

The reactor core is an assembly of about 100 fuel elements surrounded by an annular graphite neutron reflector. Fuel elements are positioned by an upper and lower grid plate, with penetrations of various sizes in the upper grid plate to allow insertion of experiments. Each fuel element consists of a fueled region with graphite sections at top and bottom, contained in a thin-walled stainless steel tube. The fuel region is a metallic alloy of low-enriched uranium in a zirconium hydride (UZrH) matrix. 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 and automatically returns to normal power levels. Pulse operation, a normal mode, is a practical demonstration of this inherent safety feature.

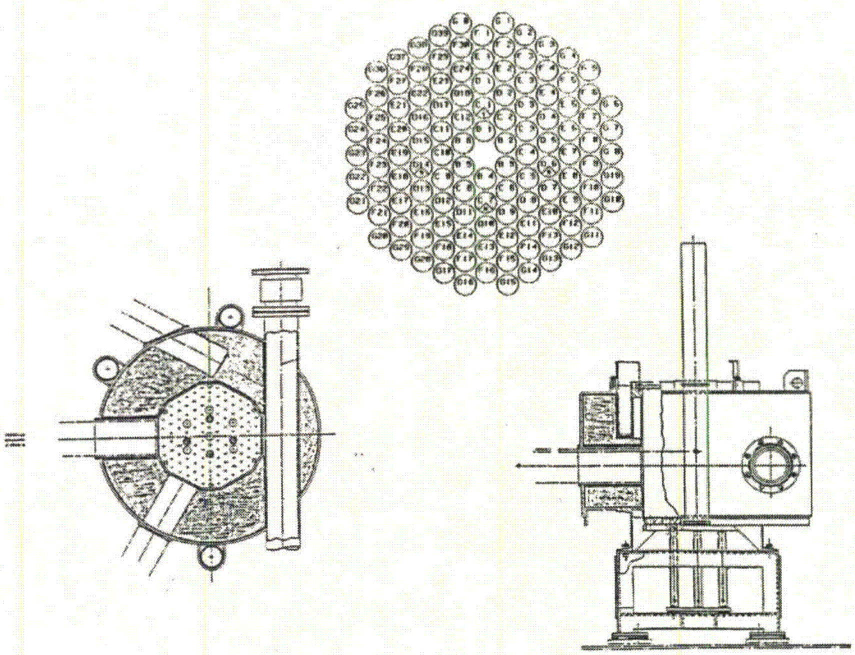


Figure 4-2, Core and Support Structure Details

4.2 Reactor Reflector.

The reflector is a graphite cylinder in a welded aluminum-canister. A 10" well in the upper surface of the reflector accommodates an irradiation facility, the rotary specimen rack (RSR), and horizontal penetrations through the side of the reflector allow extraction of neutron beams. In 2000 the canister was flooded to limit deformation stemming from material failure in welding joints. In 2004, the reflector was replaced with some modification, including a modification to the upper grid plate for more flexible experiment facilities.

4.3 Reactor Control.

The UT-TRIGA research reactor can operate continuously at nominal powers up to 1.1 MW, or in the pulsing mode with maximum power levels up to 1500 MW (with a trip setpoint of 1750 MW) for durations of about 10 msec. The pulsing mode is particularly useful in the study of reactor kinetics and control. The UT-TRIGA research reactor uses a compact microprocessor-driven control system. The digital control system provides a unique facility for performing reactor physics experiments as well as reactor operator training. This advanced system provides for flexible and efficient operation with precise power level and flux control, and permanent retention of operating data.

The power level of the UT-TRIGA is controlled by a regulating rod, two shim rods, and a transient rod. The control rods are fabricated with integral extensions containing fuel (regulating and shim rods) or air (transient rod) that extend through the lower grid plate for full span of rod motion. The regulating and shim rods are fabricated from B_4C contained in stainless steel tubes; the transient rod is a solid cylinder of borated graphite clad in aluminum. Removal of the rods from the core allows the rate of neutron induced fission (power) in the UZrH fuel to increase. The regulating rod can be operated by an automatic control rod that adjusts the rod position to maintain an operator-selected reactor power level. The shim rods provide a coarse control of reactor power. The transient rod can be operated by pneumatic pressure to permit rapid changes in control rod position. The transient rod moves within a perforated aluminum guide tube.

5.0 EXPERIMENT AND RESEARCH FACILITIES

Neutrons produced in the reactor core can be used in a wide variety of research applications including nuclear reaction studies, neutron scattering experiments, nuclear analytical techniques, and irradiation of samples. Facilities for positioning samples or apparatus in the core region include cut-outs fabricated in the upper grid plate, a central thimble in the peak flux region of the core, a rotary specimen rack in the reactor graphite reflector, and a pneumatically operated transfer system accessing the core in an in-core section. Beam ports, horizontal cylindrical voids in the concrete shield structure, allow neutrons to stream out away from the core. Experiments may be performed inside the beam ports or outside the concrete shield in the neutron beams. Areas outside the core and reflector are available for large equipment or experiment facilities. Current NRE and NETL personnel and active projects are tabulated at the end of this section (Table 5.3, 5.4).

In addition to reactor facilities, the NETL has a subcritical assembly, various radioisotope sources, radiation producing machines, and laboratories for spectroscopy and radiochemistry.

5.1 Upper Grid Plate 7L and 3L Facilities

The upper grid plate of the reactor contains four removable sections configured to provide space for experiments otherwise occupied by fuel elements (two three-element and two seven-element spaces). Containers can be fabricated with appropriate shielding or neutron absorbers to tailor the gamma and neutron spectrum to meet specific needs. Special cadmium-lined facilities have been constructed that utilize three element spaces.

5.2 Central Thimble

The reactor is equipped with a central thimble for access to the point of maximum flux in the core. The central thimble is an aluminum tube extending through the central penetration of the top and bottom grid plates. Typical experiments using the central thimble include irradiation of small samples and the exposure of materials to a collimated beam of neutrons or gamma rays.

5.3 Rotary Specimen Rack (RSR)

A rotating (motor-driven) multiple-position specimen rack located in a well in the top of the graphite reflector provides for irradiation and activation of multiple samples and/or batch production of radioisotopes. Rotation of the RSR minimizes variations in exposure related to sample position in the rack. Samples are loaded from the top of the reactor through a tube into the RSR using a specimen lifting device. A design feature provides the option of using pneumatic pressure for inserting and removing samples.

5.4 Pneumatic Tubes

A pneumatic transfer system supports applications using short-lived radioisotopes. The in-core terminus of the system is normally located in the outer ring of fuel element positions, with specific in-core sections designed to support thermal and epithermal irradiations. The sample capsule 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 to three different sender-receiver stations. One station is in the reactor confinement, one is in a fume hood in a laboratory room, and the third operates in conjunction with an automatic sample changer and counting system.

5.5 Beam Port Facilities

Five neutron beam ports penetrate the concrete biological shield and reactor water tank at core level. Specimens may be placed inside a beam port or outside the beam port in a neutron beam from the beam port. The beam ports were designed with different characteristics to accommodate a wide variety of experiments. Shielding reduces radiation levels outside the concrete biological shield to safe values when beam ports are not in use. Beam port shielding is configured with an inner shield plug, outer shield plug, lead-filled shutter, and circular steel cover plate. A neutron beam coming from a beam port may be modified by using collimators, moderators and/or neutron filters. Collimators are used to limit beam size and beam divergence. Moderators and filters are used to change the energy distribution of neutrons in beams (e.g., cold moderator).

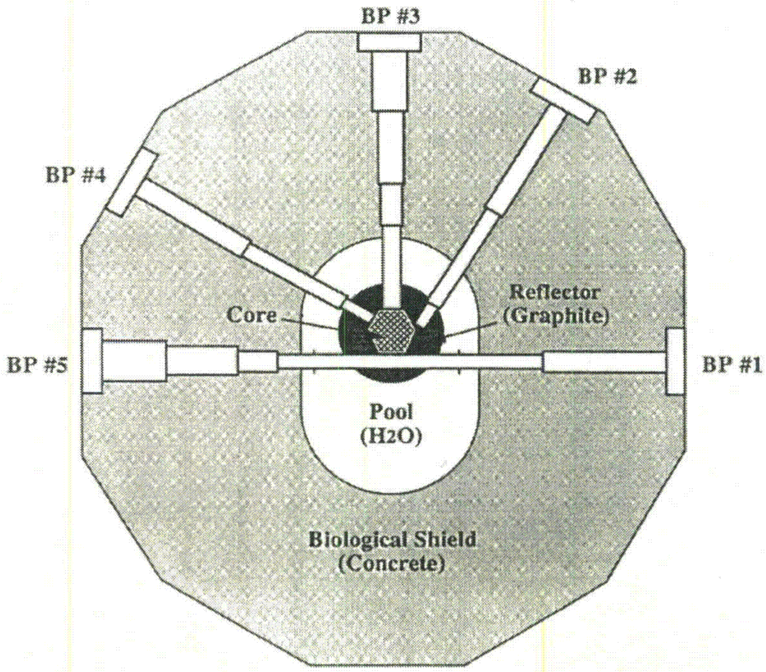


Figure 5-2, Beam Ports

Table 5-2, Dimensions of Standard Beam Ports		
	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

5.5.1 Beam Port 1 (BP1)

BP1 is connected to BP5, forming a through port. The through port penetrates the graphite reflector tangential to the reactor core, as seen in Figure 5-2. This configuration allows introduction of specimens adjacent to the reactor core to gain access to a high neutron flux from either side of the concrete biological shield, and can provide beams of thermal neutrons with relatively low fast-neutron and gamma-ray contamination.

A reactor-based slow positron beam facility is being fabricated at BP1. The facility (Texas Intense Positron Source) will be one of a few reactor-based slow positron beams in the world. 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.

The copper source will be irradiated 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, with the branching ratio for β^+ emission of 19 %.. A source transport system in a 4 meter aluminum 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 outside the biological shielding to an ultra high vacuum (at around 10^{-10} torr) chamber, where the moderator assembly is located. 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 to deliver about 10^8 positrons/sec in the energy range of 0 - 50 keV.

5.5.2 Beam Port 2 (BP2)

BP2 is a tangential beam port, terminating at the outer edge of the reflector. A void in the graphite reflector extends the effective source of neutrons into the reflector for a thermal neutron beam with minimum fast-neutron and gamma-ray backgrounds. Tangential beams result in a "softer" (or lower average-) energy neutron beam because the beam consists of scattered reactor neutrons. BP2 is configured to support neutron depth profiling applications, with a prompt-gamma neutron activation analysis sharing the beam port.

<u>Neutron Depth Profiling (NDP)</u> Some elements produce charged particles with characteristic energy in neutron interactions. When these elements are distributed near a surface, the particle energy spectrum is modulated by the distance the particle traveled through the surface. NDP uses this information to determine the distribution of the elements as a function of distance to the surface.

Prompt-Gamma Neutron Activation Analysis (PGNAA) Characteristic gamma radiation is produced when a neutron is absorbed in a material. PGNAA analyzes gamma radiation to identify the material and concentration in a sample. PGNAA applications 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) multi-element 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) multi-element 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.

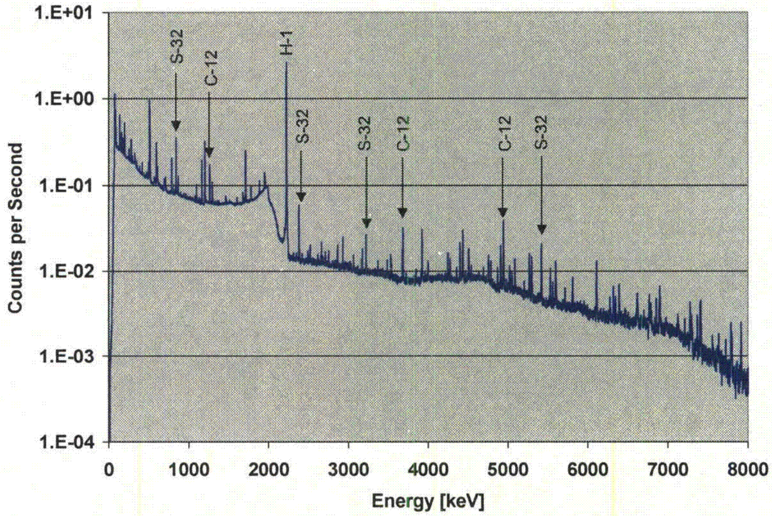


Figure 5-3, PGAA Spectra of Carbon Composite Flywheel

5.5.3 Beam Port 3 (BP3)

BP3 is a radial beam port. BP3 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. BP3 contains the Texas Cold Neutron Source Facility, a cold source and neutron guide system.

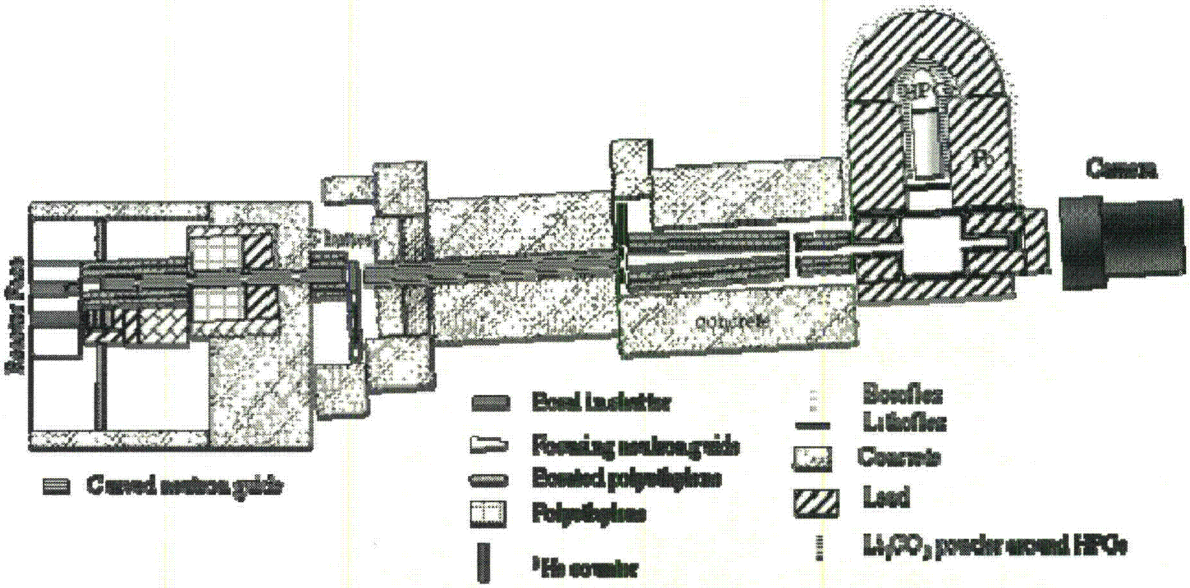


Figure 5-4, Prompt Gamma Focused-Neutron Activation Analysis Facility

Texas Cold Neutron Source. The TCNS provides a low background subthermal neutron beam for neutron reaction and scattering research. The TCNS consists of a cooled moderator, a heat pipe, a cryogenic refrigerator, a vacuum jacket, and connecting lines. The TCNS uses eighty milliliters of mesitylene moderator, maintained by the cold source system at ~36 K in a chamber within the reactor graphite reflector. A three-meter aluminum neon heat pipe, or thermosyphon, is used to cool the moderator chamber. The heat pipe working fluid evaporates at the moderator chamber and condenses at the cold head.

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

Prompt Gamma Focused-Neutron Activation Analysis Facility 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 to provide an enhanced reaction rate with lower background at the sample-detector area as compared to other facilities using filtered thermal neutron beams. The sample handling system design permits the study of a wide range of samples and quick, reproducible sample-positioning.

5.5.4 Beam Port 4 (BP4)

BP4 is a radial beam port that 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. BP4 was configured in 2005 to support student laboratories.

5.5.5 Beam Port 5 (BP5)

A Neutron Radiography Facility is installed at BP5 (Figure 5-5). Neutrons from BP5 illuminate a sample. The intensity of the exiting neutron field varies according to absorption and scattering characteristics of the sample. A conversion material generates light proportional to the intensity of the neutron field as modified by the sample.

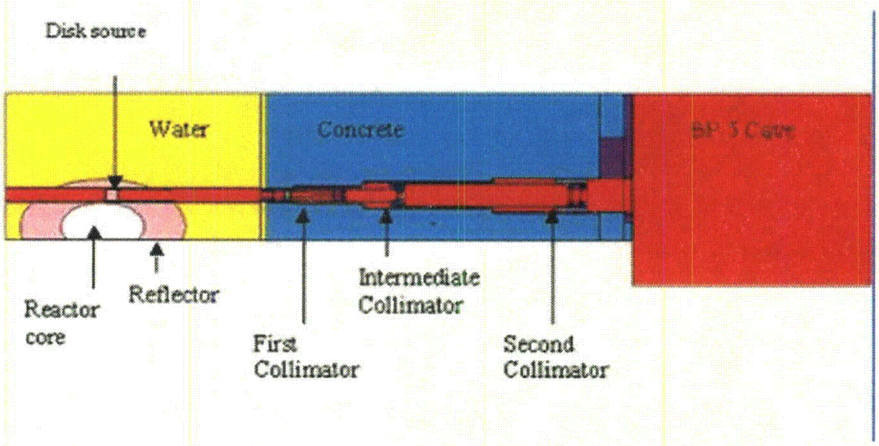


Figure 5-5, Neutron Radiography System

The conversion material is integral in one imaging system at the NETL; there are two independent conversion devices available at the NETL. A Micro-Channel Plate image intensifying technology system (NOVA Scientific) is characterized by high resolution (up to 30 μm) over a small (approximately ½ in.) field of view. A larger image can be obtained using a more conventional 7X7 in.^{2} ^{6}LiF/ZnS scintillation screen.

A conversion screen mounted on a video tube provides a direct single in one neutron radiography camera at the NETL. The image produced by the independent conversion apparatuses can eb recorded in one of three available digital cameras. Cameras include a charge injection device (CID) camera, a cryogenically cooled charge coupled device (CCD) camera, and an electronically cooled CCD camera. The digital image is captured in a computer, where image analysis software produces the final product.

5.6 Other Experiment and Research Facilities

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, various radioisotope sources, machine produced radiation fields, and a series of laboratories for spectroscopy and radiochemistry.

5.6.1 Subcritical Assembly

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 previously at the Manhattan College Zero Power Reactor is currently at the facility.

5.6.2 Radioisotopes

Radioisotopes are available in a variety of quantities. Gamma and beta sources generally in microcurie to millicurie quantities are available for calibration and testing of radiation detection equipment. Neutron sources of plutonium-beryllium and californium-252 are available. Laboratories provide locations to setup radiation experiments, test instrumentation, prepare materials for irradiation, process radioactive samples and experiment with radiochemical reactions.

5.6.3 Radiation Producing Machines

The NETL houses a 14-MeV neutron generator. The generator is currently being developed for high-energy neutron activation analysis and portable neutron radiography applications.

5.6.4 Support Laboratories

There are several laboratories adjacent to the reactor. One laboratory supports sample and standards preparation. Labs are also used for various types of radio assay, with one dedicated to a receiving station for rabbit system operations and sample counting. A control system permits automated operations.

The DOE is anticipating a loss of nuclear workforce with limited prospects for replacement of radio chemists in the national laboratory system. Therefore, a graduate-level radiochemistry laboratory was developed with support from the Department of Energy (DOE). The laboratory consists of state-of-the-art Alpha Spectroscopy Systems, Liquid Scintillation Counting System and several High Resolution Gamma Counting Systems. Students are encouraged to develop skills and interests that make them viable replacements for the nuclear workforce.

5.7 Experiment Facility Utilization

Figure 5-1 provides the number of hours of reactor operation allocated to experiments in the applicable facility, with abbreviations in Figure 5.1 explained in the table following. There were 1180.1 hours of utilization for experiments; operations supported irradiation in more than one experiment facility simultaneously for 30.2 hours in 2011, therefore total time for reactor operations was 1149.9 hours. The number of operating hours allocated to experiments includes the "console key on" time.

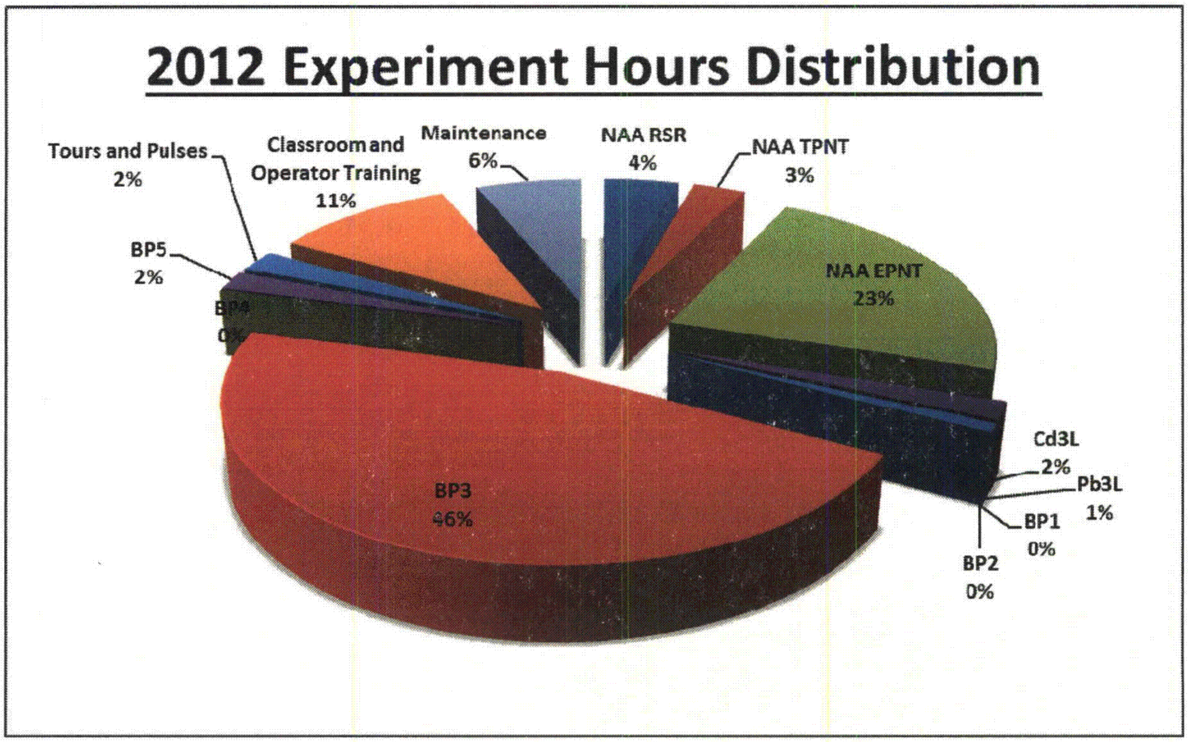


Figure 5-1, Utilization of Experiment Hours

Table 5.1

Terminology for Figure 5-1	
PGNAA	Prompt Gamma Neutron Activation Analysis
Pb3L	Sample material irradiated in the lead-lined (enhanced for lower gamma) 3-element position in-core facility (isotope production)
Cd3L	Sample material irradiated in the cadmium-lined (enhanced for epithermal neutrons) 3-element position in-core facility (generally used for NAA)
NAA EPTNT	Neutron Activation Analysis for samples irradiated in epithermal neutron pneumatic tube (irradiation position lined with cadmium)
NAA TPNT	Neutron Activation Analysis for samples irradiated in thermal neutron pneumatic tube
NAA RSR	Neutron Activation Analysis for samples irradiated in rotary specimen rack
Tour	General facility tours
Classes	Academic support (*ME337, ME361, ME388, ME389N, Health Physics, Summer Nuclear Engineering Institute*)
Training	Operations supporting reactor operator training or requalification program
Pulse	Time required to support approximately 36 pulses
Radiography	Neutron radiography

5.8 Nuclear Program Faculty Activities

Projects and publications associate with the NETL during 2012 are provided below.

Table 5.4, Publications - 2012

CA Rios Perez, SR Biegalski, MR Deinert, "Methodology for using prompt gamma activation analysis to measure the binary diffusion coefficient of a gas in a porous medium," Nuclear Instruments and Methods: B, 293, 21-25, 2012.
S.R. Biegalski, TW Bowyer, P Eslinger, JA Friese, LR Greenwood, DA Haas, JC Hayes, I. Hoffman, M Keillor, HS Miley, M. Moring, "Analysis of Data from Sensitive U.S. Monitoring Stations for the Fukushima Daiichi Nuclear Reactor Accident," Journal of Environmental Radioactivity, 114, 15-21, 2012.
C. Rios Perez, J. Lowrey, S. Bieglski, M. Deinert, "Xenon Diffusion Studies with Prompt Gamma Activation Analysis," Journal of Radioanalytical and Nuclear Chemistry, 291(1), 261-265, 2012.
C. Egnatuk, J. Lowrey, S. R. Biegalski, D. Haas, J. Orrell, V. Woods, M. Keillor, "Production of 47Ar in the University of Texas TRIGA Reactor Facility," Journal of Radioanalytical and Nuclear Chemistry,291(1), 257-260, 2012.
J. Lowrey, S. Biegalski, "Comparison of Least-Squares vs. Maximum Likelihood Estimation for Standard Spectrum Technique of b-g Coincidence Spectrum Analysis," Nuclear Instruments and Methods: B, 270(1), pp. 116-119, 2012.
C. Egnatuk, S. Biegalski, "Production of 37Ar through the Irradiation of Ca-Containing Compounds," Transactions of the American Nuclear Society, Vol. 106, 2012.
M. Deinert, Los Alamos National Laboratory, December 13, 2012. Transport processes and the detection of clandestine nuclear materials and tests
M. Deinert, American Society of Mechanical Engineers International Mechanical Engineering Congress and Exposition, November 11-15, 2012, Houston, TX. Traveling wave reactors, the future of sustainable nuclear power?
M. Deinert, American Nuclear Society Annual Meeting, November 11-15, 2012, San Diego, CA. Velocity of a fission front in a traveling wave reactor
M. Deinert, American Nuclear Society Annual Meeting, June 24-28, 2012, Chicago, IL. Increasing Inert Matrix Fuel Burnup
M. Deinert, Society of Industrial and Applied Mathematics Conference on Non-Linear Waves and Coherent Structures, June 13-16, 2012, Seattle, WA. Propagation of a constant velocity fission wave
M. Deinert, Pacific Northwest National Laboratory, June 12, 2012. Advance fuel cycles and reactors for sustainable nuclear power
M. Deinert, Physics of Reactors (Physor) 2012, April 15-20, 2012, Knoxville TN. Axial grading of Inert Matrix Fuels
M. Deinert, Physics of Reactors (Physor) 2012, April 15-20, 2012, Knoxville TN. Neutron damage reduction in a traveling wave reactor
M. Deinert, MARC 2012, March 27, 2012, Kona Hawaii. Differential transport of Noble gases in porous media and its effect on isotopic ratios
American Society of Mechanical Engineers International Mechanical Engineering Congress and Exposition, Houston, November 11-15, 2012. Performance of inert matrix fuel for actinide transmutation. GD Recketenwald, MR Deinert.
American Society of Mechanical Engineers International Mechanical Engineering Congress

and Exposition, Houston, November 11-15, 2012. A simple model for the intensity and angular distribution of radiation transmitted through clouds. GD Recketenwald, MR Deinert
American Society of Mechanical Engineers International Mechanical Engineering Congress and Exposition, Houston, November 11-15, 2012. Measuring diffusion coefficients for Noble gasses through a geological medium using prompt gamma activation analysis. CR Perez, MR Deinert
TFS/NRE student seminar series. March 29, 2012. Study of xenon diffusion on a Comprehensive Nuclear-Test-Ban Treaty frame using prompt gamma activation analysis. CR Perez, MR Deinert
American Society of Mechanical Engineers International Mechanical Engineering Congress and Exposition, Houston, November 11-15, 2012. Scale effects in the latent heat of liquid-solid phase transitions. J-H Shin, MR Deinert
American Society of Mechanical Engineers International Mechanical Engineering Congress and Exposition, Houston, November 11-15, 2012. How Dynamic Cloud Cover Affects the Performance of Solar Power Facilities. BL Stoll, MR Deinert
TFS/NRE student seminar series. March 29, 2012. How dynamic cloud cover affects the performance of solar power facilities. BL Stoll, MR Deinert
Recktenwald, GD, MR Deinert (2012): Cost probability analysis of reprocessing spent nuclear fuel. Energy Economics, 34, 1873-1881
Osborne, A, GD Recktenwald, MR Deinert (2012): Propagation of a solitary fission wave. Chaos, 22, 0231480
Osborne, AG, GD Recktenwald, MR Deinert (2012): Propagation velocity of a fission front in a traveling wave reactor. Transactions of the American Nuclear Society, Vol. 107
Recktenwald, GD, MR Deinert (2012): Increasing Inert Matrix Fuel Burnup. Transactions of the American Nuclear Society, Vol. 106
Osborne, AG, MR Deinert (2012): Neutron damage reduction in a traveling wave reactor. Proceedings of Physor 2012, Knoxville, TN, April 15-20, 2012
Recktenwald, GD, MR Deinert (2012): Axial grading of Inert Matrix Fuel. Proceedings of Physor 2012, Knoxville, TN, April 15-20, 2012

6.0 FACILITY OPERATING SUMMARIES

6.1 Operating Experience

The UT-TRIGA reactor operated for 1160 hours on 215 days in 2012, producing a total energy output of 591.8 MW-hrs. The history of operations over the past seventeen years of facility operation is provided in Figures 6-1 and 6-2. As illustrated, operating time has shown a marked increase from the first several years and has been relatively stable for the past decade. Varying research requirements over the past few years have led to a decrease in total energy generation.

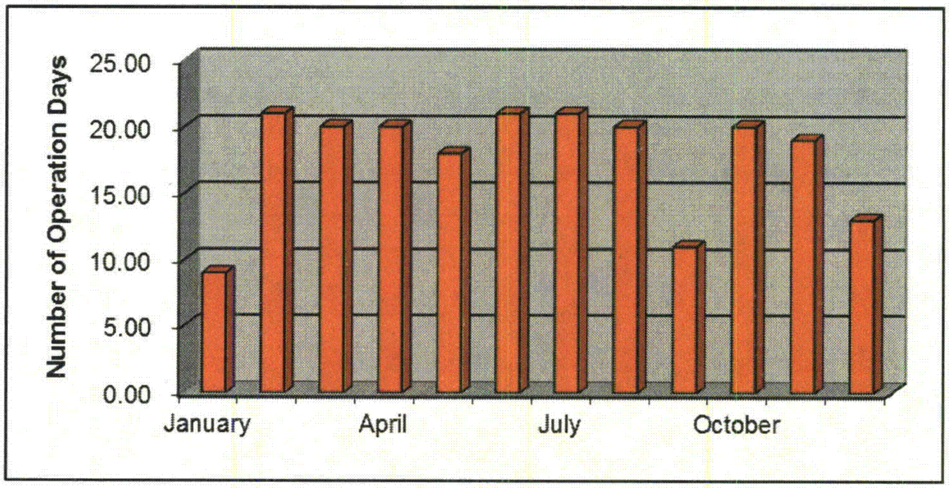


Figure 6-1, Days of Operation

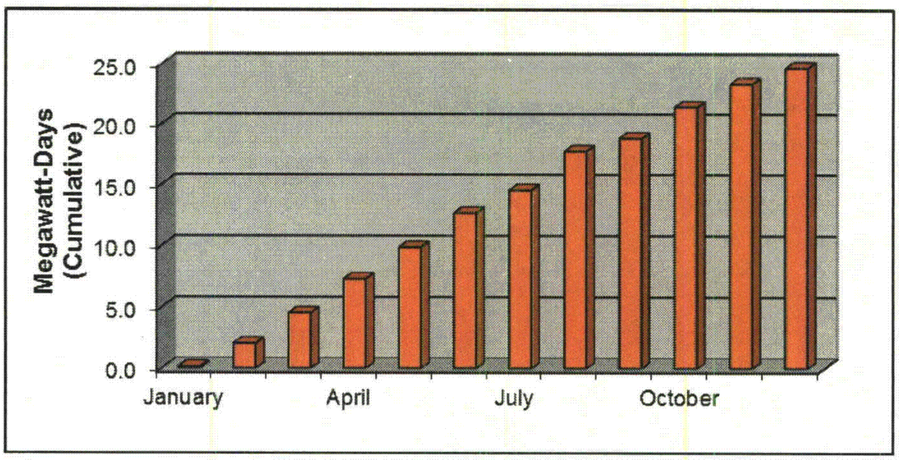


Figure 6-2, Energy Generation

6.2 Unscheduled Shutdowns

Reactor safety system protective actions are classified as limiting safety system (LSSS) trip, a limiting condition for operation (LCO) trip or a trip of the SCRAM manual switch. The use of the manual scram switch in normal reactor shutdowns is not a protective action. The following definitions in Table 6.1 classify the types of protective actions recorded.

Table 6.1, Protective Action Definitions

Protective Action	Description
Safety System Setting LSSS	Automatic shutdown actuated by detection of limiting safety system setting such as fuel temperature or percent power
Condition for Operation LCO - (analog detection)	Automatic shutdown actuated detection of a limiting condition for operation within a safety channel or the instrument control and safety system such as pool water level, a loss of detector high voltage or an external circuit trip
Condition for Operation LCO - (digital detection)	Automatic shutdown actuated by software action detecting inoperable conditions within a program function of the instrument control and safety system such as watchdog timers or program database errors
Manual Switch (protective action)	Manually initiated emergency shutdown

Table 6.2 lists 12 unscheduled shutdowns that occurred in 2012, all of which were initiated by the reactor safety system.

Table 6.2, SCRAM Log for 2012

Date	Time	Type	Comments
02/09/2012	14:26	SCRAM FT1	Thermocouple Intermittent Failure
02/22/2012	16:22	SCRAM KEY OFF	Spurious Intermittent Key Contact Break
02/23/2012	13:45	SCRAM KEY OFF	Spurious Intermittent Key Contact Break
03/02/2012	08:46	SCRAM KEY OFF	Spurious Intermittent Key Contact Break
03/02/2012	08:49	SCRAM KEY OFF	Spurious Intermittent Key Contact Break
03/02/2012	08:54	SCRAM KEY OFF	Spurious Intermittent Key Contact Break
03/26/2012	14:39	SCRAM FT1	Thermocouple Intermittent Failure
04/02/2012	13:56	SCRAM FT1	Thermocouple Intermittent Failure
06/15/2012	11:36	SCRAM FT1	Thermocouple Intermittent Failure
09/28/2012	11:23	SCRAM OP ERROR	Power Fluctuations in Auto Operation Mode
11/02/2012	14:30	SCRAM OP ERROR	Operator Error in Pulse Operation
11/20/2012	09:38	SCRAM OP ERROR	Power Fluctuations in Auto Operation Mode

The five key off scrams were the major contributor to the safety system scrams that took place in 2012. In all the instances the Key-Off Scrams occurred due to potential intermittent contact continuity issues between the reactor key and its slot. Due to the intermittent behavior of the contact, it was attributed to potential oxidation at the contact point. However, the symptoms stopped following more usage. Attempts to recreate the failure have not been successful. The failure mode is conservative and acceptable until the channel fails in a more consistent mode.

There were four temperature channel trips related to thermocouple intermittent. In all cases, time dependent data indicates fuel temperatures were normal and the trips occurred because of signal transients not indicative of actual fuel temperature. Attempts to isolate the trip to a specific component or recreate the failure have not been successful. The failure mode is conservative and acceptable until either the channel fails in a more consistent mode or the characteristics leading to the actuations can be identified.

Power level monitoring signals during steady state operations fluctuate because the digital power level monitoring has some intrinsic noise related to signal sampling and analysis. Three reactor trips occurred as transient fluctuations during high power operations exceeded the steady state power level trip point. Safety analyses demonstrate transients (pulses) to orders of magnitude greater than the steady state power level limit do not result in unacceptable consequences, and these trips are not a safety issue.

6.3 Utilization

Utilization of the NETL reactor facility is near the maximum possible under a 5-day per week schedule. The main categories of facility utilization include education, undergraduate research, graduate research, and external research collaborations. Fig. 6-3 provides a representation of the facility research with these categories. Table 6.3 list the external research collaborations at NETL since 2009. Facility usage is largely dominated by the use of nuclear analytical techniques for sample analysis. These techniques include neutron activation analysis, neutron radiography, neutron depth profiling, and prompt gamma activation analysis.

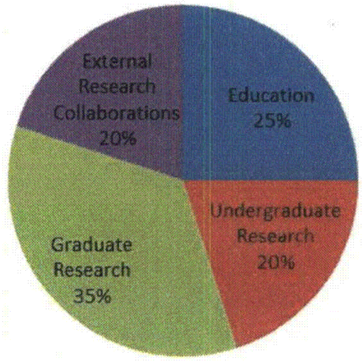


Figure 6-3, Facility Utilization

Table 6.3, NETL External Research Collaborations since 2009

External Collaborator	Location	Facility Utilization
Trinitek Services, Inc.	Sandia Park, NM	Soil sample analysis
Environment Canada	Gatineau, Quebec, Canada	Arctic air filter analysis
Bridgeport Instruments	Austin, TX	Radiation detector development
Carollo Engineering	Austin, TX	Radiation damage studies
Evergreen Solar	Marlboro, MA	Silicon wafer trace element analysis
Kaizen Innovations	Georgetown, TX	Soil sample analysis
Idaho National Laboratory	Idaho Falls, ID	Isotope production
Illinois State Geological Survey	Champaign, IL	Water sample analysis
UT Biology	Austin, TX	Soil sample analysis
Department of Geological Sciences	Austin, TX	Geological sample irradiation
Los Alamos National Laboratory	Los Alamos, NM	Sample irradiations
LoIodine, LLC	Jersey City, NJ	Nut Analysis
UT Health Science Center	Houston, TX	Nanoparticle analysis
Pacific Northwest National Laboratory	Richland, WA	Isotope Production
RMT, Inc.	Madison, WI	Water sample analysis
Signature Science	Austin, TX	Material irradiations and shrapnel analysis
Biomedical Engineering Department	Austin, TX	Tissue sample analysis
Southwestern University	Georgetown, TX	Plant sample analysis and student laboratories
Comprehensive Nuclear-Test-Ban Treaty Organization	Vienna, Austria	Radioxenon production
Clarkson University	Potsdam, NY	Air filter analysis
JWK Corporation	Annandale, VA	Sample irradiations
Civil and Environmental Engineering Department	Austin, TX	Fly ask sample analysis

Table 6.3, NETL External Research Collaborations since 2009

External Collaborator	Location	Facility Utilization
National Center for Energy, Science and Nuclear Technologies	Rabat, Morocco	Soil sample analysis
Nanospectra Biosciences, Inc.	Houston, TX	Tissue sample analysis
U.S. Nuclear Regulatory Commission	Rockville, MD	Reactor operations training
NTS	Albuquerque, NM	Isotope production
Omaha Public Power District	Blair, NE	Boral coupon analysis
TEKLAB	Collinsville, IL	Water sample analysis
XIA	Hayward, CA	Radioxenon production
Lawrence Livermore National Laboratory	Livermore, CA	Isotope production

Various activation and analysis services were carried out in support of the overall UT mission and for public service. Analytical service work was performed for outside agencies. Over 3200 samples were irradiated during 2011, fairly consistent with previous years of NETL operations as illustrated in Figure 6-4.

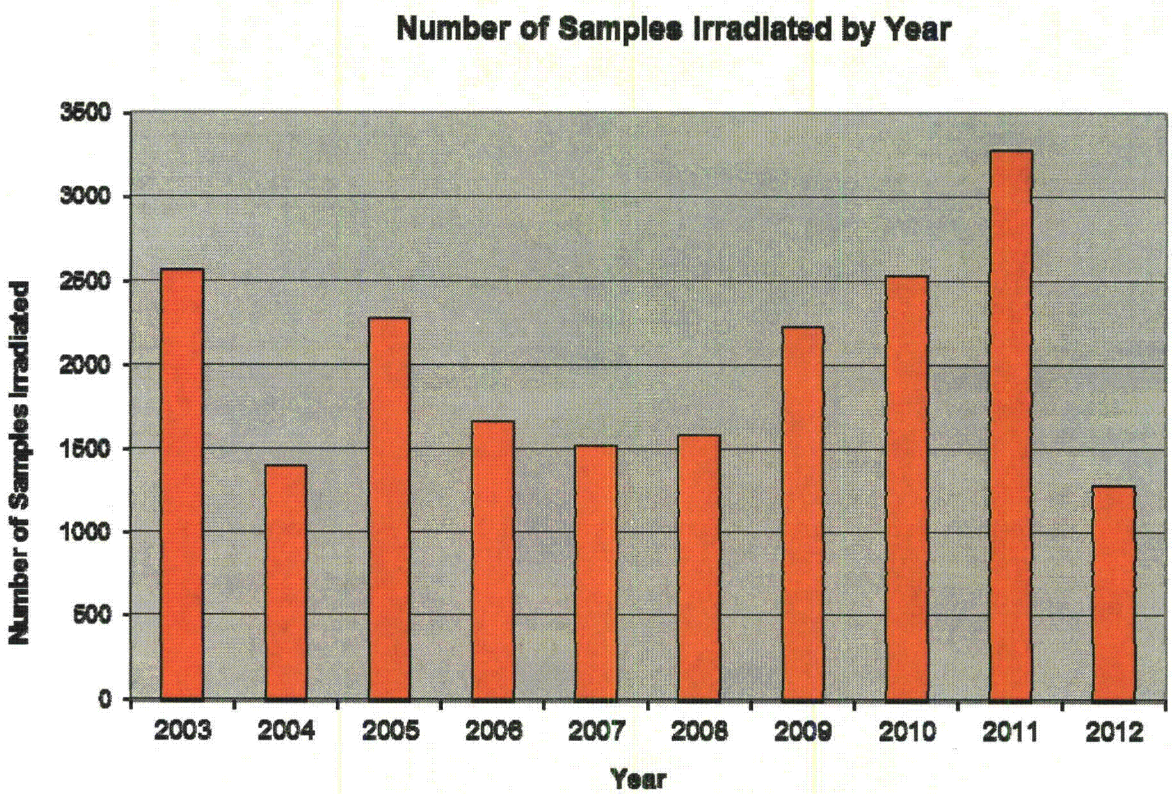


Figure 6-4, NETL Sample Activation

6.4 Routine Scheduled Maintenance

All surveillances and scheduled maintenance activities were completed during the reporting year at the required frequencies. All results met or exceeded the requirements of the Technical Specifications.

6.5 Corrective Maintenance

Activities this reporting period predominately consisted of adjustment of instrument system components (potentiometers or digital system constants) to re-tune or recalibrate the circuits to recommended levels. Corrective maintenance activities included the replacement of individual components or assemblies with like or similar replacement parts. The following list is a summary of the corrective maintenance activities accomplished by facility staff:

- Replacement of burnt out indicator lamps in radiation monitoring systems from an incandescent lamp to an LED.
- Adjustment of NM1000 Startup Fission Chamber cable shield ground.
- Replacement of Argon CAM reading meter from paper to digital record and indication
- Replacement of a cracked fitting to the pool water Purification Pump conductivity sensor
- Replacement of control console video/computer monitors.
- Replacement of malfunctioning Action Pak in DAC

6.6 Facility Changes

During the 2012 calendar year changes in in facility staffing included termination of two Senior Reactor Operator (SRO) Licenses. Additionally there were two new operator licenses issued by the NRC, one of which was a SRO License. Facility modifications and procedures changes are described below.

6.6.1 Staff changes:

There were two Senior Reactor Operator Licenses terminated during 2012, both of whom graduated the University of Texas at Austin and left to further their careers'. Two reactor operator licenses were granted to undergraduate students (one of which was an SRO License)

6.6.2 Facility changes

During 2012 enhancements to the existing facility access control and security monitoring systems supported by the Global Threat Reduction Initiative (DOE/NNSA) was done. Facility modifications included the upgrading and addition of security systems for the reactor facility.

6.6.3 Procedure revision/updates

Several minor procedure revisions were made in 2012 and one new procedure change was proposed. Minor revisions were made in MAIN-5, OPER-2 and PLAN-E. These changes were made to clarify some wording and better explain the reasoning for procedures, without changing the procedures intent.

Pending procedure updates include revision of security procedures based on NRC rulemaking in 10CFR73, and changes to HP procedures. Additional changes pending include changes resulting from requested but not yet approved Technical Specification amendments.

6.6.4 Facility Changes Accomplished in Accordance with Other Regulatory Requirements:

There were no changes the license, or Technical Specifications.

Proposed or Pending Changes:

- Some Technical Specifications and license changes have been proposed and submitted to the USRNC for final review and approval, including:
  - i. A set of changes for clarification and correction of terminology,
  - ii. A request for a license amendment/revision to permit byproduct and source material under the control and used by the reactor facility to support reactor operations to be controlled under the reactor license,
  - iii. A request to define initial startup, and
  - iv. A request to require an operator at the controls when the reactor is not secured (currently required when the reactor is shutdown).
- A request for renewal of the facility operating license was made, with notification by the USNRC that the UT facility meets requirements for operation under "timely renewal."

6.7 Oversight & 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 on the dates listed in Table 6.4.

Table 6.4, Reactor Oversight Committee Reviews

First Quarter	April 18, 2012
Second Quarter	None
Third Quarter	None
Fourth Quarter	November 28, 2012

No recommendations were identified by the Committee.

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 State Health Services (TDSHS) Radiation Control Program. An NRC inspection was conducted as indicated in Table 6.4. No findings of significance were identified. Table 6.4, License Inspections at the NETL

Table 6.5, License Inspections

License	Dates
R-129	None
R-129	None
SNM-180	None
L00485 (81)	27 march 2012

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.

Table 6.6, Other Oversight Inspections

Function	Dates
FAA inspection for hazmat shipping	12 January 2012
USDA inspection for Regulated Soils Permit	16 October 2012

7.0 RADIOLOGICAL SUMMARY

7.1 Summary of Radiological Exposures

The 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 as indicated in Table 7.1. Site area measurements include exterior points adjacent to and distant from the building.

Table 7.1, 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 & interior area monitoring dosimeters. Review dosimetry reports. Response check emergency locker portable rad. measuring equipment. Review Radiation Work Permits. Response check of the argon monitor. Response check hand and foot monitor. 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, provide HP for maintenance operations. Conduct orientations and training.
Quarterly	Exchange OSL 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, area rad. 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

7.2 Summary of Radioactive Effluents

The radioactive effluent paths are ventilation for air-borne radionuclides, and the sanitary sewer system for liquid radionuclides. The most significant airborne radionuclide effluent is 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 during normal operations.

7.2.1 Released

There were no releases of solid radioactive materials during calendar year 2011. A small quantity of radioactive waste is stored for decay or aggregation for a shipment. A small amount of liquid radioactive waste was transferred to OEHS for consolidation and disposal with other university radioactive waste.

7.2.2 Discharged

Airborne Releases. A differential pressure control system in the facility assures airborne radioactive releases are controlled. The reactor room is ventilated by a general area system, and a sub-system to collect and discharge argon 41 generated from routine reactor operations. There were 6.79×10^{6} µCi of argon 41 discharged during calendar year 2012, with the annual average release 3% of the value permitted by Technical Specifications.

Liquid Discharges. There are no routine releases from the facility associated with reactor operation. Large liquid-volume radioactive waste is captured in holding tanks, where liquid radioactive waste may be held for decay or processed to remove the radioactive contaminants as appropriate. To date no discharges have occurred.

Small quantities of liquid scintillation cocktail or dilute concentrations below the limits of 10 CFR 20 in the NETL laboratories may be disposed directly to the sanitary sewer. Liquid disposals are infrequent.

7.3 Radiation Exposure Received by Facility Personnel and Visitors

For calendar year 2012, no facility personnel received radiation exposures in excess of 25% of the allowed limit. Similarly, no visitors to the facility received in excess of 25% of the allowed limit.

7.4 Environmental Surveys Performed Outside the Facility

NETL monitors exterior locations indicated as positions 1 through 6 on the exterior dosimeter map. During 2012, the dosimeter vendor used by NETL went through an extensive upgrade of their processing system. Apparently due to the changes in progress throughout the year, the NETL environmental dosimeters experienced processing issues. The first quarter dosimeters were processed using a control value of 6 mrem per month (3 months of actual exposure time plus approximately 2 weeks of transit time for shipping prior to and after the exposure period for a total of approximately 4 months or 24 mrem) without using the actual control badge value (41 mrem). The reported doses for positions 1, 4, and 6 were "minimal" (< 1 mrem), positions 3 and 5 were 2 mrem, and position 2 was 4 mrem. Had the actual control dose been used, all positions would have been minimal. For the second quarter, no control value was used and thus no background was subtracted. The actual control value was 55 mrem. Reported doses for all the positions ranged from 20 to 26 mrem. Again, had the actual control value been used, all positions would have been minimal. For the third quarter, the actual control value was used and all positions were reported as minimal dose. For the fourth quarter, an "average control value" of 25 mrem was used instead of the actual control value of 70 mrem. The reported doses for all the positions ranged from 2 to 7 mrem. Again, had the actual control value been used, all positions would have been minimal. NETL continues to work with the vendor to reach a consistent and reliable approach to processing the environmental dosimeters.

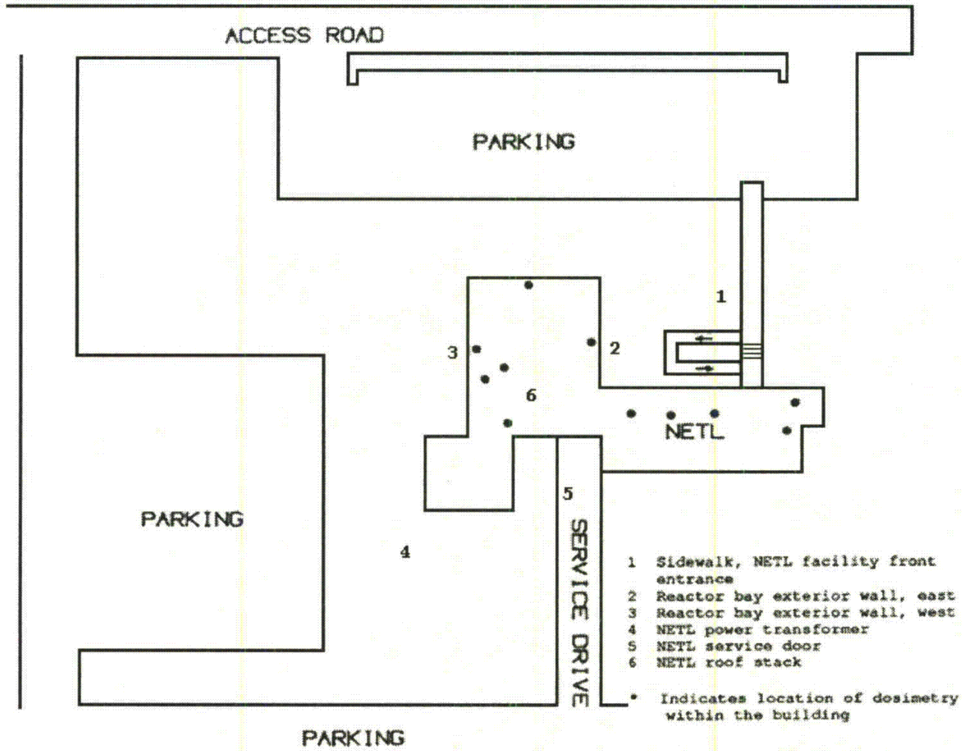
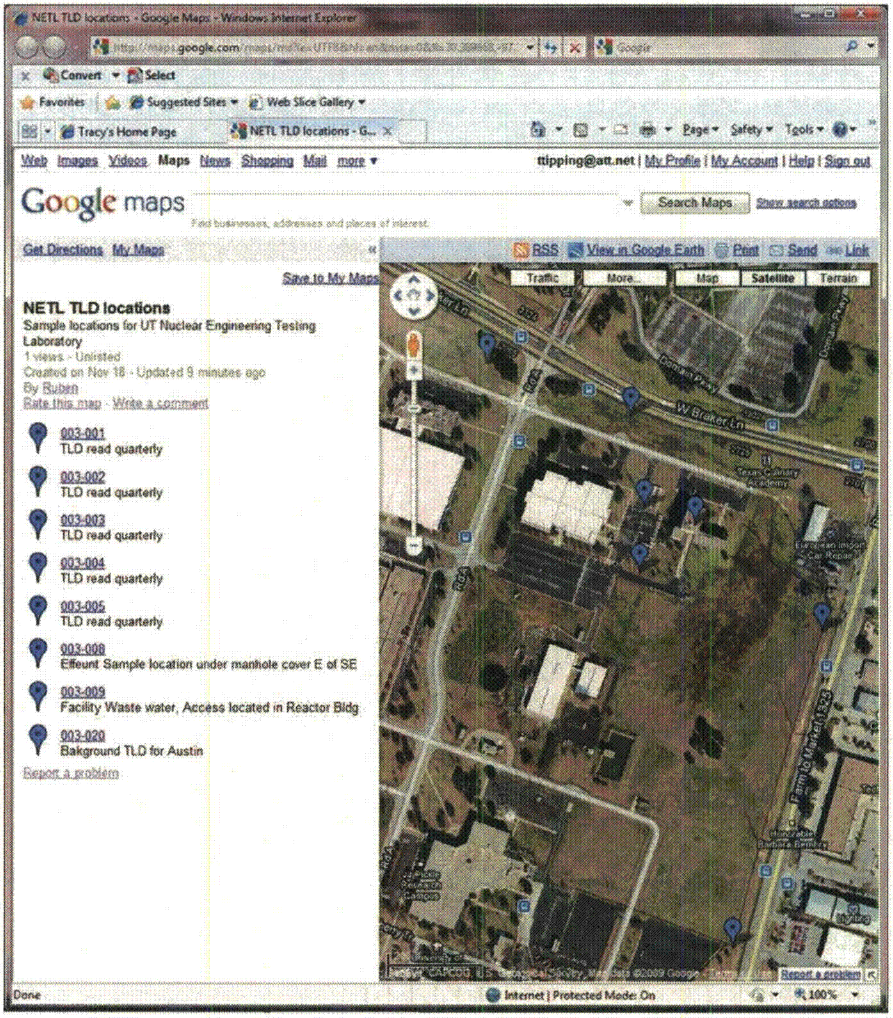


Figure 7-1, NETL Environmental Monitor Locations

In addition to the NETL monitors, the Texas Department of State Health Services monitors exterior locations near NETL indicated as positions 1 through 5 on the TDSHS TLD map. The only report received in 2012 was for the second quarter in which a dose of 0 mrem was reported for all positions. In January 2013, TDSHS notified NETL that at the beginning of 2012, they had switched from an in-house dosimetry program to an external dosimetry vendor (the same vendor used by NETL) and they were experiencing significant issues with how results were to be interpreted. They hoped to provide monitoring results once they worked through the issues. As yet, no additional reports have been received.


NETL TLD locations - Google Maps - Windows Internet Explorer
Google maps
Search Maps
Get Directions My Maps
Save to My Maps
NETL TLD locations
Sample locations for UT Nuclear Engineering Testing Laboratory
1 views - Unlisted
Created on Nov 18 - Updated 9 minutes ago
By Ruben
Rate this map - Write a comment
003-001
TLD read quarterly
003-002
TLD read quarterly
003-003
TLD read quarterly
003-004
TLD read quarterly
003-005
TLD read quarterly
003-008
Effeunt Sample location under manhole cover E of SE
003-009
Facility Waste water, Access located in Reactor Bldg
003-020
Bakground TLD for Austin
Report a problem
Traffic
More...
Map
Satellite
Terrain
W Braker Ln
Texas Culinary Academy
European Import Car Repair
Farm to Market 1325
Done
Internet | Protected Mode: On
100%