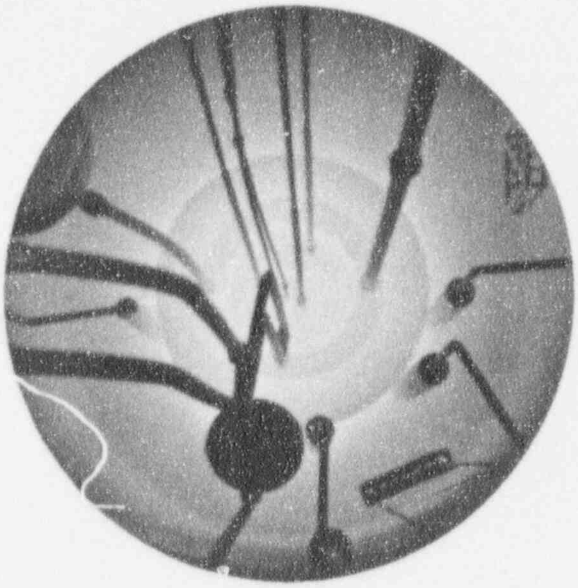

NUCLEAR REACTOR LABORATORY

TECHNICAL REPORT

THE UNIVERSITY OF TEXAS

COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Annual Report

1992

Nuclear Engineering Teaching
Laboratory

Balcones Research Center

The University of Texas at Austin

Figure

List of Tables

Table

EXECUTIVE SUMMARY

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

1. preserve disseminate, and create knowledge,
2. help educate those who will serve in the rebirth of nuclear power and in the expanding use of nuclear technology in industry and medicine,
3. provide specialized nuclear resources for educational, industrial, medical, and government organizations.

The above objectives are achieved by carrying out a well-balanced program of education, research, and service. the focus of all of these activities is the new TRIGA research reactor, the first new U.S. university reactor in 18 years.

The UT-TRIGA research reactor supports hands-on education in reactor physics and nuclear science. In addition, the reactor can be used in laboratory course work by students in non-nuclear fields such as physics, chemistry, and biology. It may also be used in education programs for nuclear power plant personnel, secondary schools students and teachers, and the general public.

The UT-TRIGA research reactor provides opportunities to do research in nuclear science and engineering. It can also contribute to multidisiplinary studies in medicine, epidemiology, environmental sciences, geology, archeology, paleontology, etc. Research reactors, one megawatt and larger, constitute unique and essential research tools for examining the structure of crystals, magnetic materials, polymers, biological molecules, etc.

The UT-TRIGA research reactor benefits a wide range of on-campus and off-campus clientele, 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.

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 facility. A TRIGA nuclear reactor is the primary piece of equipment at the facility. The reactor operates at power levels up to 1100 kilowatts or with pulse reactivity insertions up to 2.2% $\Delta k/k$.

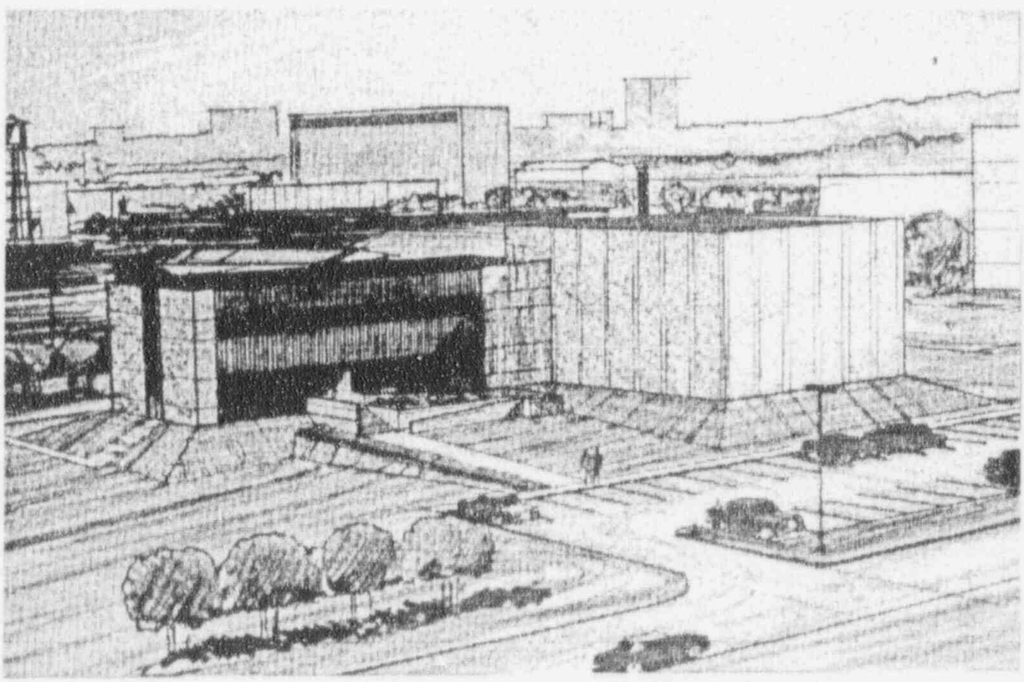

Figure 1-1 NETL - Nuclear Engineering Teaching Laboratory

The report also satisfies requirements of the University Fuel Assistance Program, U.S. Department of Energy (DOE) [contract number DE-AC07-ER03919, Amendment A015], and the licensing agency, the U.S. Nuclear Regulatory Commission (NRC) [docket number 50-602]. This report covers the period from January 1, 1992 to December 31, 1992.

Availability of the Facility

The NETL facility serves a multipurpose role beyond the research of facility faculty, staff and students. Use of NETL by faculty, staff and students in the College of Engineering is the facility's primary function. However, a supplemental goal of the facility is the development and application of nuclear methods to assist the research of university, industry, government and other researchers.

NETL provides services to industry, government and other laboratories for the testing and evaluation of materials. Public education through tours and demonstrations are 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 R-129 a class 104c research reactor license. Another 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 Safety Office.

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. The program installed, operated and dismantled a TRIGA nuclear reactor at a site on the main campus in the engineering building, Taylor Hall. Operating requirements were intermittent from 1963 to 1988, accumulating a total burnup of 26.1 megawatt-days. Reactor initial criticality 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). Pulse capability of the reactor was 1.4% Δk/k with a total of 476 pulses during the operating history. Dismantlement and decommissioning of the facility was completed in December 1992.

Planning for a new facility, which led to the shutdown of the campus facility, began in October 1983, with construction taking from December 1986 to May 1989. The final licensing was issued January 1992 with initial criticality occurring March 1992. The new facility, including support laboratories, administrative offices and the reactor is the central location for all NETL activities. The reactor as the primary piece of equipment operates at power levels up to 1100 kilowatts and pulses to reactivity insertions of 2.2% Δk/k.

1.2 **NETL Building**

Balcones Research Center

The Balcones Research Center (BRC) is a multi discipline research center on 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. Ten separate research units and several academic research programs, including the NETL facility, have research efforts with locations at the research center. 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 at the center. A Commons Building provides cafeteria service, recreation areas, meeting rooms and conference facilities. Access to the NETL site is shown in Figure 1-2.

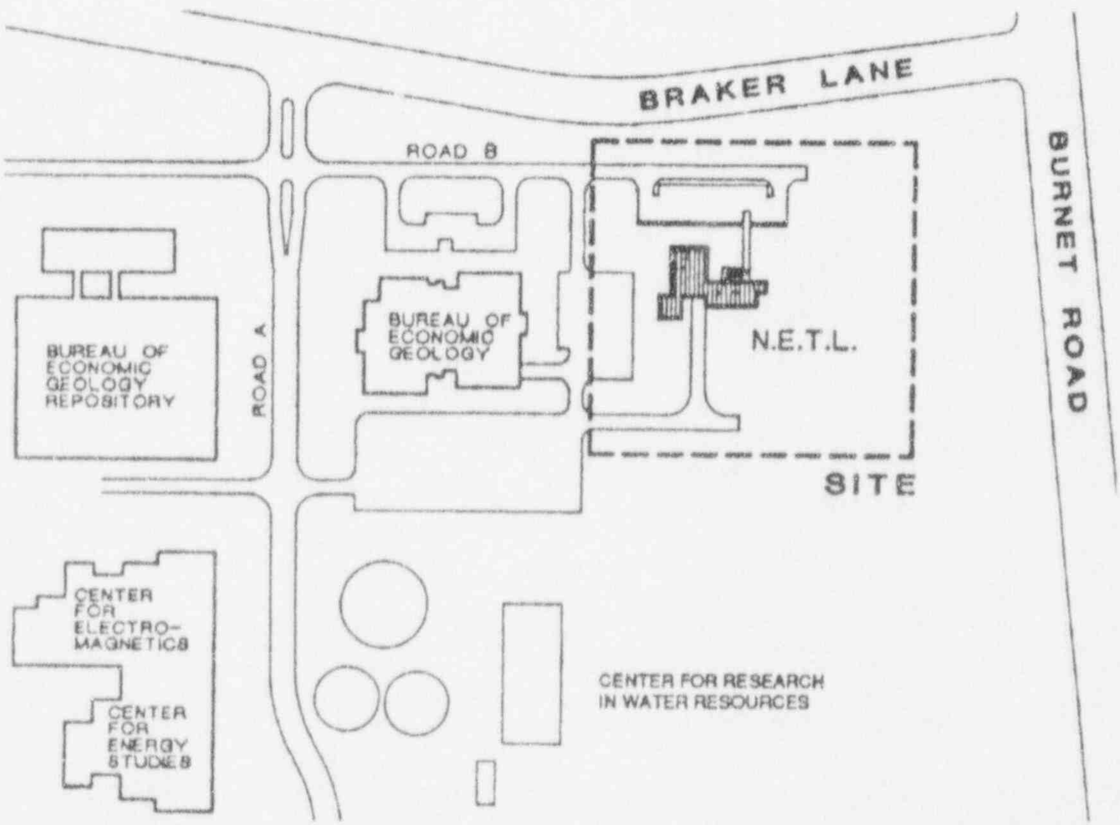

Figure 1-2 NETL Site - Balcones Research Center

NETL Building Description

The NETL building is a 1950 sq. meter (21,000 sq. ft), facility with laboratory and office areas. Building areas consist of two primary laboratories of 330 sq. m (3600 sq. ft) and 80 sq. m (900 sq. ft), 8 support laboratories (217 sq. m, 2340 sq. ft), and 6 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 and shield structure including 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. Figure 1-3 and 1-4 show the building and floor layouts for office and laboratory areas.

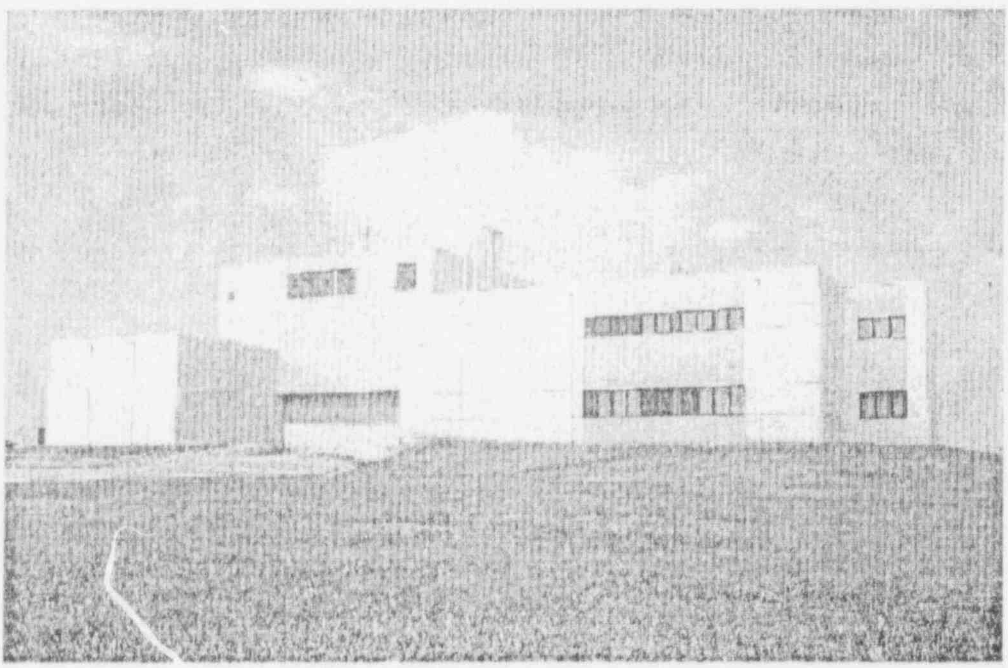

Figure 1-3 NETL Building Profile

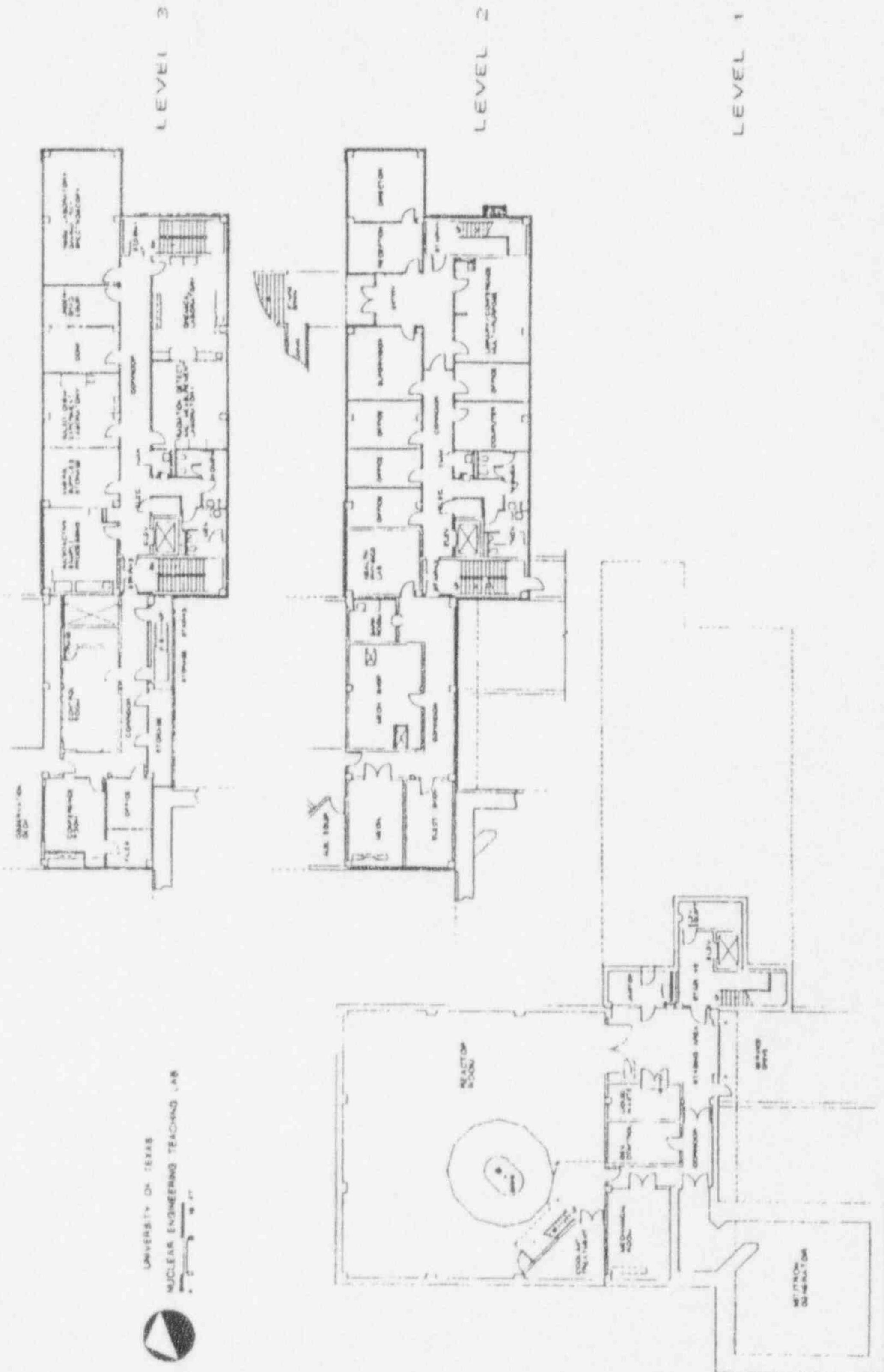

Figure 1-4 NETL Building - Layout

Laboritories, Equipment

The NETL facility makes available several types of radiation facilities and an array of radiation detection equipment. Besides the reactor, facilities include a subcritical assembly, a gamma irradiator, miscellaneous radioisotope sources and one or more radiation producing machines.

The gamma irradiator is a multi curie cobalt-60 source with a design activity of 10,000 curies. Radioisotopes of cobalt-60, cesium-137 and radium-226 are available in millicurie quantities.

Neutron sources of plutonium-beryllium and californium-252 are available. A subcritical assembly of 20% enriched uranium in a polyethylene moderated cylinder provides an experiment device for laboratory demonstrations of neutron multiplication and neutron flux measurements.

Radiation producing equipment such as x-ray units for radiography and density measurements are available as both fixed and portable equipment. 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 a 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 requirements for 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, and General Atomics. Figure 1-5 is a picture of the reactor core structure.

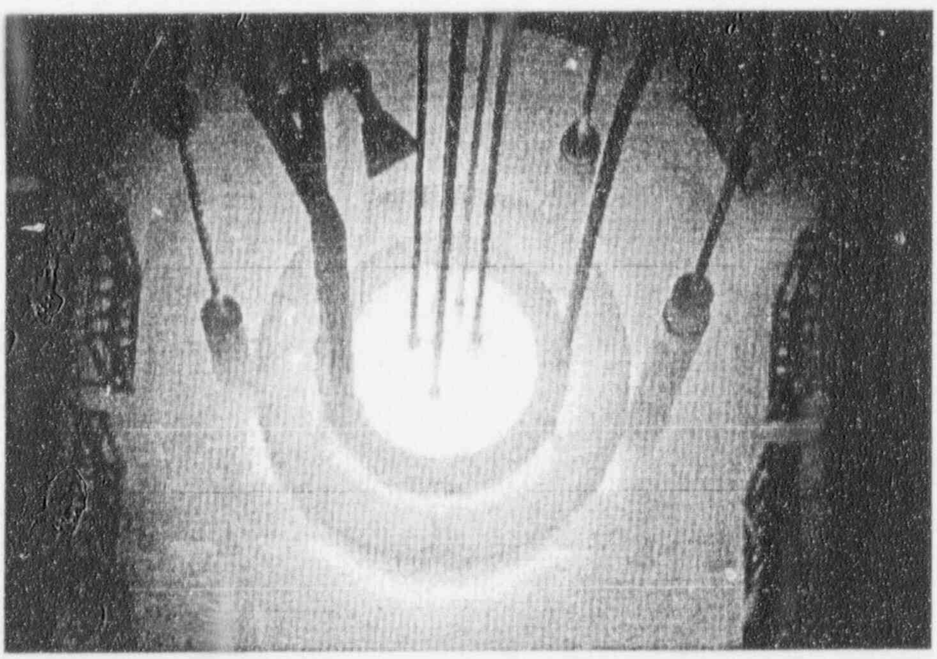

Figure 1-5 TRIGA Reactor Core

Reactor Description

Reactor Operation. The UT-TRIGA research reactor can operate continuously at nominal powers of up to 1 MW or in the pulsing mode where typical peak powers of 1500 MW can be achieved for short times of about 10 msec. The UT-TRIGA with its new digital control system provides a unique facility for performing reactor physics experiments and 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 can 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 rises 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 continual demonstration of this inherent safety feature.

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 (neutron absorber) leaves the core and UZrH (fuel) enters the core, increasing power. The fourth control rod, the transient rod, is a solid cylinder of borated graphite followed by air, clad in aluminum, and operated by pneumatic pressure to permit pulse operation. The sudden ejection of the transient rod produces an immediate burst of power.

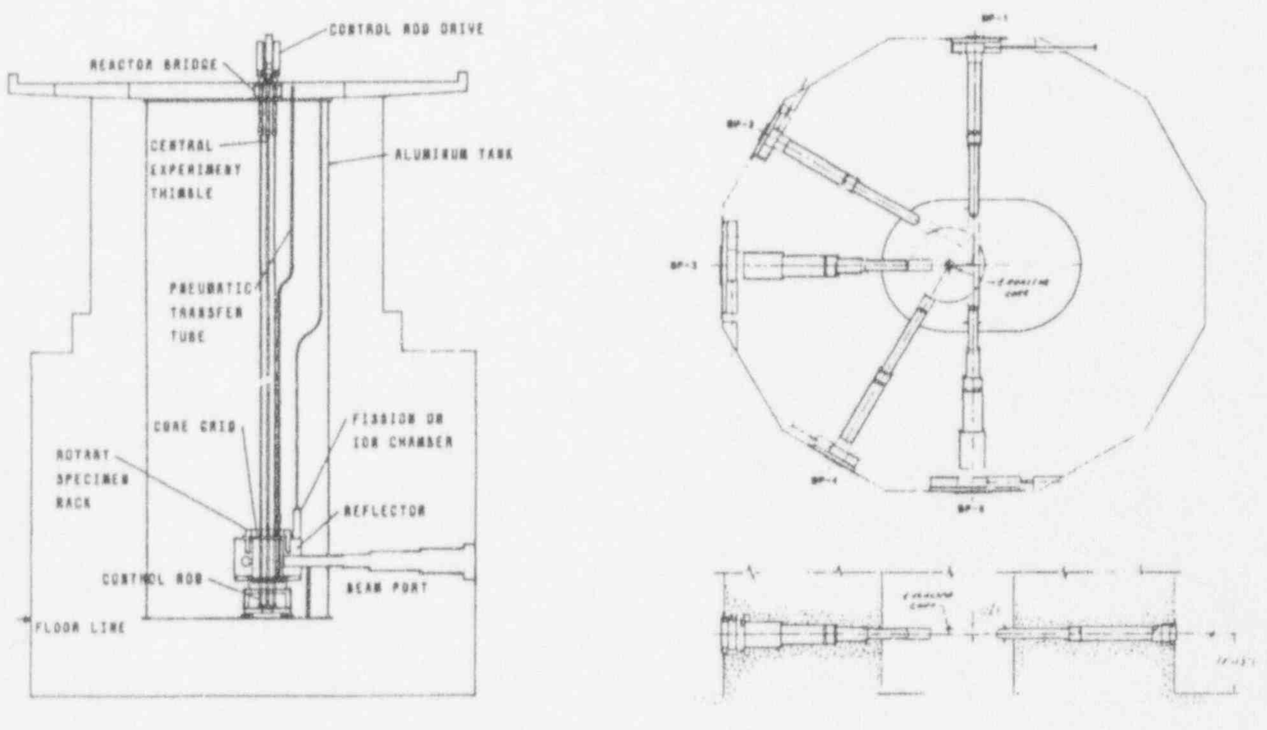

Figure 1-6 Reactor Pool and Beam Ports

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. Table 1-1 lists the workable experiment volumes available in the standard experiment facilities.

Table 1-1
Physical Dimensions of Standard
Experiment Systems

Center Tube		
Length:	15.0 in	38.1 cm
Tube OD:	1.5 in	3.81 cm
Tube ID:	1.33 in	3.88 cm
Rotary Rack		
Length:	10.8 in	27.4 cm
Diameter:	1.23 in	3.18 cm
Pneumatic Tube		
Length:	4.5 in	11.4 cm
Diameter:	0.68 in	1.7 cm

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 the batch production of radioisotopes and for the activation and irradiation of multiple samples. All forty positions in the rack are exposed to neutron fluxes of comparable 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.

Beam Port Facilities

The beam ports penetrate through the concrete shield and the reactor tank water, making beams of neutrons available for a variety of experiments. Five tubular beam ports provide access to the reactor core neutrons. Two beam port categories are defined by the reactor reflector interface.

Penetrating beam ports are the thru port beam ports #1 and #5 and the radial beam port #3. Thru beam ports, beam port BP#1 and BP#5, are connected together to result in one thru tube beam port. These tubes penetrate the concrete shield and are each coupled to opposite ends of a tube extending from the reflector with a flexible bellows. Penetrating Beam Port, BP#3 pierces the graphite reflector and terminates at the inner edge of the reflector. This beam port permits access to a position adjacent to the core.

Two beam ports, non penetrating beam ports #2 and #4, do not provide physical access beyond the reactor reflector interface. BP#2 is oriented tangentially to the outer edge of the core terminating at the outer edge of the reflector. A hole is drilled in the graphite tangential to the outer edge of the core. BP#4 is a radial beam port that terminates at the outer edge of the reflector. A hole is drilled in the graphite radially to the outer edge of the core. Both BP#2 and BP#4 penetrate the concrete shield structure and the reactor water.

The inner section of each beam tube is an aluminum pipe that penetrates the pool wall to the reactor reflector. The outer sections of beam ports BP#1, BP#2 and BP#4 are formed of a stainless steel pipe. Outer sections of the beam ports BP#3 and BP#5 are composed of three sections joined to form a diverging cavity. Neutrons passing through the beam tubes can be defined by using filters, collimators and moderators. Table 1-2 lists the size of each beam port access to the reactor.

Table 1-2
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
At Exit:	8 in	20.32 cm
	10 in	25.40 cm
	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 an NE dissertation committee.

Of the five undergraduate Nuclear Engineering courses and the dozen graduate Nuclear Engineering courses, five 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
Graduate	
ME 388R.3	Kinetics and Dynamics of Nuclear Systems
ME 389R.1	Nuclear Engineering Laboratory
ME 389R.2	Nuclear Analytical measurement Techniques

1.5 **NETL Divisions**

The Nuclear Engineering Teaching Laboratory is under the Department of Mechanical Engineering at The University of Texas. The attached figure shows the staff organization of the Nuclear Engineering Teaching Laboratory. It is based on three divisions, each with a manager and workers. The remaining staff, called the administration, supports the three divisions. Health physics is a support group for all three divisions.

The Operation and Maintenance Division (OMD) is responsible for the safe and effective operations of the TRIGA nuclear reactor. Other duties include maintenance of the 14-MeV neutron facility, the gamma irradiation facility, industrial x-ray units and the NETL computer system. Activities of OMD include neutron and gamma irradiation service, operator/engineering training courses, and giving reactor short courses.

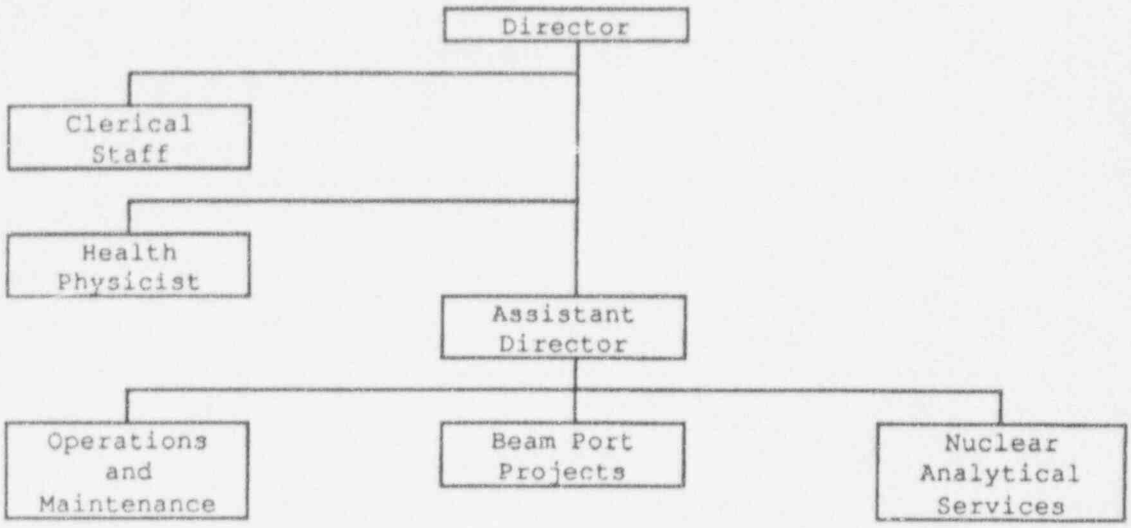

Figure 1-8 NETL Staff Organization

The Nuclear Analytical Services Division (NAS) is responsible for providing, in a safe and effective manner, analytical services such as Neutron Activation Analysis, low level radiation counting, and isotope production. Other service activities of NAS include teaching NAA short courses.

The Neutron Beam Projects Division (NBP) is responsible for the development and operation of experimental projects associated with neutron beam tubes. One permanent facility, a cold neutron source/neutron guide tube facility, is a unique facility for experimenting with low energy neutrons.

Operation and Maintenance Division

The primary purpose of the Operation and Maintenance Division is the routine maintenance and safe operation of the TRIGA Mark II Research Reactor. This division performs most of the work necessary to meet Technical Specifications of the reactor license. Work by the division implements modifications to reactor systems and furnishes design assistance for new experiment systems. The division operates standard reactor experiment facilities.

Other activities of the division include operation and maintenance of radioisotope irradiators, such as the cobalt-60 irradiator, and radiation producing equipment. Radiation producing equipment consists of a 14-MeV neutron generator, and industrial x-ray machines.

Services provided to other divisions at the laboratory include assistance in the areas of initial experiment design, fabrication, and setup. Maintenance and repair support for computer, electronic, and mechanical equipment is provided. Coordination of building systems maintenance is also coordinated by the Operation and Maintenance Division.

Nuclear Analytical Service Division

The main objectives of the nuclear analytical services division include services and education. In the area of services, the division serves the university at large. Elemental measurements using instrumental neutron activation analysis to provide nuclear analytical support for individual projects range 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. Similar services have been made available to different state agencies in order to assist with quality control of sample measurements and evaluation of environmental effects of some toxic elements. In the area of education, the division, with available state-of-the-art equipment, helps stimulate the interest of students about 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.

Radiation measurement systems available include several high purity germanium detectors with relative efficiencies ranging from 20 to 40%. The detectors are coupled to a Vaxstation 3100. 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. The Vaxstation is connected to a campus wide network. This data acquisition and analysis system can be accessable from any terminal on campus and to any user with proper authorization, a modem and the necessary communication software. However, safeguards by special protocols guard against any unauthorized access.

Beam Port Division

The Beam Port Division manages the use of the five beam ports. Experiments at the beam ports may be permanent systems that will function for periods in excess of 1 or 2 years or temporary systems. Temporary systems function once or for a few months, generally requiring removal and replacement as part of the setup and shutdown process. The reactor bay contains floor space for each of the beam ports with available beam paths ranging from 6 meters (20 ft) to 12 meters (40 ft).

The main objective of the neutron beam projects division is to develop and operate experimental research projects associated with the neutron beam tubes. 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 create new funded research programs promoting the capabilities of the neutron beam projects division to academic, government and industrial organizations and/or groups.

Beam port management assists with all phases of a projects, beginning with the proposal, design, proceeding to the fabrication, test, and concluding with the operation, evaluation and dismantlement. Projects to be available at NETL are both traditional, such as neutron radiography, and unique, as is the cold neutron source facility. Two nuclear diagnostic techniques, neutron depth profiling (NDP) and prompt gamma activation analysis (PGAA) are examples of neutron beam port experiment facilities.

Health Physics Group

The Health Physics group is responsible for radiation safety and protection of personnel at the NETL as well as protecting the general public. The laws set down by Federal and State government are maintained and enforced at the facility by various means. Health Physics procedures have been developed that are facility specific to ensure that operation complies with all facets of the regulations. Periodic monitoring for radiation and contamination ensures that the use of the reactor and radioactive nuclides is conducted safely with no hazard to personnel outside of the facility. Personnel exposures are at all times maintained ALARA ("as low as is reasonably achievable") consistent with the mission of the NETL. Collateral duties of the Health Physics group include inventory and monitoring of hazardous materials, and environmental health.

The Health Physics group consists of one full time Health Physicist. The Health Physicist is functionally responsible to the Director 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 ensure 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 equipment currently in use by the Health Physics group is presented in Table 1-4. Other health physics equipment and supplies such as plastic bags, rubber gloves, radiation control signs/ropes are kept available for immediate use.

Table 1-4
Health Physics Survey Equipment

Equipment	Radiation	##
High and low range self-reading pocket dosimeters	gamma	>10
Thin window friskers	alpha/beta/gamma	> 8
Scintillation micro remmeter	low level gamma	1
High range portable ion chamber	beta/gamma	1
BF3 proportional counter	neutron	2
Hand and Foot monitor	beta	1
Low level gas-flow proportional counter	alpha/beta	1
Continuous air particulate monitor	alpha/beta	1
Gaseous Ar-41 effluent monitor	beta	1

The Health Physics Group provides radiation monitoring, personnel exposures, and educational activities. Personnel who are issued permanent dosimeters are required to attend an eight hour course given by the Health Physicist. This course covers basic radiation principles and facility specific procedures and rules. Each trainee is given a guided tour of the facility to familiarize him with emergency equipment and procedures. The group supports University educational activities by assisting with student experiments and projects by demonstrating proper radiation work techniques and controls to the students. The Health Physics group participates in emergency planning between NETL and the City of Austin to provide basic response requirements and radiation training to emergency personnel such as Fire and EMS crews.

2.0 ANNUAL PROGRESS REPORT

2.1 **Faculty, Staff and Students**

Organization. The administrative structure of 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.

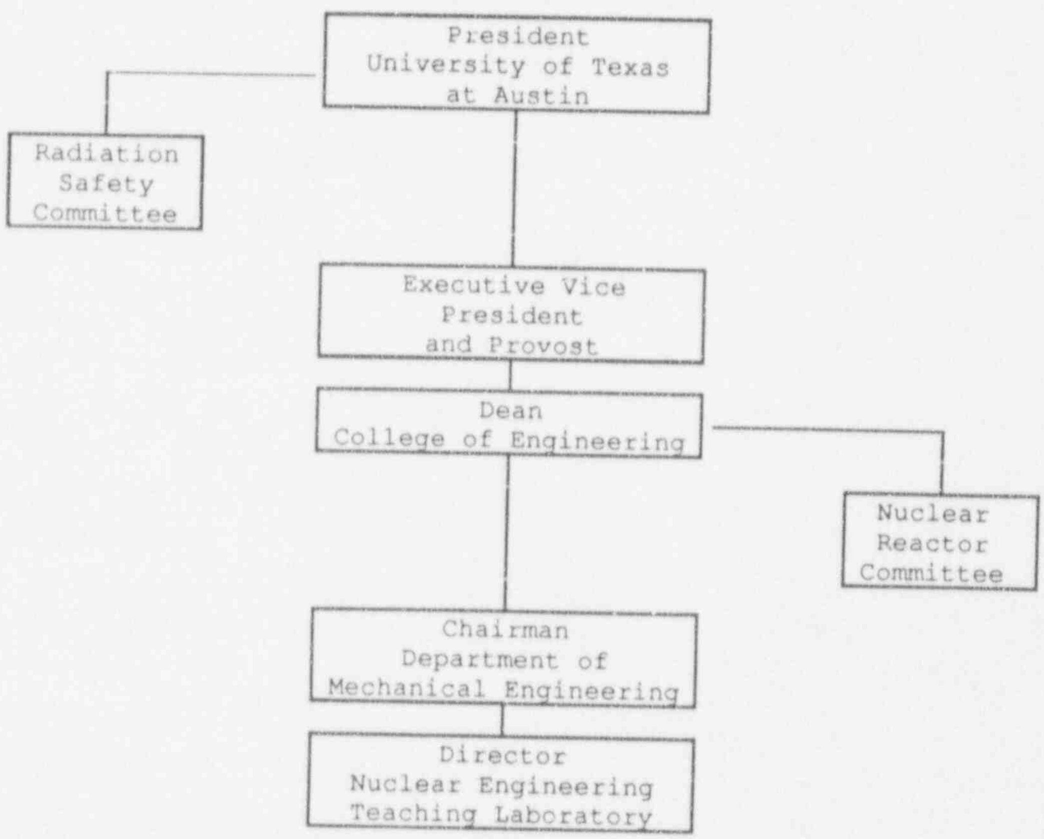

Figure 2-1 - NETL Administrative Structure

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 or 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

Chairman	L.A. Beecherl, Jr.
Vice Chairman	M.E. Ramirez
Vice Chairman	R.J. Cruikshank
Executive Secretary	A.H. Dilly
Chancellor	Hans Mark 1992 William Cunningham Fall 1992-Present

Member 1993	Member 1995	Member 1997
S. Barshop	R.J. Cruikshank	Z.W. Homes, Jr.
L.A. Beecherl	T. Loeffler	B. Rapaport
W.A. Moncrief	M.E. Ramirez	E.C. Temple

Table 2-2
The University of Texas at Austin
Administration

President	William Cunningham
Executive Vice President and Provost	Gerhard Fonken
Dean of College of Engineering	Herbert Woodson
Chairman of Department of Mechanical Engineering	Kenneth Diller

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
Radiation Safety Committee

Chairman	E.L. Sutton
Member	B.W. Wehring
Member	D.E. Klein
Member	B.G. Cook
Member	G. Hoffmann
Member	S.A. Monti
Member	L.O. Morgan
Ex officio member	H.W. Bryant-1992

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

Table 2-4
Nuclear Reactor Committee

Chairman	H. Marcus	Fall 1992
	R. Charbeneau	Fall 1992-Present
Member	B.W. Wehring	
Member	D.E. Klein	
Member	J. Reis	
Member	D. Blackstock	Fall 1992-Present
Student Member	A.B. Preece	January 1993
	R. Canaan	March 1993-Present
Ex officio member	T.L. Bauer	
Ex officio member	H.W. Bryant	1992
	J. White	1993-Present
Ex officio member	K. Diller	

Personnel. Budgeting of NETL funding of the primary staff supports full time positions for a Supervisor/Assistant Director, health physicist, reactor operator and secretary. Other budget support includes funding for two research associates and a part time research assistant or office assistant. Positions for persons in this budget are Managers for the three divisions, Operation and Maintenance, Nuclear Analytical Services, Beam Port Projects and a Senior Administrative Associate.

Personnel associated with the laboratory consist of NETL staff, faculty, students, and certain other university personnel. The personnel involved in the NETL program during the year are summarized in Table 2-5.

Table 2-5
NETL Personnel

NETL Facility Staff	
Director	B.W. Wehring
Assistant Director/Supervisor	T.L. Bauer
Research Scientist/NAA	F.Y. Iskander
Research Scientist/NBP	K. Unlu
Manager of Reactor Operations	M.G. Krause
Health Physicist	J.C. White
Sr. Administrative Associate	J.G. Rawlings
Sr. Office Assistant	M. McGee
Post Doctoral Fellow	T. Emoto
Faculty	
N.E. Hertel	B.V. Koen
D.E. Klein	B.W. Wehring
Student Assistants	
Graduate Level:	
Jong-Youl Kim	Desh Anand
Carlos Rios-Martinez	Mohit Dikshit
Hector Vega Carrillo	
Undergraduate Level:	
Roger Manteufel	William Rosella
Sharla Bertrum-McUne	Ralph Graham
Chris Lindemann	Scott Daniel

Funding. NETL funding is provided by state funds, research contracts and miscellaneous service work. A base budget for the staff, maintenance and operation, and teaching is provided by the state allocations. Research funding supplements the base funds and are provided 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. Table 2-6 lists the current supplemental funds.

Table 2-6
Supplemental Funds

Project Title	Funding Period	Funding Source	Amount
Reactor Sharing	9/30/92-9/29/94	DOE	$ 5,000
Instrumentation for the University of Texas Reactor (III)	9/30/92-9/29/93	DOE	32,937
Study of Neutron Focusing at the Texas Cold Neutron Source	4/15/92-4/14/94	DOE	98,179
An Expert System to Enhance Software Reliability	9/30/91-9/29/92	NRC	49,998
Data System for the University of Texas Reactor	9/10/91-9/9/92	DOE	8,290
Report Analysis for Selenium Quality Assurance	3/6/92-8/31/93	TPW	20,286
Neutron Shielding Analysis	2/1/92-8/31/92	UTHSC-SA	5,114
		Total	219,804

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 a routine activity of NETL staff and students. A typical tour is general presentations 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 886 visitors were given access to the facility during the reporting period. The total includes tour groups, official visitors, and facility maintenance personnel. Tours for 18 groups with an average 24 persons/group were taken through the facility during the reporting period.

Table 2-7
Public Access

Tour Groups	429
Individuals	86
Workers	371
Total	886

Two special group projects by area students were done by arrangement with NETL staff. Another two persons conducted individual projects with NETL staff. Presentations by NETL staff, including demonstrations with laboratory equipment, were given to both girl scout and boy scout organizations. These presentations were done as part of area wide programs sponsored by the scouting organizations.

2.3 *Service and Commercial Activities*

PROJECT: Determination of Selenium and Other Toxic Elements
SPONSOR: Texas Parks And Wildlife Department

Tissue from muscle and liver of fish samples from several Texas lakes are analyzed for selenium, mercury, arsenic, chromium and zinc. These measurements are part of an environmental project for the State of Texas to examine the conditions of waters subjected to certain types of power plant or industrial effluent releases.

PROJECT: Testing of Integrated Radiation Mapper Assembly
SPONSOR: ODETICS

A partnership formed by ODETICS and three nuclear power utilities is addressing this specific area of occupational radiation exposure (ORE) by developing a remote radiation survey system. Initial laboratory testing has successfully demonstrated the operation of the IRMA sensor unit which consists of: a directional radiation detector, an omnidirectional radiation detector, laser rangefinder, a CCD video camera, and pointer laser all mounted on a pan and tilt platform.

Tests of the sensor platform were done in the Radiation Experiment Facility, room 1.102, at NETL. The test uses the radiation detector mounted on a pan and tilt platform with the camera and laser ranger. A computer will be programmed to move the platform under operator control and collect data from the radiation sensor, camera, and laser ranger. These tests were performed using various isotopes including ^{241}Am, ^{137}Cs, and ^{60}Co.

PROJECT: Determination of ^{60}Co and ^{137}Cs in Contaminated Sludge, West Settling Tank, BRC
SPONSOR: Center Of Energy Studies The University Of Texas At Austin

The objective of the project is to determine if the supercritical water oxidation coupled with other conventional treatment technologies is effective in the volume reduction of class A contaminated sludge. The work involves the treatability of a low level radioactive waste containing both ^{60}Co and ^{137}Cs which have an activity of 10-3 µCi, or nearly one hundred times the acceptable limit for placement in municipal landfill.

PROJECT: Determination of Selenium in Fish and Sediments

SPONSOR: Houston Lighting And Power Company

This project is undertaken by Houston Lighting and Power Company to determine the concentration of Se in fish and sediments in lakes around power plants to insure compliance with environmental requirements and regulations.

PROJECT: Determination of Uranium and Thorium in Water Residue

SPONSOR: Radian Corporation, Austin, Texas

The advantages of low detection limit and no sample processing were the important factor in selecting the concentration of uranium and thorium in over 80 samples.

2.4 *Research and Development Projects*

PROJECT: Determination of Toxic and Other Elements in Town Lake Water Shed.

SPONSOR: City Of Austin Environmental And Conservation Services Department

Water samples from several Austin area creeks were collected and the dissolved matter was separated and subjected to instrumental neutron activation analysis to determine the elemental content in these water samples. The project was carried out by students enrolled in chemistry and environmental science class at Austin Community College North Ridge Campus. This project offer a unique education experience to the students.

PROJECT: Determination of Toxic and Other Elements in Walnut Creek and in Sediment Run-off from a Landfill

SPONSOR: Science Academy Of Austin - LBJ High School

High School students from the Science Academy at LBJ High School in Austin collected several water and sediment samples from upstream location, runoff water from the landfill and other locations. Samples are analyzed for the presence of heavy metals.

PROJECT: Determination of Osmium in Thin Carbon Foils

SPONSOR: Department Of Chemical Engineering - The University Of Texas At Austin

An osmium containing electrode device to monitor the glucose level in blood is under investigation and development. Leach of Os from the surface of the electrode to the blood stream is one of the major concern. Simulated biological fluids and used electrodes were analyzed for their osmium content.

PROJECT: Determination of 27 elements in Garden and Lawn Fertilizers Using Instrumental Neutron Activation Analysis

SPONSOR: NETL

Several locally available garden and lawn fertilizers wee analyzed for elemental content using instrumental neutron activation analysis. Although some of the measured elements are recognized as micronutrients, other (e.g. Co, Cr, Th, U) are not. The indiscriminate use of fertilizers may result in the increase in the concentration of these elements in underground water supplies.

PROJECT: Determination of Toxic and Other Elements in Wild Medicinal Plant Grown in the Egyptian desert.

SPONSOR: Department of Science, University of El-Minia, El-Minia, Egypt

Several wild plants, some used in folk medicine, were analyzed for toxic and other elements using INAA. Arsenic, Antimony and selenium were among the elements measured.

PROJECT: Determination of Some Rare Earth Elements in Fluorite

SPONSOR: NETL and Universidad Autonoma De Nuevo Leon, Mexico

Approximately 2000 tons of fluorite are produced in Mexico. This project is aimed at determining the concentration of rare earth elements in fluorite using INAA. Results of the project constitute a M.S. thesis for Mr. S.C. Tovar-Saldana.

PROJECT: Trace Elements Determination in Cements

SPONSOR: NETL and Universidad Autonoma De Nuevo Leon, Mexico

Several locally produced cements were sampled and analyzed for major, minor and trace element content. Data obtained were compared to the literature values. Results of the project constitute a M.S. Thesis for Mr. O. Villarreal-Reyes.

PROJECT: Trace Elements in Medical Alloys

SPONSOR: Centro De Investigation Metalurgica, S.A.Mexico

Several metal alloys used for medical purposes were analyzed by instrumental neutron activation analysis to determine the concentration of impurities at a trace and ultratrace levels.

PROJECT: Trace Elements in Powdered Milk and Infant Formula.

SPONSOR: Centro De Investigation Metalurgica, S.A.Mexico

Several powdered milk and infant formula available in the open market in Mexico were analyzed for essential elements as Ca, Fe, Na,.etc. Also for nondesirable contaminants as As, Hg, etc.

PROJECT: Nickel and Chromium in Dental Alloy

SPONSOR: Centro De Investigation Metalurgica, S.A.Mexico

Several metal alloys used for dental purposes were analyzed by instrumental neutron activation analysis to determine the concentration of nickel and chromium.

PROJECT: Trace Element Impurities in Fiber Polymer

SPONSOR: Centro De Investigation Metalurgica, S.A.Mexico

Fiber polymer made of polyamide-6 manufactured in Belgium and used to in cases of bone fissures were analyzed by instrumental neutron activation analysis for trace element impurities.

PROJECT: Design of Beam Port Collimators

SPONSOR: NETL

A high quality thermal neutron beam should have a good neutron intensity and minimum contamination with fast neutrons and gamma rays. To achieve this goal for the beam port BP#2 (designated for neutron depth profiling) an evaluation has been done and a collimator designed.

Various single crystals have been used to filter out the fast neutron component of a beam coming from a reactor while allowing thermal neutrons to pass through with little attenuation. Examples of single crystal filters are: silicon (Si), quartz (SiO_2), sapphire ($A_{12}O_3$), MgO, etc. Heavy elements such as bismuth can have the extra advantage of reducing the gamma ray background but are not available because large size single crystals cannot be grown. Sapphire and Si were considered initially as neutron filters. By using available data on sapphire and Si, the thermal neutron transmission and optimum filter length with arbitrarily selected fast neutron attenuation values are calculated.

Single crystal sapphire was chosen as a neutron filter for its relatively high thermal neutron transmission rate. For 99% fast neutron attenuation, a 14.4 cm. length of sapphire single crystal should be used and the calculated thermal neutron transmission would be 74%. Sapphire single crystals are grown by a motionless crystal growth process called Heat Exchanger Method (HEM). HEM sapphire is available in four separate grades and in a variety of orientations. Thermal neutron transmission properties of a premium grade, HEMEX, and a standard optical grade, HEMLITE, is currently being investigated in collaboration with the National Institute of Standards and Technology (NIST).

The sapphire single crystal filter is designed to be located approximately 150 cm. away from the core and at the end of the first segment of the beam tube. Due to this location of the filter, a 8.9 cm. diameter sapphire single crystal is required to cover the entire beam with focuses about 1 cm. diameter aperture at the end of the beam tube. Collimation of the beam after passing through the filter was accomplished by several annuli of lead and steel which are tapered to the final inner diameter of 1.5 cm. The surface of some steel annuli is covered with boral. The overall length of the collimator is ~140 cm. The last 20 cm. of the collimator is designed entirely using steel with various straight cylindrical apertures of 0.5 to 2.5 cm. in diameter. The segment of this last piece is designed in such a way that the final aperture size of the beam can be changed if necessary. Other collimator designs are currently under way and will be completed in the near future.

PROJECT: Neutron Depth Profiling
SPONSOR: NETL

A neutron depth profiling instrument is being designed and will be constructed at the beam port BP#2. Neutron depth profiling (NDP) is an isotope-specific nondestructive nuclear technique for measuring the concentration-versus-depth distributions in the near-surface regions of solids. The profiles are determined for depths up to a few micrometers. This technique is an effective tool for the determination of helium, lithium, boron, and nitrogen. Possible applications include the study of implanted boron in semiconductor material as a function of wafer treatment; study of boron concentration in microelectronic passive layers as it affects melting temperatures; study of nitrogen in metals as it affects wear resistance, hardness, and corrosion; and study of helium behavior in metals, and metallic and amorphous alloys.

The depth profiling chamber will be constructed from an aluminum cylinder 78.7 cm. high with a 40.6 cm. inside diameter. O-rings will be used to form a vacuum seal between the chamber and the bottom support plate and the removable upper cover. On opposite sides of the chamber, thin aluminum windows of 8.9 cm diameter (0.13 mm. thick) will serve as entrance and exits for the neutron beam. The chamber will be evacuated with a turbomolecular pump. A manually controlled goniometer system will be installed on the bottom plate of the chamber. This will give a capability of rotating both sample and the detectors to adjust the sensitivity of the depth profiling technique.

PROJECT: Texas Cold Neutron Source/Neutron Focusing Elements
SPONSOR: Advanced Technology Program, State of Texas Department of Energy

The Texas Cold Neutron Source (TCNS) is currently under construction and was supported by the State of Texas for a two-year research grant. Proposal for a focusing element for the TCNShas been submitted to the Department of Energy. TCNS mainly consists of a cooled moderator, a cryogenic refrigerator, a neon heat pipe, and neutron guide tubes. The cooled moderator used in the Texas source is mesitylene, a 1,3,5-trimethyl benzene. Because mesitylene freezes at 228 K and boils at 437 K, it is safer and much simpler to use than liquid hydrogen, D_2O ice, or solid methane, the more traditional cold-neutron-source moderators. The handling system for mesitylene does not need to withstand large or abrupt changes in pressure, but must be a closed system to avoid contaminating the mesitylene or releasing it since it is slightly carcinogenic and toxic. The cooled moderator is contained in a thin-walled aluminum right-circular cylinder 7.6 cm diameter by 2.0 cm deep position inside a beam tube at the graphite reflector of the reactor. The moderator is cooled by a neon heat pipe 340 cm long, connected to the 25 K stage of a cryogenic refrigerator located outside the biological shield of the reactor. The moderator cooling system was tested. A Cryomech model GB04 Cryorefrigerator, a 3 meter aluminum pipe (1.9 cm O.D. , 1.6 cm I.D.) and a 6 liter cylindrical container filled with neon gas under 12 atm pressure were used for the test. To simulate the nuclear and thermal radiation heating at the moderator, the end piece of the aluminum pipe was attached to an aluminum block and about 4.2 watts of heat generation was created continuously. At operating condition, 5.0 gm of neon remained at the cylindrical container at 1 atm pressure and the remaining 55.0 gm was in the heat pipe with 1 atm pressure. A constant temperature of 29 K was obtained at the end of the aluminum pipe.

The neutron guide of the Texas Cold Neutron Source consists six 1 meter long elements. We are currently in the process of ordering these elements. The neutron beam cross-section is 50 x 15 mm^2, separated by two vertical mirrors of 1 mm thickness into 3 channels. All neutron reflecting walls are coated by a Ni-58 layer about 1000 Å thick, evaporated on the specially cleaned, boron free glass. All elements are 1 m long and curved to a radius of 300 meters. Two elements of 1 m length are glued together to a 2 m long unit. The two 2 m guides outside the biological shielding are installed without a vacuum jacket. Since the guide tubes have enough glass thickness they can be precisely aligned and than evacuated without changing the alignment of the guides. The glass guides are shielded by a 5 mm thick B_4C / epoxy layer put around the glass.

PROJECT: Fission-Fragment Spectrometer (HIAWATHA)

SPONSOR: Bernard W. Wehring (NETL)

Fission yield data are essential to both nuclear reactor engineering calculations and the continuing development of the fundamental understanding of the fission process. Due to the continuing interest in fission-fragment spectrometer (HIAWATHA) which was developed at the University of Illinois, plans are under way to set up the fission yield system.

The fission-fragment recoil mass spectrometer HIAWATHA is a unique instrument that was conceived, designed, constructed and used to measure the independent yields for the light-fragment groups in thermal-neutron fission of ^{233}U and ^{235}U. The energy and mass resolution achieved by HIAWATHA, 0.3% and <0.5 amu, respectively, permitted the unique determination of fission-fragment mass and also, the use of energy loss for atomic-number identification.

Research at the University of Texas TRIGA Mark II reactor will concentrate on the application of HIAWATHA to the heavy-product group and on measuring the nuclide yields for thermal-neutron fission of ^{239}Pu and possibly other fission materials. The use of HIAWATHA for heavy-ion energy loss characterization will also be studied.

2.5 *Significant Modifications*

No significant modifications have been made to the NETL building, TRIGA reactor or experiment facilities. A summary of the types of modifications that did occur during the year follows. A significant effort was in progress during the year to develop a cold neutron source for the reactor.

Building. Minor modifications were necessary to correct design or installation flaws in the original equipment of several building utilities. These repairs were to correct problems with sump pumps, electrical controls, and other physical plant systems. No changes to the building systems effect the safety of operation of the reactor.

Reactor. Startup of the reactor, fuel loading , initial acceptance tests, and operation at full power were the most significant change to the reactor. The startup and acceptance was done according to a written startup plan. A startup report was written to document the data and measurements made during the startup.

Experiment Facilities. Standard experiment facilities for the reactor are the center tube, pneumatic tube, rotary specimen rack and beam ports. No significant modifications were made to the original installation for any of the standard experiment facilities.

The pneumatic tube, including support equipment is not currently part of the installation. Installation of the pneumatic system was a low priority during this year, although planning for the installation was in progress.

Design, analysis, fabrication and testing of components for a neutron cold source was in progress for installation as a unit into the beam port. The cold neutron source system will insert into the beam port #3, taking advantage of the reflector penetrating port and 16 inch (40.6 cm) diameter access at the reactor shield exit.

2.6 *Publications, Reports and Papers*

Various publications, reports, papers and presentations are written or given each year by NETL personnel. The following list documents work efforts by faculty staff and students.

Publications:

Dissertations:
None

Theses:

1. H.J. Gepford, "Utilization of the Texas Cold Neutron Source for Neutron Scattering Research," Thesis, Univ, of Texas, May 1991.

2. E.L. Takesuye, "Photon Dose Equivalents in Phantoms," Thesis, Univ. of Texas, May 1991.

Periodicals:

1. F.Y.Iskander, K.R. Davis, "Mineral and Trace Elements Content in Bread," J. Food Chemistry 45:(2)269 (1992).

2. F.Y. Iskander, "Multielement Determination in a Chinese Cigarette Brand," J. Radioanal. Nucl. Chem. 159(1):105 (1992).

3. K. Ünlü, "Experimental Investigation of Helium-3 Migration in Amorphous $Ni_{63.5}Zr_{35.5}$ by Means of $^{3}He(n,p)^{3}H$ Nuclear Reactions," Bull. Am. Phys. Soc. Vol. 37, No. 1, 670 (1992)

4. K. Ünlü, D. H. Vincent, "Helium-3 Behavior in Some Nickel-based Amorphous Alloys," Nuclear Science and Engineering, Vol. 110, No. 4, April 1992.

Reports:

1. B.W. Wehring, K. Ünlü, "Experimental Review of Neutron Beam Port Usage," Experiment Authorization, The University of Texas at Austin, Nuclear Engineering Teaching Laboratory, 1992.

2. B.W. Wehring, K. Ünlü, T.L. Bauer, "Safety Analysis Report for Texas Cold Neutron Source," The University of Texas at Austin, Nuclear Engineering Teaching Laboratory, 1992.

3. B.W. Wehring, K. Ünlü, "Experimental Review of Usage of the Texas Cold Neutron Source," Experiment Authorization, The University of Texas at Austin, Nuclear Engineering Teaching Laboratory, Jan 1992.

4. B.W. Wehring, K. Ünlü, "Study of Neutron Focusing at the Texas Cold Neutron Source," Progress Report, DE-FG02-92ER75711, Office of Science and Technology, U. S. Department of Energy, Jan 1993.

5. T.L. Bauer, B.W. Wehring, "An Expert System to Enchance Software Reliability," Progress Report, U.S. NRC Grant #04-91-094, 1-9-1991 - 1993.

6. S. Manson, R. Canaan, A. Preece, C. Martines, J.Y. Kim and H.R. Vega Carrillo, "The Development and Benchmarking of an Analytical Moisture Separation Model for Boiling Water Reactors," Graduate entry to the 1992 American Nuclear Society Student Design Contest Nov. 17, 1992.

Papers and Presentations:

Abstracts:

1. K. Ünlü, T.L. Bauer, and B.W. Wehring, "Safety Aspects of the Texas Cold Neutron Source," Trans. Am. Nucl. Soc. 65, 135 (1992).

2. K. Ünlü, T. Emoto, T.L. Bauer, and B.W. Wehring, "Design Features of the Texas Cold Neutron Source," Trans. Am. Nucl. Soc. 65, 134 (1992).

3. K. Ünlü, C. Rios-Martinez, and B.W. Wehring, "Performance of Texas Cold Neutron Source," Trans. Am. Nucl. Soc. 66, 160 (1992).

4. F.Y. Iskander, "Neutron Activation Analysis of Heavy Metals in the Town Lake Watershed. A Meeting of the Monitors." A statewide conference for Texas Water Monitors, Austin, Texas, Feb 20-22, 1992. (Abstract).

5. H.R. Carrillo, F.Y. Iskander and A. Mar[illegible], "INAA Elemental Analysis of El-Pedernalillo' Dam Sediments," 1992 ANS Western Region Student Conference, Albuquerque, New Mexico, April 2-4, 1992. (Abstract).

6. F.Y. Iskander, "Measurements of 27 Elements in Garden and Lawn Fertilizers Using Instrumental Neutron Activation Analysis," The Second International Symposium on Nuclear Analytical Chemistry, Toronto, Ontario, Canada, June 3-5, 1992. (Abstract).

Presentations:

1. H.R. Vega Carrillo, "Uses and Abuses of Linear Models," American Association of Physics Teachers Winter Meeting, Orlando, FL, January 1992.

2. H.R. Vega Carrillo, R. Lugo, D. Hernandez, H. Martinez, "Neutron Howitzer, Design and Construction," American Nuclear Society, 1992 Western Region Student Conference, Albuquerque, NM, April 1992.

3. H.R. Vega Carrillo, "Measured Neutron Spectra and Dosimetric Quantities in the Vicinity of a PET Cyclotron Facility," Annual Meeting South Texas Chapter, Health Physics Society, Waco, TX, April 1992.

4. T.L. Bauer, B.W. Wehring, "Startup of the University of Texas at Austin Mark II TRIGA Reactor," Thirteenth U.S. TRIGA Users Conference, Cornell University, Ithaca, New York, May 18-20, (1992).

5. K. Ünlü, T.L. Bauer, and B.W. Wehring, "Development of Neutron Beam Projects at The University of Texas TRIGA Mark II Reactor," Thirteenth U.S. TRIGA Users Conference, Cornell University, Ithaca, New York, May 18-20, (1992).

6. N.E. Hertel, H.R. Vega-Carrillo, A.B. Preece, B.K. Nabelssi, B.W. Wehring, C.A. Shriver, C.E. Johannes, and P.A. Jerabek, "Neutron Spectra Measured in the Vicinity of a PET Cyclotron," Health Physics Society Annual Meeting, Columbus, OH, June 21-25, 1992.

7. B.W. Wehring, K. Ünlü, and T.L. Bauer, "Research at The University of Texas TRIGA Mark II Reactor," The Joint meeting of the Texas Section of the American Physical Society, Texas Section of the American Association of Physics Teachers and Society of Physics Student, Rice University, Houston, Texas, 7-8 Nov 1992.

8. H.R. Vega Carrillo, L.L. Quirino Torres, F. Mireles Garcia , "Experimental Determination of Fermi Age in Polyethylene," Tercer Congreso Anual De La Sociedad Nuclear Mexicana, Cuernavaca Mor., Mexico, November 1992.

9. C. Rios-Martinez, K. Ünlü, and B.W. Wehring, "Development of a Prompt Gamma Activation Analysis Facility at The Texas Cold Neutron Source," Sociedad Nuclear Mexicana A.C., Tercer Congreso Anual Memorias, 159 (1992).

3.0 FACILITY OPERATING SUMMARIES

3.1 **Operating Experience**

The UT-TRIGA reactor at the Balcones Research Center became operational during 1992. Initial loading of fuel type control elements into the reactor core began January 18, followed by fuel loading from February 10 to March 18. Initial criticality was on March 12, with nominal full power operation on March 26. Acceptance of all phases of the startup test program was June 16. A total of 34.5 MW-hours were generated in the first year of operation. The reactor was critical for approximately 186 hours. A summary of the burnup history is shown in Figure 3-1.

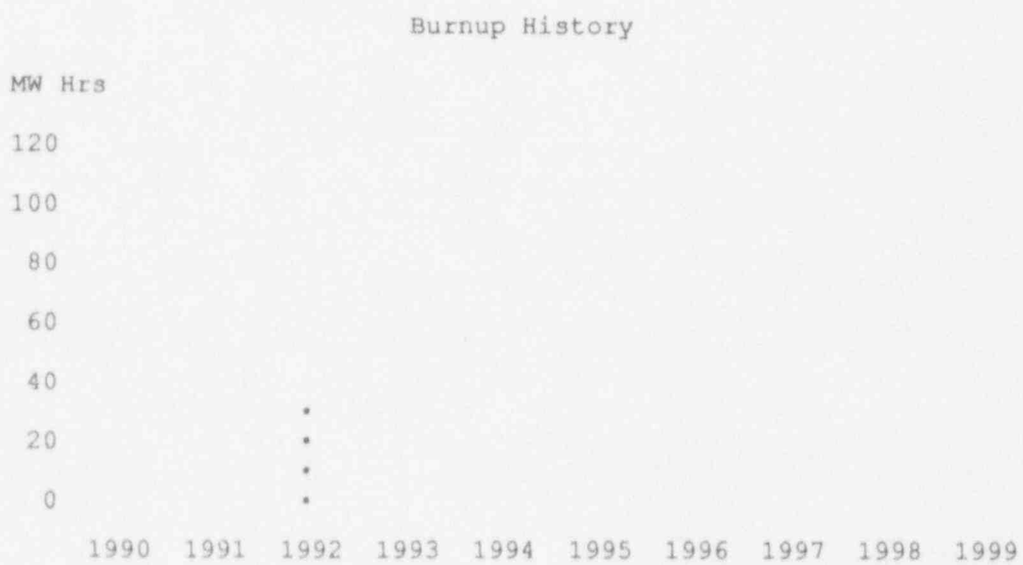

Figure 3-1 Operating History

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

Scrams are further categorized according to the technical specification requirement given in Table 3-2. External scrams which provide protection for experiment systems are system operable conditions.

The total number of safety system protective actions during 1992 was eight. Of the eight total protective action shutdowns four were actions of a safety system setting, and four were actions of a system operable condition (see Table 3-3).

Table 3-2
Instrumentation, Control and Safety System
Protective Action Events (1)

Technical Specification Requirement	Yes	No
SCRAM Type		
Safety System Setpoint (LSSS)	1	3
System Operable Condition (LCO)		
Analog detection (hardware)	0	1
Digital detection (software)	2	1
Manual Switch		
Protective action	0	0
Intentional operation (2)	-	-
Total Safety System Events	3	5

(1) Tests of the SCRAM circuits are not recorded

(2) Intentional SCRAMS (non-protective action) are not recorded

A review is always done to determine if routine corrective actions are sufficient to prevent the recurrence of a particular reactor safety system shutdown.

Table 3-3
Summary of Safety System
Protective Actions

Trip Action	Number of Occurrences
Safety System Setpoint	4
System Operable Condition	4
Total	8

Previous SCRAM History

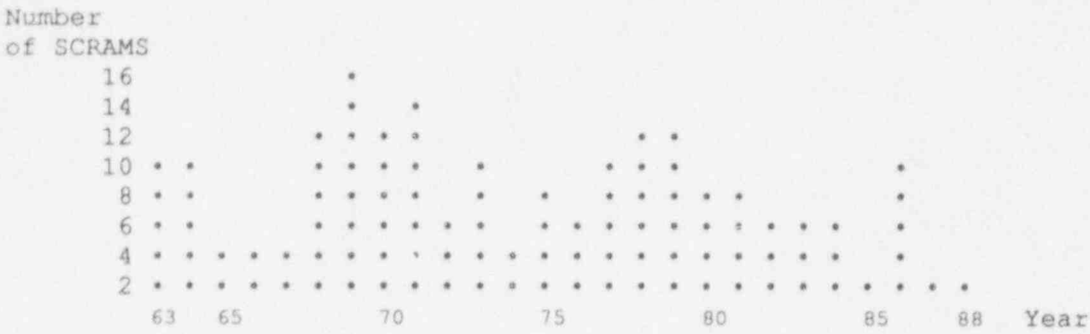

Figure 3-2 250 KW TRIGA - Taylor Hall 1963-1988

3.3 Utilization

Primary utilization of the reactor during the year was by NETL staff. The first half of the year concentrated on the performance of reactor equipment, instrumentation and control systems. The latter half of the year concentrated on the development of two application areas, neutron activation analysis and neutron beam port facilities. One significant research project for construction of a cold neutron source for the radial beam port proceeded throughout the course of the year.

A summary of the reactor utilization for 1992 is presented in Table 3-4 with the monthly distribution shown in Figure 3-3. Table 3-5 summarizes the sample irradiations and experiments. Figure 3-4 records the historical trend of sample irradiations.

Table 3-4
Summary of 1992
UT-TRIGA Operation

	Q1	Q2	Q3	Q4	Total
<u># of "Key On" Hours</u>					
Operator #1			7.7	0.5	8.0
Operator #2			16.9	13.4	30.0
testing/maintenance	58.4	79.1	4.8	5.7	148.0
Total hours	58.4	79.1	29.4	19.6	186.5
<u>MW-Hours Energy</u>					
Operator #1			1.1	0.0	1.0
Operator #2			13.9	10.9	24.1
testing/maintenance	1.3	2.1	2.1	3.1	8.1
Total	1.3	2.1	17.1	14.0	34.1

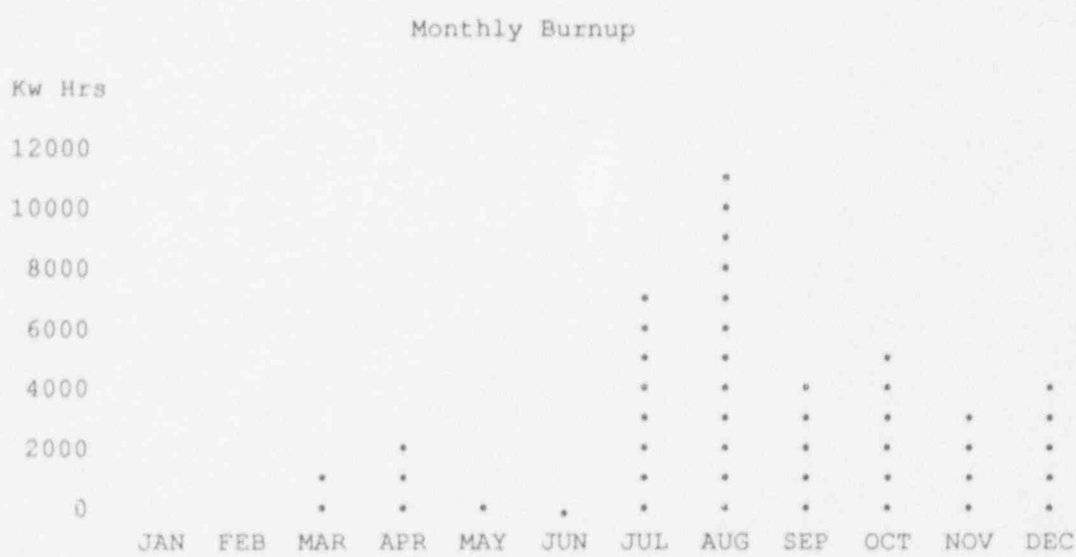

Figure 3-3 Operating Data 1992

Table 3-5
Summary of Utilization 1992
UT-TRIGA Experiments

	Q1	Q2	Q3	Q4	Total
No. of Samples					
In-core	-	-	365	154	519
Ex-core	-	-	0	0	0
No. of Experiments					
Type A	-	-	8	5	13
Type B	-	-	1	6	7
Other	-	-	2	2	4
Total	-	-	11	13	24

Number of Sample Irradiations

Figure 3-4 Operating Data 1992

3.4 Maintenance

Maintenance in 1992 was mainly routine repair and modifications to equipment. All changes were made to meet or exceed original manufacturers specifications. No significant safety considerations were detected during the maintenance activites.

One repair, however, was accomplished during the startup test program pertinent to the proper operation of the two standard control rod drives. Although the safety operation of the drives was never in question, their performance was inadequate for fully withdrawing the fuel follower control elements. Replacement of the drive motors with higher torque capacity motor gear assemblies was necessary to provide more reliable drive operation.

3.5 Facility Changes

Two significant experiment authorizations became effective during 1992. These two experiment authorizations concern the two most significant applications of reactor operation. Both authorizations were written to provide for general use of the available experiment facilities.

The first authorization is for neutron activation of samples. Analysis demonstrates the allowable range of sample composition of various types of materials according to three sample classifications: biological materials, geological materials and man-made engineering materials.

The second authorization was for the general use of the neutron beam ports. A radiation level requirement for shielding in beam areas was set to 5 mrem/hr. Constraints are made for the control and access to experiment beams.

Both experiments were written to allow the general use of irradiation facilities for neutron activation (excluding isotope production), and the general use of beam ports for temporary or permanent installation of beam type experiments. Safe use of the reactor facilities is assured through written experiment authorizations requiring review of experiment requests.

3.6 **Laboratory Inspections**

Inspections of laboratory operations are conducted by university and licensing agency personnel. Among the functions of the Radiation Safety Committee and Nuclear Reactor Committee was the review of inspections by university personnel. These committees convened at the times listed in Table 3-6.

Table 3-6
Committee Meetings

Radiation Safety Committee	
Spring Term	April 13, 1992
Fall Term	November 18, 1992
Nuclear Reactor Committee	
First Quarter	January 24, 1992
Second Quarter	April 29, 1992
Third Quarter	July 14, 1992
Fourth Quarter	October 15, 1992

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	Feb 10-13, 1992
	Mar 2-6, 1992
	Dec 7-11, 1992
SNM-180	none
L00485(48)	May 5-6 1992

No items of non-compliance were found during the inspection process. The inspection reports for the year include the

No items of non-compliance were found during the inspection process. The inspection reports for the year include the startup activities of the R-129 license and the dismantling and decontamination activities of the R-92 license.

3.7 Radiation Exposures

Radiation exposures for personnel, building work areas and areas in the vicinity of the building are shown in the following tables. Table 3-8 lists NETL personnel dose exposure data for the calendar year. Table 3-9 is a list of the Radiation Protection Requirements and Frequencies. Figure 3-5 locates the building internal and external dosimetry sites. Numbers identify the immediate vicinity radiation measurement sites exterior to the building. These sites do not indicate any measurable dose from work within the NETL building. Table 3-10 and Table 3-11 list doses recorded in facility work areas and the immediate area adjacent to the building.

Table 3-8
Annual Summary of Personnel Radiation
Doses Received Within the NETL Reactor Facility

	Personnel	Students	Visitors
Average Annual Dose(1)			
Whole Body	14	M(2)	M
Extremities	82	N/A(3)	N/A
Greatest Individual Dose			
Whole Body	70	M	M
Extremities	330	N/A	N/A
Total Person-mrem for Group			
Whole Body	200	M	M
Extremities	1070	N/A	N/A

(1) Dose is in mrem.

(2) "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, 4 mrem for energetic betas, 20 mrem for fast neutrons, and 10 mrem for thermal neutrons.

(3) "N/A" indicates that there was no extremity mo itoring conducted or required for the group.

Table 3-9
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 survey of exterior walls and roof. Neutron survey of exterior walls and roof. Swipe survey of 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 wasted and liquid effluent discharges. Prepare and record radioactive material shipments. Survey and record incoming radioactive materials. Perform and record special radiation survey. Issue radiation work permits and provide health physics coverage for maintenance operations. Conduct orientations and training.
Quarterly	Exchange TLD environmental monitors. Gamma survey of all non restricted areas. Swipe survey of all non restricted areas. Swipe survey of building exterior areas. Calibrate personnel pocket dosimeters. 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. Leak test and inventory sealed sources.
Annual	Conduct ALARA Committee meeting. Conduct personnel refresher training. Calibrate emergency locker portable radiation detection equipment

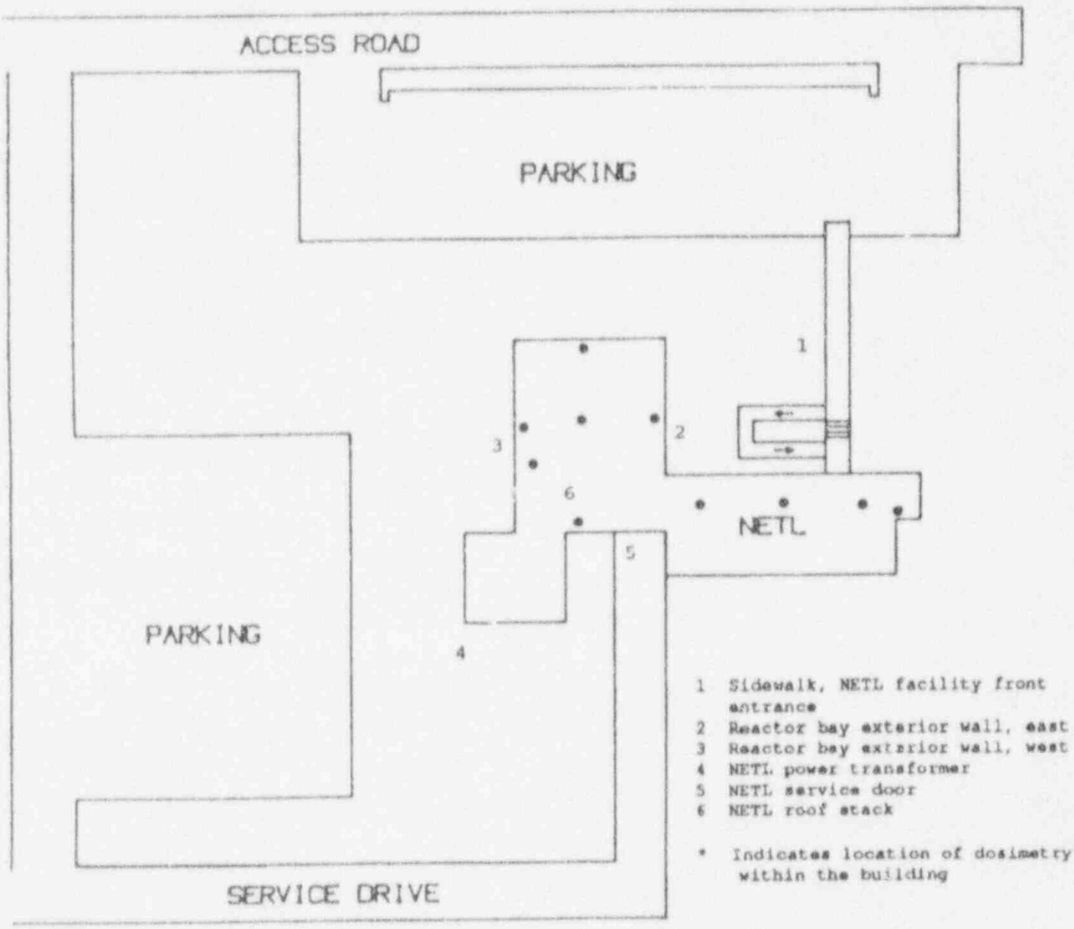

Figure 3-5 Environmental TLD Locations

Table 3-10
Total Dose Equivalent Recorded on
TLD Environmental Monitors
Around the NETL Reactor Facility

Location in Reactor Facility	Monitor ID	Total Dose[1]
Sidewalk, NETL facility front entrance	00156	30
NETL power transformer	00157	M[2]
NETL Roof stack	00158	M
Reactor bay exterior wall, east	00159	M
Reactor bay exterior wall, west	00160	M
NETL service door	00161	30

(1) Dose is in mrem.

(2) "M" indicates that each of the dosimeters during the period was below vendor's minimum measurable quantity of 10 mrem for x- and gamma rays, 40 mrem for energetic betas. The total recorded dose equivalent values do not include natural background contribution and reflect the summation of the results of four quarterly TLD dosimeters for each location.

Table 3-11
Total Dose Equivalent Recorded on
Area Dosimeters Located Within the
NETL Reactor Facility

Location in Reactor Facility	Monitor ID	Total Dose[1] β,γ,X	n
Reactor Bay, North Wall	00167	M[2]	M
Reactor Bay, East Wall	00168	10	M
Reactor Bay, West Wall	00169	M	M
Water Treatment Room	00170	430	M
Reactor Pool Area, Roof	00171	M	M
Shield Area, Room 1.102	00172	2000	1430
Sample Processing, Room 3.102	00173	40	N/A[3]
Gamma Spectroscopy Lab, 3.112	00174	10	N/A
Radiation Experiment Lab, 3.106	00175	M	N/
Reception Area, 2.102	00176	M	N/A

(1) Dose is in mrem.

(2) "M" indicates that each of the dosimeters during the period was below vendor's minimum measurable quantity of 10 mrem for x- and gamma rays, 40 mrem for energetic betas, 20 mrem for fast neutrons, and 10 mrem for thermal neutrons. The total recorded dose equivalent values 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. These dose equivalent values do not represent radiation exposure through and exterior wall directly into an unrestricted area.

(3) "N/A" indicates that there was no neutron monitoring at that location.

3.8 **Radiation Surveys**

Radiation su:veys 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 Levels and Contamination Levels Within the Reactor Area and NETL Facility

Accessible Location	Whole Body Radiation Levels (mrem/hr)[1]		Contamination Levels [2] ($dpm/100cm^2$)	
	Average	Maximum	Average	Maximum
TRIGA Reactor Facility	0.014	0.05	<MDA[2]	88
NETL Facility				
Rm 3.102 NAA sample processing	0.18	1.6	<MDA	7
Rm 3.112 NAA sample counting	0.007	0.015	<MDA	<MDA
Rm 1.102 RAM Storage	0.42	2.0	<MDA	<MDA

(1) Measurements with a Bicron Microrem portable survey meter.
(2) Made with G5000 low level alpha-beta radiation counting system. MDA is 3.318 dpm/100 cm2 beta, and 0.60 dpm/100 cm2 alpha. Calculation of MDA based on NCRP Report No. 58.

3.9 **Radioactive Effluents, Radioactive Waste**

Radioactive effluent releases to the air, to the sanitary sewer and disposals of radioactive materials are shown on the following pages. Argon-41, with a half-life of 109 minutes is the only airborne radionuclide emitted by the facility. A summary of the Argon-41 releases are shown in Table 3-13.

Table 3-13
Monthly Summary of Argon-41 Effluent Releases(1)

Date of Discharge (Month, 1992)	Total Quantity of Argon-41 Release (microCuries)	Average Concentration at Point of Release (microCurie/cm^3)	Fraction of Technical Specifications(2) (%)
January	-	-	-
February	-	-	-
March	0	0.00E-00	0.00
April	570	5.65E-11	.00283
May	185	1.83E-11	.000917
June	76	7.52E-12	.000376
July	168000	1.67E-08	.836
August	450000	4.47E-08	2.23
September	191000	1.89E-08	.945
October	230000	2.28E-08	1.14
November	304000	3.02E-08	1.51
December	49600	4.92E-09	.246
ANNUAL VALUE	1390000	1.14E-08	0.57

(1) Point of release is the roof exhaust stack. Concentration includes dilution factor of 0.2 for mixing with main exhaust.

(2) Technical Specification limit is 2.00E-6 microCurie/cm^3.

Table 3-14
Monthly Summary of Liquid Effluent Releases to the Sanitary Sewer From the NETL Reactor Facility

Date of Discharge (Month, 1992)	Release Volume (m^3)	Total Quantity of Radioactivity (Curies)
January		No Releases
February		No Releases
March		No Releases
April		No Releases
May		No Releases
June		No Releases
July		No Releases
August		No Releases
September		No Releases
October		No Releases
November		No Releases
December		No Releases

Table 3-15
Monthly Summary of Solid Waste Transfers for Disposal

Date of Discharge (Month, 1992)	Release Volume (m^3)	Total Quantity of Radioactivity (Curies)
January		No Releases
February		No Releases
March		No Releases
April		No Releases
May		No Releases
June		No Releases
July		No Releases
August		No Releases
September	4.5	8.06 E-1
October		No Releases
November		No Releases
December		No Releases

Releases to the sanitary sewer are done from waste hold up tanks at irregular intervals. To date no releases have been made from the NETL facility at the Balcones Research Center.

Radioactive waste disposal of solids are shown in Table 3-15. The inventory of material in Table 3-15 represents the disposal of the unrecoverable components of the Taylor Hall TRIGA installation. The disposal of radioactive components consisted of reactor core components, reactor mechanical structure and miscellaneous operating materials. The total activity sent to disposal was 806 millicuries primarily of the isotope cobalt-60. Structural materials of the pool liner and pool concrete are to be removed from the Taylor Hall site in 1993. No solid waste disposals were made from the Balcones Research Center site.