February 20, 2009

APPLICATION FOR RENEWAL
OF LICENSE SNM-180
SPECIAL NUCLEAR MATERIALS

Submitted to

Director, Fuel Facility Licensing Directorate
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

by

Nuclear Engineering Teaching Laboratory
J.J. Pickle Research Campus
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December, 2007

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I. Name of License Applicant [10 CFR 70.22(a)(1)]

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II. Activity and location for which Special Nuclear Material License is requested [10 CFR 70.22(a)(2)]

The Nuclear Engineering Teaching Laboratory (NETL) of the University of Texas at Austin (UT) uses Special Nuclear Material (SNM) to supplement the training and instruction programs in the field of nuclear engineering. The items described in this application are used for junior, senior and graduate level laboratory courses in the Nuclear Engineering Program of the Mechanical Engineering Department.

The licensed materials are to be used in experiments in the Nuclear Engineering Teaching Laboratory (NETL) facilities located at the University's J.J. Pickle Research Campus (formerly known as the Balcones Research Center). Laboratory facilities associated with the Nuclear Engineering Program include a research reactor with appropriate Nuclear Regulatory Commission license (R-129).

A map and diagram of the facility location is found in Appendix A. The NETL (or NEL on UT maps) building designation is Building 159 at the J.J. Pickle Research Campus. The primary location for storage and operation of the special nuclear materials will be Room 1.104 of Building 159. Building schematics of NETL are located in Appendix B-D.

III. Requested Duration of License [10 CFR 70.22 (a)(3)]

The University of Texas at Austin requests the license (SNM-180) be renewed for an additional ten years.

IV. Description of Special Nuclear Material [10 CFR 70.22(a) (4)]

Withheld from Public Disclosure Under 10 CFR 2.390

V. Technical Qualifications of Applicant [10 CFR 70.22(a)(6)]

A. Administrative Structure

Staff qualifications for responsible utilization of licensed special nuclear materials in the Nuclear Engineering Teaching Laboratory (NETL) include the administration of a special nuclear material license, a nuclear reactor operating license, and a state radioactive materials license. The NETL administrative structure consists of a Radiation Safety Committee, Radiation Safety Officer, Reactor Oversight Committee, NETL Director, NETL Associate Director and Laboratory Staff. Laboratory staff includes reactor operators, health physicist, research associates, technicians, administrative secretary and student research assistants.

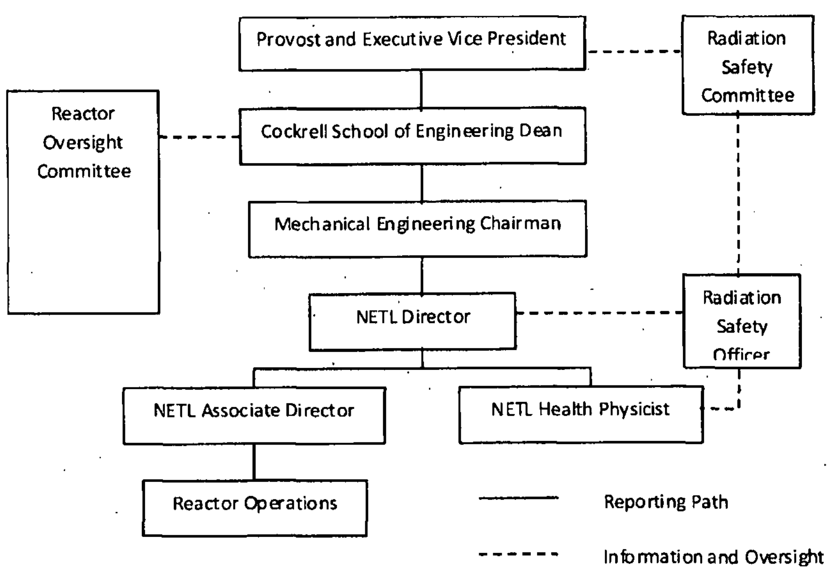

Figure 1 NETL Line Management

B. Radiation Safety Committee

The Radiation Safety Committee (RSC) is established through the office of the University President and contains at least 6 faculty and/or staff members from Science or Engineering Departments. A member of the NETL staff (usually the NETL Health Physicist) is a member of the RSC. The campus Radiation Safety Officer shall be an ex-officio member of the RSC. The RSC approves and reviews the use of radioactive materials licensed by the State of Texas. The RSC reviews all campus radiation exposures but does not have oversight responsibility over the NRC issued reactor or materials license at the NETL.

1. University Radiation Safety Officer

The University holds a large broad scope radioactive materials license with the State of Texas. The campus Radiation Safety Officer (RSO) is responsible for maintaining and implementing the radiation protection program for the radioactive material uses authorized by the State of Texas license. The RSO has no responsibility for the implementation of the independent NETL Radiation Protection Program; however, the RSO and his/her staff may advise the NETL Health Physicist and provide technical assistance as needed.

C. Reactor Oversight Committee

A Reactor Oversight Committee (formerly known as the Nuclear Reactor Committee) is responsible to the Dean of the College of Engineering with at least three members knowledgeable in the fields of nuclear safety. The Reactor Oversight Committee shall review, evaluate, approve and audit activities and procedures associated with the operation of the NETL facility. Jurisdiction shall include all nuclear reactor, special nuclear material and radiological operations in the facility and general safety standards. The Radiation Safety Officer and NETL Director are members of the committee. The Radiation Safety Officer may inform the campus Radiation Safety Committee of activities at the NETL but a formal report is not required. The Reactor Oversight Committee meets at least two times annually and audits or has audits performed annually of the NETL radiation safety program

D. ALARA (As Low As Reasonably Achievable) Committee

The NETL has established an ALARA program with an annual review of that program by the NETL ALARA Committee. The ALARA Committee consists of the NETL Director, Associate Director, Reactor Supervisor, NETL Health Physicist and the University Radiation Safety Officer. The ALARA Committee reviews the NETL ALARA program, personnel radiation exposures and the radiation work permit program.

E. Laboratory Administration

1. NETL Director and Associate Director

Daily activities of the laboratory are managed and directed by the NETL Director who may or may not be an NRC licensed senior operator and whose responsibility is to direct and supervise the operation of the nuclear reactor and other laboratory activities either directly or by delegation to the NETL staff. The NETL Director has ultimate responsibility for the NETL radiation protection program and the use of all radioactive materials at the facility. A NETL Associate Director or Assistant Director will perform the Director's duties in the absence of the Laboratory Director.

1. Qualifications of the NETL Director and Associate Director

The position of NETL Director requires a Bachelor's degree in engineering or science with three years experience in a nuclear related field. Preferred qualification is a Master's or Ph.D. degree in a field of nuclear engineering or science with appropriate experience. Experience preferred is five years including two in a supervisor position. Knowledge of nuclear facility operation, radiation detection systems, data acquisition and analysis systems, electronic and mechanical measuring equipment and utilization of computer equipment are required skills. The NETL Director is generally a faculty member with a Ph.D. in nuclear engineering or a related field. The Associate Director's qualifications will be equivalent to the Director position. The Reactor Oversight Committee and Radiation Safety Committee will review the technical qualifications of an individual prior to their appointment as Director or Associate Director.

F. NETL Staff

1. Reactor Operations

Duties of a reactor operator include operation and maintenance of the reactor and associated equipment, review of procedures and regulations, instruction and assistance of students or researcher, and assist in record maintenance and report preparations.

Qualifications require an engineering or science degree, appropriate laboratory experience with radioactive materials and radiation detectors or prior work experience in the nuclear field (e.g. U.S. Navy). An NRC issued operator or senior reactor operator license is required or the active pursuit of a license in an NRC approved qualification program. Preferred experience includes advanced knowledge of electronics, computer programming or other valuable laboratory discipline.

2. Health Physicist

The Health Physicist (HP) shall direct monitoring and training programs in order to protect the reactor and laboratory personnel from radiation hazards, and to assure compliance with federal, state, and UT Austin regulations. Additionally the HP administers and implements the NETL's safety program and provides technical assistance to all personnel using radiation and radioactive materials at the reactor facility. The HP reports directly to the NETL Director but has the authority to report safety and operational concerns directly to the UT Radiation Safety Officer and the Radiation Safety Committee. Additionally, the HP has "stop work" authority overriding all other NETL staff and management to suspend work activities due to safety concerns. The HP must immediately or as soon as possible make a report to the NETL Director and the Radiation Safety Committee upon invoking this authority explaining the circumstances of the safety issue.

Qualifications for this position are a Bachelor's degree in health physics, radiological health, nuclear engineering, or nuclear medicine. An individual without a college degree is acceptable if the person has formal training in the radiation protection field representing equivalent knowledge and training (e.g. U.S. Navy nuclear program) with at least six years experience. Preferred qualification is a Master's degree in health physics, radiological health, nuclear engineering, or nuclear medicine with at least one year of experience in the nuclear field.

3. Other Laboratory Staff

An administrative secretary aids in the preparation of reports and documents. Other staff, students or researchers, are employed as projects warrant. The minimum NETL staff is considered to consist of a NETL Director, at least two reactor operators, a health physicist, and one part-time technician. Although all staff personnel are not required to be in the building when handling licensed materials, this list represents the minimum acceptable staffing to adequately implement the reactor and materials license requirements. Additional technical support is also available from faculty members of the Mechanical Engineering Department employed to teach courses in the Nuclear Engineering Program.

VI. Facilities and Equipment for Handling Special Nuclear Material [10 CFR 70.22(a)(7)]

A. Areas of Storage and Use

Withheld from Public Disclosure Under 10 CFR 2.390

B. Shielding, Equipment and Handling Devices

The low specific activity of the non-operating subcritical core material allows for direct handling of materials. A polyethylene jacket protects and seals the core assembly disk units against the small risk of radioactive contamination from the fuel pellet disks. Tweezers and small lead shields or other shield materials are available to handle radioactive foils generated by neutron exposure in the subcritical assembly. Signs and rope are available to define radiation areas during assembly operation.

Routine handling of the plutonium-beryllium sources is accomplished with long-handled tongs and long threaded rods. Shielding material such as paraffin, borated polyethylene, lead, concrete block, and shield casks are available to provide improved radiation safety in various neutron source applications. The MCZPR fuel elements may be handled individually in accordance with existing procedures for inspection.

C. Measuring and Monitoring Devices

Personnel monitoring devices are required of all persons working in the laboratory with radiation sources if the individual is likely to exceed 10% of their allowable annual limits in accordance with 10 CFR 20.1502. Monitoring of additional individuals for particular environments is at the discretion of the NETL HP. Film badges or equivalent personnel dosimetery for laboratory personnel that are sensitive to gamma radiation (minimum measurable quantity ("M") of 10 mrem), energetic beta ("M" of 40 mrem), fast neutron ("M" of 20 mrem), and thermal neutron ("M" of 10 mrem), are provided by Landauer or other vendor as required. Direct-reading pocket dosimeters (ionization chambers) are available for dose measurements of gamma radiation (0-200 mrem). Direct-reading pocket dosimeters shall be calibrated semi-annually.

Portable radiation monitors utilized in the facility shall have the capability to detect alpha, beta, gamma, or neutron radiation. Operational parameters should include the ability to detect alpha above 4 MeV, beta above 100 keV, gamma and x-radiation above 7 keV, and neutrons over the energy range from 0.025 (thermal) to about 10 MeV. In addition, sufficient portable instruments should be available to detect radiation fields at ranges of up to 50 R/hr for gamma and neutron radiation.

As required by the facility reactor license (R-129), a program of environmental radiation monitoring has been established to ensure radiation doses to members of the public are in compliance with 10 CFR 20. This monitoring program utilizes fixed, integrating dosimetery provided by a contracted NVLAP (National Voluntary Laboratory Accreditation Program) vendor (i.e. Landauer, Inc.). Additional dosimeters are placed in specific locations where licensed materials are stored or used within the NETL to serve as accident dosimetry and provide trending data for the NETL ALARA program. A dosimeter responsive to neutron and gamma fields will be placed near Room 2.204 to specifically monitor the MCZPR storage location.

The Nuclear Engineering Teaching Laboratory shall maintain and calibrate portable radiation detection instruments, or radiation detection instruments with equivalent performance characteristics (i.e., range, sensitivity, type of radiation detected) or have the means for the instruments to be calibrated. Portable radiation detection instrumentation shall be calibrated annually in accordance with manufacturer's specifications.

Specialized detection systems are available for analytical radiation measurements that are routinely required in a gamma spectroscopy laboratory. Room 1.104 (the Reactor

Room) is continuously monitored by at least five area radiation monitors (ARM) with preset alarms set at 100 mR/hr (Alert at 5 mR/hr) and a continuous air monitor with fixed filter for particulate monitoring that also provides an audible alarm and warning indications. A gamma spectroscopy system (HpGe) and alpha-beta windowless proportional counter plus other miscellaneous detectors and equipment represent substantial capability to analyze radioactive materials.

Neutron monitoring by BF_3 proportional counters and U-235 fission counters with associated electronics are available to monitor and demonstrate operation of the subcritical assembly. Other detection systems, such as gaseous, scintillation or solid state detectors, allow students to count neutron activated foils.

D. Criticality Accident Alarm System (CAAS)

Criticality monitoring is performed by two independent Ludlum Model 375 Area Monitors and meets the requirements of ANSI/ANS-8.3-1997 as modified by NRC Regulatory Guide 3.71. One system is configured as a gamma radiation detector and one system is configured as a neutron monitor. The Model 375 detectors (gamma and neutron) are located adjacent to the stored Manhattan College Zero Power Reactor (MCZPR) fuel in Room 2.204. The facility area radiation monitoring (ARM) system described above provides a backup gamma radiation monitoring system with one detector located fifteen feet from the 2.204 doorway. The digital display and alarm units of the Model 375 CAAS are mounted outside the locked Room 2.204. Only the MCZPR fuel is monitored for inadvertent criticality as the other materials under this license were previously considered exempt from the requirements of 10 CFR 70.24.

A second dual Ludlum Model 375 Area Monitor is available for replacement if the CAAS instrument fails or has been removed from service for annual calibration. A channel check of the CAAS shall be performed once per week not to exceed seven days when the NETL building is accessible (alarm system not active) and the system shall have an annual calibration not to exceed 15 months. The CAAS may be out of service (OOS) for up to three weeks to allow for repairs or temporary facility closures (i.e. University shutdowns with no personnel access). However, no movement of materials into or out of Room 2.204 is allowed while the CAAS is OOS and a portable, alarming radiation detector must monitor the immediate vicinity of Room 2.204 while the facility is occupied.

The CAAS and detectors are fixed firmly to an inner wall of cinder block construction. The NETL facility was constructed to meet the requirements of the Uniform Building Code for Zone 0 (zero) seismic activity. The NETL is located in an area of low earthquake probability with all local identified faults considered to be inactive [L. Garner and K. P. Young, "Environmental Geology of the Austin Area: An Aid to Urban Planning"]. Therefore, the solid-state construction of the Model 375 is considered to be adequate to remain operational during credible seismic shocks caused by the design basis earthquake.

The environment within Room 1.104 which contains Room 2.204 and the CAAS is strictly controlled under the research reactor license to minimize the probability of an event such as a fire, explosion or corrosive materials affecting the reactor control and monitoring systems. The CAAS digital display and alarm system is located in a protected area formed by cinder block walls and concrete flooring with no flammable materials stored in the vicinity. Room 2.204 where the MCZPR materials are stored, immediately adjacent to the CAAS display, has a heat sensor that will set off the facility fire alarm system and alert NETL personnel and the local responders. Room 1.104 ventilation system exhaust has two smoke detectors either of which will cause a fire alarm and shutdown the building ventilation system. A significant event such as a tornado or large explosive device could severely damage the NETL building but this damage would primarily be on the outside building walls and not significantly affect the CAAS located in the protected area formed by internal walls and floors. Essentially, there are no credible environmental events (i.e. fire, explosion, or corrosive atmosphere) that would affect the operability of the CAAS.

The Model 375 Monitor (CAAS) is powered from 115 VAC with an internal battery backup power supply. On battery power, the CAAS will operate for 18 hours with no alarm condition and 5 hours with an alarm condition. Portable instruments will be available for periods with no electrical power greater than that provided by the CAAS battery supply.

The alarm level produced by the Model 375 has been measured at 75 dB above the ambient noise level in the area covered by the Model 375 CAAS. Other areas are notified that evacuation is necessary by the control room initiating a building-wide evacuation alarm and public announcement (PA) of the event over the building PA system.

E. Radioactive Waste Disposal

Sources of radioactive waste material from the operation of the subcritical assembly are slightly contaminated gloves and tools from contract with the polyethylene impregnated fuel pellets, activation products exposed in the assembly, and fission products generated by operation. These materials are expected to have very low contamination levels based on previous experience.

Provisions exist through the Office of Environmental Health and Safety for the collection and disposal of low level radioactive waste materials such as gloves, rags, and paper created by routine handling and maintenance of the assembly. Disposal of materials to the sanitary sewer system are also monitored by the Radiation Safety Officer and NETL Health Physicist as allowed by state licenses. Subcritical irradiations are at fluxes of approximately 10^8 neutrons/sec for a few minutes to hours. In general, foils or materials irradiated in the assembly are short half-life and reusable, and thus do not represent a radioactive waste stream. Alternatively, these materials or foils may be stored until the radioactive hazard decays.

Calculations indicate that the total fission product inventory of the assembly should not exceed a few microcuries of fission product activity. Contained as an integral part of the assembly, the activity is primarily a hazard while directly handling the subcritical assembly and is not considered waste until the assembly is decommissioned. (Calculations in Appendix G).

VII. Safety procedures to protect health and minimize danger to life or property [10 CFR 70.22(a)(8)]

Procedures are applied to establish safe conduct of activities with radioactive materials and radiation sources. The procedures satisfy various requirements of federal NRC licenses for special nuclear materials and state licenses for radioactive materials. Procedures are reviewed by staff, researchers and students during initial training as radiation workers and at least every two years following initial training. The laboratory staff may draft procedures and minor changes may be approved by a supervisor with concurrence of the NETL Director. Substantive changes to procedures are reviewed and approved by the Reactor Oversight Committee. The Procedures are categorized into four basic functional groups; monitoring, calibration, operation, and emergency.

A. Monitoring Procedures

- Access to radiations areas is controlled by staff personnel with radiologically posted restricted areas off-limits to unescorted persons who have not completed radiation worker training and security background checks. It is the responsibility of the HP to maintain proper signs and label posting, and other access controls based on periodic radiation and contamination surveys as required by NETL procedures.

- Personnel dosimetry badges are required in the laboratory for staff when radiation sources are in use.

- Dosimeters are required for occasional visitors and unusual source handling conditions.

- All personnel who have handled radioactive materials or entered a restricted area where licensed material is stored or used shall perform a contamination survey using the building portal monitor or hand-held frisker as appropriate prior to exiting the building. Personnel who have handled radioactive materials shall survey their hands before exiting the immediate area.

- Status of special nuclear material is verified by periodic inventory (annually).

- Status of plutonium-beryllium is monitored by leak tests of source (6 mo. cycles).

B. Operating Procedures

- Routine operation of the subcritical assembly shall consist of insertion of one of the plutonium-beryllium sources (including fuel pellets and non-fissile foils) into the subcritical core assembly with any of the designed conditions for reflector or moderator components.

- Routine operation of the subcritical assembly will be authorized by the reactor supervisor.

- A survey of gamma and neutron radiation levels during subcritical assembly experiments will be made and an area radiation monitor with alarm will be continuously active or a monitor available at all times during the experiment.

C. Emergency Procedures

- Basic emergency procedures and the NETL Emergency Plan (approved by the U.S. NRC under R-129) in effect for radiological emergencies in the Nuclear Engineering Teaching Laboratory are contained in Appendix H. The NETL Emergency Plan follows the guidance of ANSI/ANS 15.16-2008 and requirements of 10 CFR 50 Appendix E. The NETL considers all significant radiological and security incidents to be reportable at the Notification of Unusual Event (NOUE) level as the fission product inventory of the reactor fuel has been analyzed in the Final Safety Analysis Report to produce minimal doses at the building exterior. An inadvertent criticality of licensed materials stored outside the reactor is not explicitly covered in the Emergency Plan at this time but a change to the Emergency Plan under 10 CFR 50.54(q) will include a criticality accident under events reported to NRC as NOUE without regard to radiation levels at the site boundary. The NETL Emergency Plan requires an annual drill for training and to test response of emergency support organizations. Following ANSI/ANS 8.23-2007 guidance, an additional requirement shall be added to the Emergency Plan (10 CFR 50.54(q)) that will require an annual criticality accident evacuation drill.

- All site security incidents (bomb threat, civil disturbance, security threats or breaches) are reported at the NOUE level with response determined by the NRC approved NETL Physical Protection Plan. These notification levels have been previously reviewed and approved by the NRC under the reactor facility license R-129.

- Special precautions for material storage are required to minimize the potential for airborne radioactivity from exposure to fire hazards. Storage of the subcritical assembly when not in use will be in a tightly closed 55 gallon barrel. The barrel is stored away from flammable materials. The PuBe sources are stored in deep (16 feet) storage pits when not in use. All materials licensed under this application will be stored within the confines of Room 1.104 which is locked and monitored by an alarm system when the facility is not occupied. The laboratory is constructed of firewall and concrete construction. Leakage to the environment during normal operation is controlled by weather stripping entrances, pressure control zones and filtered exhausts.

D. Radiation Safety Training Program

The primary use of radiation sources and the subcritical assembly in the Nuclear Engineering Teaching Laboratory is to support and extend the education of undergraduate and graduate students in basic concepts of nuclear engineering. All staff and students must complete a formal occupational radiation worker training program in accordance with 10 CFR 19.12 before performing radiation experiments or handling radioactive materials. This program will consist of material on radiation interactions, radiation hazards, dose measurements, maintaining personal doses as low as reasonably achievable (ALARA), and laboratory procedures. Specific laboratory procedures include survey requirements, contamination action levels and actions if an individual is found to be contaminated. The course incorporates NRC Regulatory Guide 8.13 and 8.29. Knowledge evaluation is performed by written examination at the completion of the initial training. All personnel (staff and students) who are radiation workers are required to attend refresher training every two years. The Health Physics records and training program are audited and reviewed every year and the results presented to the Reactor Oversight Committee.

VIII. As Low As Reasonably Achievable (ALARA) Program [10 CFR 20.1101]

The "as low as reasonably achievable" goal of a radiation safety program is supported by the procedures of the Radiation Safety Committee, Reactor Oversight Committee and Nuclear Engineering Teaching Laboratory. Many experiments performed on a routine basis do not represent significant radiation doses. Less routine experiments may be occasionally required that represent more significant doses but these experiments are strictly reviewed and controlled under the NETL Radiation Work Permit (RWP) program. RWPs are prepared by the individual responsible for the experiment or project and approved by the HP and Reactor Supervisor. RWPs are reviewed monthly by the NETL HP or a person delegated by the HP. All RWPs are reviewed annually by the ALARA Committee.

Periodic review of radiation doses of staff, students, and visitors is carried out by the HP and the campus Office of Environmental Health and Safety monthly or when the vendor dosimeter reports are received. The NETL ALARA Committee shall annually review dose reports, radiation experiments performed and significant deviations from expected values.

The ALARA Committee will review the circumstances if an individual exceeds the local NETL administrative annual dose limit (currently 1000 mR). The NETL Director may authorize an individual who has exceeded the administrative limit to continue to receive occupational radiation dose with the concurrence of the ALARA Committee.

IX. Material Control and Accountability [10 CFR 70.53 and 70.54]

The Nuclear Engineering Teaching Laboratory maintains a special nuclear material inventory and reporting program in accordance with 10 CFR 74.13 for the University of Texas at Austin. The facility Reporting Identification Symbol (RIS) for the University of Texas at Austin is ZVS. Annual material status reports are made to the Nuclear Materials Management and Safeguards Systems (NMMSS) within sixty (60) calendar days of the beginning of the physical inventory as required by 10 CFR 74.19(c). Transfers and receipts of special nuclear materials are reported in accordance with 10 CFR 70.54 and 10 CFR 74.15 to the NMMSS. Specific procedures for these reports are contained in NUREG/BR-0006 and NUREG/BR-0007.

The current total inventory (SNM-180 and R-129) of special nuclear material at the Nuclear Engineering Teaching Laboratory exceeds the definition of moderate strategic significance per 10 CFR72.2. However, a significant quantity of the materials are in use within the TRIGA research reactor core and are exempt from the physical protection requirements per 10 CFR 73.60. The NETL controls the total quantity of materials such that the facility does not exceed the Category III quantity of special nuclear material of low strategic importance.

X. Physical Protection of Plants and Materials [10 CFR 73]

The Nuclear Engineering Teaching Laboratory implements the requirements of 10 CFR 73 through its NRC approved Physical Security Plan. The latest revision of the Physical Security Plan (October 2006) implements additional security procedures required after September 11, 2001. The Security Plan and implementing procedures require a report to the NRC within one hour of the discovery of a loss or theft of special nuclear material in accordance with 10 CFR 74.11. The requirements and procedures of the Physical Security Plan and the NETL security systems also serve to maintain compliance with NRC Order EA-05-090.

XI. Financial Assurance and Recordkeeping for Decommissioning [10 CFR 70.25]

The subcritical assembly, MCZPR fuel elements and PuBe sources meet the 10 CFR 70.4 definition of sealed sources. The subcritical assembly is owned by the University of Texas at Austin and the PuBe sources and the MCZPR sealed-source fuel elements are U.S. Government owned material. As such, the disposal costs for retrieval and final disposition of the MCZPR and PuBe materials will be the responsibility of the U.S. Department of Energy (DOE). The PuBe sealed sources will be transferred to DOE under a source retrieval program or disposed of directly as radioactive waste, if appropriate. Additional decommissioning costs associated with the subcritical assembly, laboratory cleanup or decontamination from the use of these materials shall be the responsibility of the University of Texas at Austin. The University is a public university, an institution supported by the State of Texas and the University of Texas

System with net assets in 2008 of over $39B.

Estimated decommissioning costs for SNM-180 are estimated to be less than $50,000.00 which the University of Texas at Austin and the State of Texas are financially capable of funding. These costs are based on obtaining a suitable shipping container for the subcritical assembly, shipping costs and determining a suitable waste disposal site or transferring the materials to DOE for uranium recovery.

The Nuclear Engineering Teaching Laboratory has a fully implemented Health Physics monitoring and survey program in accordance with 10 CFR 20 that includes documentation of spills or other contamination events. Routine quarterly environmental liquid samples are performed independently by the Texas Department of State Health Services and the results are reported to the NETL. All contamination events, personnel radiation exposure and facility effluent release are tracked and records are retained for the lifetime of the facility and materials license. The HP program is inspected every other year by the U.S. Nuclear Regulatory Commission as a part of the monitoring of the reactor facility license (R-129) and annually by the State of Texas.

XII. Appendices

A. Nuclear Engineering Teaching Laboratory (NETL) Physical Location (Withheld per 10 CFR 2.390)
B. NETL Level 1 Schematic (Withheld per 10 CFR 2.390)
C. NETL Level 2 Schematic (Withheld per 10 CFR 2.390)
D. NETL Level 3 Schematic (Withheld per 10 CFR 2.390)
E. NETL Room 2.204 location of MCZPR Fuel Elements (Withheld per 10 CFR 2.390)
F. Criticality Safety Analysis for Storage of MCZPR Fuel Elements
G. Subcritical Assembly Fission Product Inventory Analysis

Appendix F: MCZPR Criticality Safety Analysis

Nuclear Engineering Teaching Laboratory
Technical Report

Criticality Safety Analysis for the
Manhattan College Zero Power Reactor
Fuel Elements Storage Rack

Prepared by
Sean O'Kelly
Associate Director

Submitted November 10, 2004

Revised February 10, 2005

Background and Introduction

The Manhattan Zero Power Reactor (MCZPR) fuel elements were transferred to the University of Texas at Austin in August 2004. The materials had been manufactured by the Department of Energy under the University Reactor Fuel Assistance Program to replace a highly enriched reactor core. The replacement core was essentially identical to the original fuel but used a higher fuel loading and lower enrichment. The Manhattan College chose to shutdown the reactor with essentially zero bumup on the fuel elements in the early 1990s. The Department of Energy (DOE) transferred the fuel elements to The University of Texas at Austin in August 2004. A total of 17 elements were received. Each element has a fuel loading of 235 grams with a density of 4.8 grams of uranium per cm^3 with an enrichment of 19.75%. A total of 3,880 grams of U-235 was received in the fuel elements. These 17 elements have been stored in the DOT 6M-type 110 gallon drums at the NETL facility since August 2004.

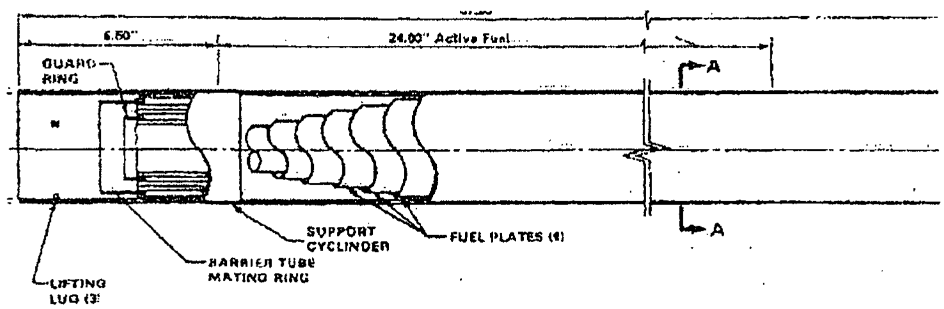

Figure 1. MCZPR Element

The MCZR elements are a uranium silicide-aluminum dispersion fuel developed by Argonne National Laboratory. The fuel elements consist of 6 concentric cylinders with a total active fuel region 24 inches (58.8 cm) tall (Figure I). The total element length is 37 inches. The elements are designed to have a central Lucite hold-down rod in the middle but these rods will not be in place while in the stored condition. The fuel loading per cylinder is given here:

Cylinder Number	Fuel Loading (gms U-235)	Inner Diameter (cm)	Outer Diameter (cm)
1	19.7	3.2	3.454
2	27.4	4.064	4.318
3	35.2	4.928	5.182
4	43.7	5.791	6.045
5	50.6	6.655	6.909
6	58.4	7.518	7.772

Table 1. MCZPR Element Uranium Loading

MCZPR Fuel Element Storage

The 6M-type drums are owned by the DOE and must be returned as soon as possible for the shipment of research reactor fuel to other facilities. The MCZPR elements will be unloaded and kept in a dry storage location until a final experimental design had been established and approved. This storage location will be in the Auxiliary Equipment Room (Room 2.204B) of the Nuclear Engineering Teaching Laboratory (Figure 2).

Description of the Auxiliary Equipment Room

The Auxiliary Equipment Room (AER) was originally planned as a radiation counting laboratory area near the UT TRIGA reactor but it has been used more for equipment and special nuclear material storage over the past ten years. There are multiple electrical outlets but no water or service air available in the room. The primary function for the AER has been to house the radioactive sample transfer pneumatic system blower and controls. Additionally, small quantities of special nuclear materials and reactor safeguards information are stored in a locked safe within the AER.

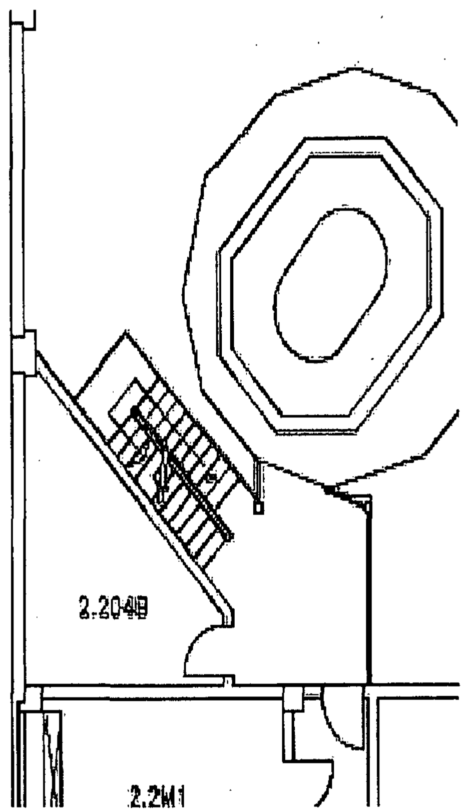

Figure 2. NETL Facility Drawing of Auxiliary Equipment Room

The AER is located on the second level of the reactor room approximately 15 feet above the lowest level of the room. Hence, there is no way for the AER to flood in the unlikely event the reactor pool (containing 10,000 gallons of demineralized water) were to drain into the reactor room.

The AER room walls are fabricated from standard cinder block construction bricks. The single AER door is a hollow fire-rated steel door with a key lock. The only keys available for the door are in the possession of the NETL Reactor Supervisor, stored in the locked key box in the reactor control room and maintained by the University Locks and Keys department. Ventilation to the room is provided by a variable speed exhaust fan. The fan vent is covered with a security grill and ventilation damper.

The AER is within the NETL Protected Area of the Reactor Room. As such, the access to the area is strictly controlled by the used of computerized pass card systems and alarms. The door to the AER is monitored by a motion sensor that alarms at the University Police Department. Full details of the facility security system is contained in the NRC approved Security Plan (approved 1990). The AER is located approximately 20 feet from NETL 1 MW TRIGA research reactor and there is no coupling of the reactor neutron flux to the AER. All NETL experimental neutron sources are stored in another location of the NETL facility and are never used or stored in the AER.

AER Fire Protection Systems

The AER has a heat sensing fire detector near the 12 foot ceiling that initiates a building alarm and an automatic signal to the local fire department. There is no sprinkler or fire suppression system in the room and no water pipes pass through the room. Fire prevention is maintained by controlling the amount of flammable materials stored within the confines of the AER. A portable carbon dioxide fire extinguisher is stored in the room with a dry powder fire extinguisher just outside the room. An additional halogen-type extinguisher is kept approximately ten feet away for fire suppression within the nuclear instrumentation and controls system.

Criticality Storage Analysis

The MCZR elements will be stored in a vertical, linear 1 by 9 array for seventeen elements (Figure 3). An extra storage location is added to maintain the symmetry of the array. The storage rack will be constructed from 4 inch diameter 6061 alloy aluminum pipe in 8 foot lengths. These tubes will be held rigidly together by another aluminum rack and a lockable hinged lid will prevent the insertion of moderating materials. This rack array will be securely fastened to the wall of the storage room. The vertical tubes will be spaced such that they are very close together with no easily accessible area between tubes for moderator material to be accidentally inserted.

Criticality analysis of the proposed storage arrangement was performed using SCALE 5 (Standardized Computer Analysis for Licensing Evaluation). Various storage rack configurations were evaluated but the preferred arrangement (due to physical space in the AER) was the linear 2 by 9 configuration. A more limiting arrangement was expected to be a tight cylindrical or square design. A square 4 by 4 arrangement was tested with the region around the storage tubes flooded, dry, with and without a water reflector. These evaluations were followed by an analysis of a 2 by 9 array and stacked 1 by 9 storage racks.

The most limiting condition was a water moderated and reflected 4 by 4 storage rack. This system would be a supercritical arrangement with a calculated k_{eff} o f 1.0866. The least limiting configuration is the proposed 1 by 9 dry storage array (against a concrete wall) with a k_{eff} of 0.5246 . The 2 by 9 array was also found to be marginally critical (multiplication approximately 1.0) if the system were water moderated and reflected. Although it is extremely unlikely that the AER could ever flood by accident there was still a possibility of inadvertent criticality in the 2 by 9 array and it was discarded for a simple linear array with two fuel elements in a single storage tube. The actual margin from critical is greater than the conservative calculations due to the aluminum extensions on either end of the MCZPR fuel elements increasing the separation of elements and a total of 18 (rather than 17 actual) elements used in the calculations.

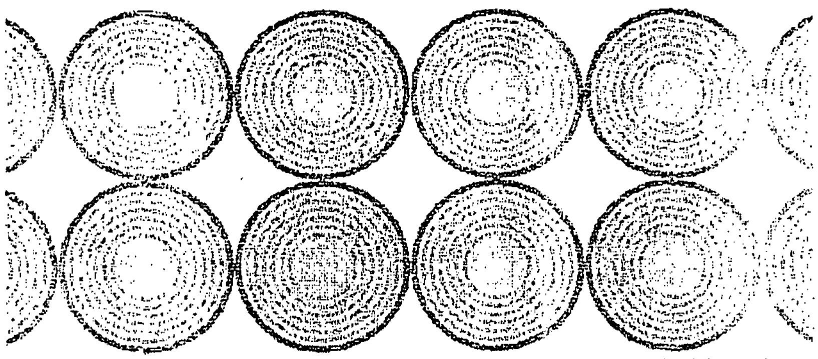

Figure 3. Partial 2 by 9 Array of MCZPR Elements Modeled in SCALE 5

MCZPR Storage Rack Configurations	Calculated Keff
4x4 Array, Water Moderated, Water Reflected	1.08660 + or - 0.00023
4x4 Array, Water Moderated, Bare	0.94998 + or - 0.00027
4X4 Array, Air Moderated, Bare	0.031943 + or - 0.000023
2x9 Array, Water Moderated, Water Reflected	0.98454 + or - 0.00071
2x9 Array, No Moderator, Bare	0.023299 + or - 0.000018
1x9x2 Array, Water Moderated, Water Reflected	0.72842 + or - 0.00067
1x9x2 An-ay, Air Moderated, Concrete Wall Moderated	0.5246 + or - 0.0010
1x9x2 Array, Air Moderated, Bare	0.014971 + or - 0.000039

Table 2. Summary of SCALE 5 Criticality Calculations

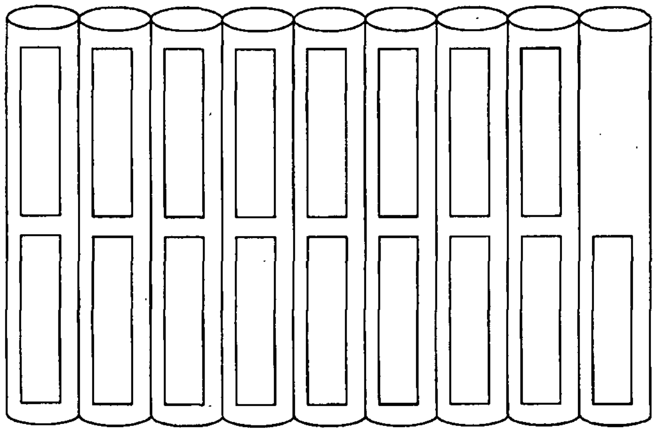

Figure 4. Proposed final design--1 by 9 by 2 Array

An example output file for the 4X4, Water Moderated, Bare SCALE run is given here:

```
*************************************************S************************************
***     ***
*** mczpr storage with H2O     ***
***
        ***********************************************************************
********************1
**I;    ****** final results table     ****** ***
***     best guess system k-eff 0.94998 + or - 0.00027 ***
***     Energy of average lethargy of Fission (eV)     6.57296E-02 + or - 3.75616E-05 ***
***     system mean free path (cm)     3.08324E-01 + or - 3.41858E-05 ***
***     system nu bar   244001E+00 + or - 6.23051E-06 ***
*1*     k-effective satisfies the chi**2 test for normality at the 95 % level
**************************************************************************************
***********************
 congratulations! you have successfully traversed the perilous path through keno v in 13.58650
minutes
```

Transfer and handling of MCZPR Elements

The NETL facility is under the direct supervision of an on-duty NRC-licensed Senior Reactor Operator (SRO) during the normal operational day. The NETL facility has standard procedures for handling special nuclear materials, reactor fuel and radioactive materials. Any fuel handling or manipulation at the NETL facility is supervised by an SRO and conducted by a member of the NETL staff (usually a Reactor Operator or Health Physicist). The MCZPR elements will be unloaded and handled one unit at a time. Each element will be inspected for corrosion or damage from prior storage, identified by a unique serial number and placed into a designated location of the AER fuel storage array.

A calibrated neutron counter and a previously installed criticality monitor will be in operation when moving all the elements into final AER storage as is standard practice when handling critical quantities of nuclear materials. Additionally, a standard so-called "1/M criticality experiment" will be conducted during the fuel transfer. The 1/M experiment evaluates the margin to criticality by performing an inverse neutron counting experiment as the materials are loaded. Work will be stopped and the project will be evaluated in the unlikely event there is a statistical increase in the number of neutron counts between MCZPR element transfers.

Following the transfer of all the MCZPR into the AER storage, the lid will be closed, locked and a serial numbered security seal will be attached to indicate tampering. The materials will be routinely inventoried with all special nuclear materials at the NETL.

Conclusion

The staff at the NETL have concluded the MCZPR elements may be safely transferred and stored in the facility. The NETL has begun acquiring the materials to build the storage rack. The Nuclear Reactor Committee of the University of Texas at Austin (oversight committee for the NETL) has reviewed the proposed storage rack design under 10 CFR 50.59 and found it satisfactory.

Appendix G: Subcritical Assembly Fission Product Inventory Analysis

Experimental measurements with a neutron source of 1.6 x 10^6 n/sec generate a neutron density approximately but conservatively represented by n(x) = a(sin bx)/x in both axial and radial dimensions. The constants are determined to be a = 50 x 10^{-3} n/cm^2, and b = .18 cm ^{1}. The total fission rate in the assembly is then determined by $\int \sum_f n(r)\ V\ dr$ where V is the thermal neutron velocity 2.2 x 10^5 cm/sec. The total fissions/sec are calculated to be 9.65 x 10^4. With an energy release of 185 MeV/fission the power of the assembly will be (9.65 x 10^4 fission/sec) x (185 MeV/fission) x (1.60 x 10^{-13} watts/MeV) equals 2.86 x 10^{-6} watts. A source strength of 8.82 x 10^6 n/sec would generate 15.8 x 10^{-6} watts. The smaller source represents about 90 watts-sec of power/year of continuous operation.

A more realistic estimate is 100 hours/year or about 5.71 watts-secs with the larger source. From 1960 till 1985 100 hr/yr operation with the larger neutron source results in (25 yr) x (3.15 x 10^7 sec/yr) x (1.15 x 10^{-5}) x (9.65 x 10^4fissions/sec) x(8.82x 10^6 n/sec) / (1.6 x 10^6 n/sec) is 4.80 x 10^{12} fissions. Assuming that after 100 days the fission products beta decay at a rate of 10^{-8} decays per fission then (4.8 x 10^{12} fissions)x (10^{-8} decays/fission) x (3.7 x 10^4 decays/u curie) is less than 1.5 u curies of activity.

Appendix H: NETL Emergency Plan

Emergency Response Plan

for the
UT TRIGA Mark II
Reactor Facility

Nuclear Engineering Teaching Laboratory

October 2006
Revision 2

Approvals:

______________________________	____/____/____
Facility Director, NETL	Date
______________________________	____/____/____
Chairperson, Nuclear Reactor Committee	Date

The University of Texas at Austin
J. J. Pickle Research Campus