# Environmental Report

## University of Utah

## Center for Excellence in Nuclear Technology, Engineering, and Research

License: R-126

Docket: 50-407

January 7, 2005

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## 1. Introduction

This environmental report is prepared in accordance with 10 CFR 51 to support the nuclear reactor license renewal application at the University of Utah. The University of Utah TRIGA Reactor (UUTR) is a light-water cooled and moderated reactor using uranium fuel enriched at <20%. The reactor is currently licensed to operate at thermal power levels up to 100 kW and application has been made to increase the maximum thermal operating power to 250 kW. The reactor is housed in the Merrill Engineering Building on the main campus of the University of Utah. A full description of the reactor is contained in the University of Utah, Safety Analysis Report, License R-126 Docket Number 50-407. The reactor and the associated laboratories, which support the reactor, are an essential teaching and research component of the Nuclear Engineering Program at the University of Utah.

## 2. Proposed Actions

We propose to continue operating the UUTR that was initially licensed in 1975. The UUTR license was renewed in April 1985 to extend to April 2005. The UUTR has a history of safe and reliable operations. With the application to extend the operating license beyond the initial 30-year authorization, an increase the maximum steady-state thermal power to 250 kW is also being requested.

## 3. Impact of the Proposed Action

The Center for Excellence in Nuclear Technology, Engineering, and Research (CENTER) is founded on the following premise: Education through Research and Service. The CENTER is the research entity on campus that is responsible for the UUTR operations and administration. The UUTR is operated solely for educational and research purposes. The reactor significantly contributes to the local and larger regional and national education community. The impact the proposed action of extending the UUTR operating license on each component education, research and service is identified in the following sections.

### 3.1 Education

The reactor is the keystone of the Nuclear Engineering Program (NEP) at the University of Utah. The UUTR is operated and maintained by the faculty and students of the NEP and provides comprehensive experience in research and training reactor operations and safety. The NEP courses include imbedded laboratories focused on reactor physics, operations, safety, regulations, radiation sciences, and other applications. The NEP typically graduates 2 Masters and 2 PhDs Nuclear Engineering Degrees and associated minors annually. In addition the NEP curriculum is accepted as undergraduate technical electives in Civil and Environmental Engineering, Chemical Engineering, Mechanical Engineering, and Electrical Engineering. This cross listing of the Nuclear Engineering curriculum promotes greater understanding and diversity for students in these disciplines. The past success of these nuclear technical electives has stimulated the NEP to create new coursework and begin the process of establishing a minor in Nuclear Engineering at the Bachelor of Science level. The faculties that service the NEP curriculum are multidisciplinary with appointments in Civil and

Environmental Engineering, Chemical Engineering, Mechanical Engineering, and the School of Medicine.

### 3.2 Research

The UUTR and the associated Radiochemistry Laboratories support a variety of research programs including radiochemistry, fission track analysis for plutonium detection, neutron induced autoradiography for determining distribution of plutonium in samples, Monte Carlo N-Particle (MCNP) modeling for reactor physics and dose reconstruction, and neutron activation analysis. These NEP research programs have crossed international boundaries including agreements with the Russian, Australian, and Marshall Island governments. National laboratories, other universities, federal contractors, and private industry have employed the graduate students funded by these research programs. The CENTER faculty, staff, and students are committed to expanding these research programs, publishing significant results, and improving nuclear engineering and nuclear science education and training. The NEP at the University of Utah is an important contributor to the scientific and technical manpower needs for the US.

### 3.3 Service

The UUTR also provides service (e.g., radiation services, health physics, regulatory support, etc.) and support for local government agencies and industries. The UUTR is the only research reactor in the intermountain region and does not compete with others to provide services available commercially. The UUTR is a major educational resource for the region and provides training, tours, and other educational activities to regional universities and high schools. The UUTR is the only NIST traceable research reactor to provide "1 MeV-Silicon equivalent neutron doses". This specialized service is essential for electronic hardening and materials damage testing required by the US Air Force and supports the mission of Hill Air Force Base and Logistic Center. Other UUTR services provided to the community include outreach programs for K-12 students including tours and simple radiation experiments, workshops for science teachers ("teach the teachers") and allowing Boys and Girls Scouts to obtain "atomic energy" badges.

### 3.4 Future Educational Needs and Goals

The US and the world are highly dependent on nuclear technologies ranging from the smoke detectors to the sterilization sources used for medical devices. These technologies need trained engineers to create and execute new applications of radiation properties. In addition to industrial needs, nuclear power remains a vital solution to the energy needs of world. To meet these needs US universities need to maintain a viable educational infrastructure for the next generation of engineers and scientists. The University of Utah remains committed to providing a strong nuclear education through the use of the UUTR. The UUTR is operated and maintained by students, creating a true hands-on learning environment superior to programs where modeling and simulation have become the standard focus.

The NEP is currently expanding its role in the College of Engineering. Long-term planning includes relicensing the TRIGA Reactor, creating three new undergraduate courses (viz., Health Physics, Nuclear Power, and a general education class entitled "Nuclear Engineering Fact, Fiction, Responsibility and Promise"). These new courses will be used to create a minor in Nuclear Engineering at the BS level while maintaining the high standards of the graduate program.

## 4. Unavoidable Environmental Risks

Great effort is taken by the CENTER the operation of a reactor to minimize the generation of hazardous and radioactive materials. The UUTR as do other university research reactors generates the following low-level environmental impacts: Solid, liquid and gaseous radioactive material releases and waste heat. All releases from the UUTR are documented and reported to the Nuclear Regulatory Commission in "The University of Utah TRIGA Reactor Annual Operating Report" submitted annually each August. Table 4 is a summary of the solid, liquid and gaseous releases from the UUTR during the past 5 years. More detailed information is contained the section addressing each release category. All releases were very low and well within regulatory limits.

**Table 4. Summary of UUTR Releases for the past 5 years.**

| Year | Release | | |
|---|---|---|---|
| | Solid | Liquid | Ar-41 |
| 1999-2000 | 0 | 15.89 mCi $H^3$ | 221.72 μCi |
| 2000-2001 | 2.08484 μCi | 0 | 44.784 μCi |
| 2001-2002 | 0 | 0 | 39.497 μCi |
| 2002-2003 | 0 | 0 | 16.731 μCi |
| 2003-2004 | 0 | 0 | 20.821 μCi |

### 4.1 Solid Radioactive Waste

Solid radioactive wastes created in using the reactor include gloves, paper towels, spent samples and sources, resin from the demineralizer system and contaminated laboratory supplies, (glass ware, spatula's). Solid waste is transferred to the University of Utah Radiological Health Department for disposal under its Broad Form License. Table 4.1 contains a description of the specific isotopes released in 2000-2001.

**Table 4-1. Solid waste shipped between 7-1-00 and 6-30-01**

| Isotopes | Amount (μCi) |
|---|---|
| Eu-152 | 0.4338 |
| Cs-134 | 0.5396 |
| Mo-99 | 0.0017 |
| Co-60 | 0.0265 |
| Mn-54 | 0.0040 |
| Sb-124 | 0.6288 |
| Nd-147 | 0.4406 |
| Sc-46 | 0.0098 |

The requested power upgrade for the UUTR will not significantly affect the anticipated solid radioactive waste generated at the UUTR.

### 4.1.1 Fuel

The UUTR uses low enriched (<20%) TRIGA fuel. The average annual burn-up rate of the fuel is less than 1 gram $U^{235}$ annually. Because of this low burn-up rate, no special requirement for fuel replacement is required. The U.S. Department of Energy retains ownership of all UUTR fuel. The UUTR is in the process of replacing the aluminum-clad fuel with stainless steel clad fuel. All fuel shipping will be performed in accordance with the current licensing and regulatory requirements.

## 4.2 Liquid Radioactive Waste

Water from routine UUTR maintenance operations is released to the sanitary sewage system. Prior to release, radiological analyses must confirm that the discharged water effluent is within regulatory release limits. This release is supervised and monitored by the Radiological Health Department. When liquid effluents may exceed regulatory release limits, these effluents are transferred to the Radiological Health Department for proper processing and disposal. In 1999 approximately 10 gallons of liquid effluent containing 0.9048 mCi of tritium was transferred to Radiological Health for disposal. This Department handles the disposal of all radioactive wastes for the University campus, research and medical facilities.

## 4.3 Radioactive Gases

The production and release of radioactive gases is related to the power level and run time of the UUTR. At 90 kW operations, argon-41 production is substantially below effluent concentration limits for unrestricted areas. The peak minimum detectable concentration of Ar-41 for the stack monitor is one-third of the 10 CFR 20 limit for release to unrestricted areas. The maximum release of Ar-41 from UUTR operations has been less than 10% of maximum permissible concentration (MPC) for unrestricted release. At 250 kW the release of Ar-41 will remain below the derived air concentrations and effluent concentrations defined in 10 CFR 20.

## 4.4 Waste Heat

The UUTR core is cooled by a natural convection. A 25kW shell and tube heat exchanger is installed to provide cooling. The heat exchanger is charged with R-134A. Heat from the R134A is transferred to an independent water source that is released to the sanitary sewer system. The heat exchanger requires a low flow rate 15gpm and the maximum temperature of the released water is less than 95 C. This release water is monitored for radiation levels. The released sewage has a negligible heating impact upon the environment.

## 4.5 Personnel Monitoring

The University of Utah Radiological Health Department issues and monitors personnel with duties in the reactor laboratory on a regular or an occasional basis as necessary. Radiological Health Department provides radiation training and dosimetry for all University personnel accessing radioactive materials or radiation areas as necessary. The duty category and monitoring period for personnel at the UUTR for the past 5 years are summarized in Table 4.5

**Table 4.5 CENTER Reactor Personnel Exposure**

| Year | Numbers of monitored persons in annual-dose category | | |
|---|---|---|---|
| | < 0.1 rem immeasurable | 0.1 –0.5 rem | > 0.5 rem |
| 1999-2000 | 15 | 0 | 0 |
| 2000-2001 | 17 | 0 | 0 |
| 2001-2002 | 13 | 0 | 0 |
| 2002-2003 | 13 | 0 | 0 |
| 2003-2004 | 12 | 0 | 0 |

### 4.6 Environmental Monitoring

Six environmental monitoring stations were established in July of 1987 for recording and documenting radiation exposures from airborne radioactivity and deposition of contamination on surrounding surfaces. Three of these stations are located on the roof of Merrill Engineering Building, where the reactor is housed. The other three stations are located on the roofs of adjacent buildings; viz., Kennecott Research Center, EMRL, and Building #80. One environmental TLD badge is placed at each station and exchanged quarterly. The data collected from 1997 to 2003 is presented in Table 4.6. The University of Utah Radiological Health Department administers these environmental stations.

## 5. Alternatives to Continued Operations of the UUTR

Each US university research reactor is a unique facility, with individual educational and research objectives. The loss of any of the remaining US university reactors would constitute a significant weakening of the US ability to operate and control nuclear related facilities. A National Academy Study performed recently confirmed this observation. The UUTR is unique and an essential training and research tool. Students and faculty have direct access to the facility and intimate involvement with operations, control, and regulation. The faculties of the NEP are fully committed to maintaining close ties between the reactor and the University's educational program. However, the continued operation of UUTR is not guaranteed and is subject to changes in U.S. policy, regulatory issues, and societal pressures. The effect of the decommissioning the UUTR would probably entail significant impact and possible closure of the Nuclear Engineering Program (NEP) and loss of research and service programs. At this time there are no plans for decommissioning the UUTR by the University of Utah Administration.

## Table 4.6 CENTER Environmental Monitoring Results (mRem)

| Year | QTR | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1997 | 1 | 28 | 34 | 35 | 42 | 35 | 40 |
| | 2 | 30 | 23 | 29 | 34 | 27 | 28 |
| | 3 | 26 | 22 | 26 | 34 | 23 | 33 |
| | 4 | 28 | 21 | 25 | 30 | 24 | 28 |
| | Average quarterly readings 29±6 Background 20% = 34 Background at location #5 28±6 | | | | | | |
| 1998 | 1 | 29 | 29 | 29 | 41 | 29 | 36 |
| | 2 | 28 | 25 | 29 | 30 | 23 | 34 |
| | 3 | 22.4 | 22.4 | 21.6 | 29 | 21.4 | Absent |
| | 4 | 21.5 | 23.6 | 26.8 | 34 | 26.2 | 57*** |
| | Average quarterly readings 28±5 Bkg 20% = 34 Bkg at location #5 28±6 | | | | | | |
| 1999 | 1 | 25 | 24.2 | Absent | Absent | 29 | 33.8 |
| | 2 | 25.8 | 29.2 | 26.8 | 32.6 | 29.2 | 34.4 |
| | 3 | 34.4 | 29.8 | 33.4 | 36.4 | 39.6 | 38.4 |
| | 4 | 29 | 33 | 30.6 | 36 | 41.4 | 38.6 |
| | Average quarterly readings 31.2±7.9 Bkg 20% = 37.4 Bkg at location #5 34.8±6.6 | | | | | | |
| 2000 | 1 | 29 | 33 | 30.6 | 36 | 41.4 | 38.6 |
| | 2 | 27.2 | 29.2 | 29.4 | 47 | 59 | 39.6 |
| | 3 | Absent | 25.2 | 23.2 | 30.2 | 35.2 | 38.6 |
| | 4 | 34.8 | 29 | 30.6 | 38.2 | 42.4 | 33.4 |
| | Average quarterly readings 34.8±7.9 Bkg 20% = 41.8 Bkg at location #5 44.5±10.2 | | | | | | |
| 2001 | 1 | 15 | 15 | 15.8 | 18.8 | 20.3 | 20.3 |
| | 2 | 26 | 29 | 29 | 31 | 37 | 36 |
| | 3 | 24 | 26 | 23 | 39 | 34 | 34 |
| | 4 | 21 | 24 | 27 | 28 | 33 | 31 |
| | Average quarterly readings 26.5±7.0 Bkg 20% = 31.8 Bkg at location #5 31.1±7.4 | | | | | | |
| 2002 | 1 | 33 | 29 | 32 | 37 | 39 | 55*** |
| | 2 | 25 | 26 | 26 | 33 | 36 | 33 |
| | 3 | 31 | 27 | 26 | 34 | 38 | 37 |
| | 4 | 37 | 35 | 35 | 42 | 50 | 42 |
| | Average quarterly readings 34.04±6.1 Bkg 20% = 40.8 Bkg at location #5 40.75±6.29 | | | | | | |
| 2003 | 1 | 35 | 31 | 32 | 39 | 42 | 40 |
| | 2 | 31 | 28 | 27 | 32 | 43 | 38 |
| | 3 | 36 | 35 | 31 | 39 | 46 | 42 |
| | 4 | 27 | 32 | 35 | 37 | 44 | 42 |
| | Average quarterly readings 36±5.56 Bkg 20% = 43.2 Bkg at location #5 43.75±6.29 | | | | | | |

***No control available for this measurement

Environmental monitor locations are defined as follows

- #1 MEB, NW - NW corner of MEB roof on steel beam
- #2 MEB, NE - NE corner of MEB roof on steel beam floor
- #3 MEB, SE - SE corner of MEB roof on steel beam
- #4 EMRL, - N end on roof facing MEB
- #5 BLDG 80 - E Window outside 2nd
- #6 KRC, N - N end on roof facing MEB

## 6. Analysis

The UUTR is an integral part of the University of Utah's Nuclear Engineering Program. Based on the data presented here the facility is operating with minimal radiation exposures and releases, well within regulatory limits. Personnel, environmental and Area radiation monitoring confirm that all exposures are within ALARA expectations. The UUTR is an existing facility. No capital funds are required for continued operation. The desirable and anticipated decision is that the UUTR Reactor License be renewed and the power upgrade be approved.

## 7. Long Term Effects on the Environment.

At the eventual closure of UUTR operations, all areas housing or impacted by the UUTR and the affiliated laboratories will be decommissioned and returned to general university use. The reactor fuel (owned by the DOE) will be shipped to a designated DOE facility. Upgrade of the UUTR power level will not materially impact this outcome. Indeed, it is anticipated that the increase in power level will significantly enhance the services and research potential of the facility. The environmental impact associated with renewing the UUTR license and upgrading the power are deemed to be insignificant compared to the positive benefits resulting from enhanced educational and research opportunities offered by the University of Utah to the nation.