ENVIRONMENTAL REPORT

Kansas State University

TRIGA Mark II Nuclear Reactor Facility

License R-88

Docket 50-188

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1. INTRODUCTION

This environmental report is prepared in accordance with 10 CFR 51 as part of the nuclear reactor license renewal at Kansas State University. The Kansas State University TRIGA Mark II nuclear reactor (K-State TRIGA) is a light-water cooled and moderated reactor using uranium fuel. The reactor is now operated at thermal power levels up to 250 kW and an application has been made to increase the maximum power level to 500 kW. The reactor is housed in the KSU Reactor Facility located in Ward Hall on the main campus of Kansas State University in Manhattan, Kansas. A full description of the reactor is contained in the Facility Safety Analysis Report, License R-88, Docket 50-188. Faculty providing training and education for nuclear engineers and heath physicists, and research scientists specializing in nuclear science and other disciplines use the reactor extensively as an education, training and research tool.

There are no safety considerations dependent on the duration of operations at the K-State facility. Because of licensed power and operating history of the facility, there are no fuel burn up or material damage issues to be considered.

2. PROPOSED ACTIONS

We propose to continue operating the Kansas State University TRIGA Research Reactor (K-State TRIGA) as we have done since 1962. The K-State TRIGA has a nearly 40-year history of safe and reliable operations. The reactor was initially licensed in 1962 to operate at steady thermal power levels up to 100 kW. In 1968, authorization was given by the Atomic Energy Commission to increase the maximum steady-state thermal power to 250 kW and to permit pulsing the reactor to a peak thermal power of approximately 250 MW (2.00$ reactivity insertion). With the application to extend the operating license beyond the initial 40 years, authorization is sought to increase the maximum steady-state thermal power to 500 kW and to permit pulsing the reactor to a peak thermal power of approximately 1000 MW (3.00$ reactivity insertion).

3. IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

The K-State TRIGA is operated solely for educational and research purposes, which benefit the community, the country and the environment. Specific benefits include:

3.1 Nuclear Education

3.1.1 Nuclear Engineering

Nuclear engineering is the principle discipline concerned with the safe release, control, and utilization of all types of energy from nuclear sources. Energy is needed to meet the world's technological needs and to maintain a suitable standard of living. Nuclear reactors are used to produce radioisotopes for diagnosis and therapy of disease, to produce research radio chemicals, and to provide energy sources for medical devices such as pacemakers and for probes to outer space. The engineering of safe nuclear power sources is vital to the future growth of the world.

K-State had one of the a seminal U.S. Nuclear Engineering departments, which evolved (along with the K-State Mechanical Engineering department) into the Department of Mechanical and Nuclear Engineering (MNE). MNE offers nuclear education under a formal Nuclear Option program. All MNE students, regardless of enrollment status in the Nuclear Option, are educated in a fundamental nuclear engineering course. Therefore, K-State has the largest population of undergraduate engineering students receiving nuclear education. One strength of the Department of Mechanical and Nuclear Engineering is the on-site nuclear reactor. The Kansas State Nuclear Engineering program builds upon the foundations of mathematics, physics, thermal hydraulics, material science, radiation protection, radiation transport, interaction of radiation with matter and applied computer science. On top of this foundation, the K-State TRIGA serves as a training site for the mechanical and nuclear engineering students. At the K-State TRIGA the students gain practical experience in reactor operations, reactor safety, environmental concerns, health physics and interactive decision-making.

3.1.2 Heath Physics

Health physics is a professional discipline based upon the scientific knowledge of, and the practical means for, radiation protection. The objective of a health physicist is to protect people and the environment from unnecessary exposure to radiation. Thus, the basic tenets of radiation must be understood, radiation knowledge explored, practical problems evaluated, radiation effects established and risk measurements relative to effect derived and implemented.

Many of the nuclear engineering graduates from Kansas State University enter professional careers in health physics and medical physics and the Kansas State University Research Reactor provides an essential component to their education. The reactor provides the student with hands on, real world laboratory experience. It is at the reactor where the health physicist or medical physicist of the future learns how to monitor accelerators or nuclear reactors for safety, how to communicate with regulatory agencies, how to implement emergency plans and how to monitor for environmental radiation.

3.1.3 Community

High school science classes use the K-State TRIGA for education and projects. The reactor is used by the Boy Scouts of American for earning the nuclear merit badge. Annual programs offered through the K-State Engineering office and the K-State Extension office use the reactor in education programs for high school students interested in science. Students and faculty at the reactor often participate in middle school or high school "career days" representing nuclear science. Extensive tours are given to elementary and secondary student groups as well as university students and civic groups. Members of the staff of the Reactor Facility are active participants in city and county emergency planning groups and frequently host emergency training, drills, and exercises. The Reactor Facility also hosts training programs for operating personnel at nuclear power plants in Kansas and Nebraska.

3.2 Support of Scientific Programs

In addition to the educational programs, the K-State TRIGA and associated laboratories support research programs not only within the university but also for educational and other public institutions throughout the country.

3.2.1 Nuclear Research Programs

The K-State reactor is supported by associated facilities, including specially equipped laboratories for neutron activation analysis and neutron radiography. Extensive use of the reactor is made by researchers in the physical sciences as well as plant and animal sciences. Over the years, neutron activation analysis work performed for geologists around the country has constituted the bulk of the scientific support work at the K-State TRIGA Reactor Facility.

3.2.2 Indirect Nuclear Research Programs

The Reactor Facility is supported by the U.S. Department of Energy as a Reactor Sharing Facility. Among institutions making use of or supported by the Reactor Facility are universities, law enforcement organizations, and such national organizations as the National Transportation Safety Board and the Armed Forces Radiobiology Research Institute.

3.3 Education for Future Energy Needs

The availability of energy strongly affects standards of living and quality of life. The increase in energy consumption is driven by the world population growth and by the desire of people everywhere to have higher standards of living. In nations where there are adequate supplies of electrical energy, health care improves, more children receive education, work is more productive, pollution control is better, life spans are longer, and more people have hopes for a better life for their children in stark contrast to energy poor countries.

Nuclear energy is a vital part of the nation's energy future. Nuclear energy produces thermal power without the release of carbon dioxide. Current scientific information indicates a strong correlation between carbon dioxide concentration in the atmosphere and mean earth temperature. An increase of mean earth temperature could cause significant worldwide environmental changes. Similarly, research suggests sulfur dioxide emissions from fossil fuel plants contributes to acid rain, particulate and nitrous oxide emissions pose health hazards. Controls for these pollutants are costly, so that revitalization of nuclear power is being encouraged from ecologic and economic imperatives.

The demand for nuclear graduates supporting research into new-generation plants, engineering and operating staff, and health physicists at current (2002) levels is not being met. As the nuclear industry becomes more active, it is essential that the education infrastructure expand to ensure an educated nuclear workforce. K-State is the only institution in the Great Plains with an active nuclear education program supported by a reactor.

4. Unavoidable Environmental Risks

Some low-level environmental risks cannot be eliminated. They include the use of nuclear fuel, the production of minimal gaseous effluents, the generation of some liquid and solid radioactive wastes, some waste heat, and some radiation exposure of personnel to radiation. None of these are considered significant with respect to environmental impact although each is individually assessed. They are:

4.1 Nuclear Fuel Cycle

The K-STATE TRIGA is designed for nominally 85 Mark II TRIGA fuel elements closely packed in a cylindrical core approximately 23 cm in radius and 38 cm in depth. Each fuel element contains up to 39 grams of uranium enriched up to 20% in ^{235}U in a $ZrH_{1.6}$ matrix. The annual burn-up rate depends on the extent of reactor usage but is typically less than 1 gram of ^{235}U annually. Because of the low burn-up rate there is no special need for fuel replacement.

4.2 Radioactive Waste

Radioactive waste is generated from the research operations of the facility. This waste is either in liquid or solid form. The solids include absorbent paper, plastic gloves, spent samples, some contaminated laboratory apparatus, spent standards, clean-up resins from the demineralizer systems, etc. Liquid wastes consist of spent standards, diluents, and rinsing of contaminated objects during the decontamination process.

All of the solid radioactive wastes generated in the entire university are accepted and processed by the University Office of Radiation Protection in the Division of Public Safety. Short-lived isotopes (< 30 d) are stored in a secure facility. Radioactive materials with a longer half-life are consolidated, compacted or treated to reduce volume and shipped to established radioactive waste disposal sites.

The recent history of solid waste transfer from the Reactor Facility is as follows:

K-STATE NUCLEAR REACTOR SOLID WASTE TRANSFERS	
YEAR	RELEASE
1994	77 mCi ^{3}H, 64 mCi ^{60}Co, 80 mCi ^{90}Sr, and 24 mCi of mixed radionuclides
1995	One 55 gal drum of dry waste containing up to 55 µCi of ^{60}Co; 29 ventilation filters with no detectable activity; 4 ventilation filters with hot spots up to 3000 cpm above background (< 1 µCi)
1996-2002	None

4.3 Release of Liquid Wastes

The history of liquid releases since 1995 is as follows. Virtually all releases are seasonal and are tritium contained in air-conditioning condensate.

K-STATE NUCLEAR REACTOR LIQUID WASTE				
Date	Quantity released (m^3)	Measured pCi/mL above background		
		Alpha	Beta[a]	Gamma[b]
11 Aug 99	2.5	0	38	0
6 Jul 99	2.5	0	26	0.034
26 Aug 98	2.5	0	55	0.10
27 Jul 98	25[c]	0	67	0
21 Jul 98	2.5	0	206	0.23
26 Jun 98	2.5	0	89	0.27
16 Oct 97	2.7	0	120	0
8 Aug 97	2.3	0	250	0
27 May 97	0.7	0	0	0
5 Dec 96	3.3	0	150	0
12 Aug 96	3.0	0.004[d]	193	0
26 Jun 96	3.2	0	116	0
5 Sep 95	3.0	0	135	0
15 Aug 95	4.2	0	138	0
17 Jul 95	4.2	0	54	0
7 Jun 95	3.2	0	54	0

[a] Tritium as HTO
[b] ^{137}Cs-^{137m}Ba
[c] Draining bulk shield tank
[d] Unidentified anomaly

4.4 Release of Radioactive Gases

In practice, ^{41}Ar gas is the only gaseous radioactive effluent emitted from the reactor. A detector located within the effluent emission flow path continuously monitors the release rate. Proposed Technical Specifications would limit releases to 30 Ci annually. Appendix A of the Facility Safety Analysis Report shows that at this limit, the maximum off-site annual dose would be only 2 mrem (0.02 mSv), well within applicable limits.

The K-State TRIGA staff routinely monitor for other potential effluent noble gases, halogens, or particulate matter. None have been detected in normal operations. During accident conditions, detection of gaseous releases would lead to reactor shutdown and closure of ventilation.

4.5 Heat Generation

The heat generated in the reactor is first passed to the primary loop of coolant water and then transferred to an isolated secondary loop of regular water. The warm water is then transferred to a cooling tower, where the environmental impact is negligible.

4.6 Radiation Exposure of Personnel

Radiation exposures to reactor users and the operating staff are very small. Radiation exposures during the most recent years studied were as follows:

K-STATE REACTOR PERSONNEL EXPSOURE				
	Numbers of persons in annual-dose categories			
Year	**Immeasurable**	**< 0.1 rem**	**0.1-0.5 rem**	**> 0.5 rem**
1992	28	0	0	0
1991	23	0	0	0
1990	20	0	0	0
1989	19	1	0	0
1988	23	3	1	0
1987	23	0	0	0
1986	26	1	0	0
1985	31	8	0	0
1984	33	1	0	0
1983	29	2	0	0
1982	26	7	0	0
1981	11	23	0	0

The K-State TRIGA Reactor Facility has an active "AS LOW AS REASONABLY ACHIEVABLE" (ALARA) policy in place. In essence, The Program attempts to achieve, through engineering controls and thorough planning, detailed procedures to minimize radiation exposures to as low as possible. The goal is no annual exposure in excess of 10% of occupational limits and 50% of public limits.

4.7 Environmental Radiation Exposure

Environmental Radiation Exposures around the reactor are monitored both by K-State TRIGA and University health physics staff. For the period 1988-1998, exposure rates at the site boundary during full power operation averaged 0.03 ± 0.02 mR/hour, with background approximately 0.01 mR/h.

5. ADDITIONAL ENVIRONMENTAL BENEFITS

5.1 Provision of Short Half-Life Radioisotopes

The availability of a nuclear reactor on campus provides researchers the opportunity to use short half-life radioisotopes unavailable to users that don't have access to an on campus reactor. For example, sodium-22 is a typical sodium isotope that scientists use if they have to purchase the isotope from a commercial source. Sodium-22 has a half-life of 2.26 years. As an alternative and because of the capabilities of an on-site nuclear reactor, sodium-24 may be used. Sodium-24 has a 15-hour half-life. Thus potential problems with packaging, shipping or receiving sodium-22 from a commercial source are diminished. Furthermore, sodium-24 can be held for radioactive decay for one week when all radioactivity has dissipated. In contrast, all materials contaminated with sodium-22 would require radioactive waste disposal in a permitted site

5.2 Public awareness of environmental energy alternatives

The K-State TRIGA faculty and staff provide an open forum for the education about alternative energy sources. An informed public can make informed decisions. Because of the K-State TRIGA, Kansas State University employs faculty and staff with an expertise in nuclear science. This expertise is used to advise on radiological safety and alternative energy sources and issues germane to the local community. Such issues include regulations, radiation safety and environmental control for other universities, colleges and schools, industry and resolution of legal issues regarding ionizing radiation.

6. ALTERNATIVES TO CONTINUED OPERATIONS OF REACTOR

There is no comparable alternative facility. If the reactor is not relicensed, the quality of education for nuclear engineers and health physicists will be diminished. Research projects will come to a halt. The forward progress of nuclear science technology will be decreased.

7. RELATIONSHIP BETWEEN LOCAL AND SHORT-TERM USES AND LONG-TERM BENEFITS

The short term use of the K-State TRIGA centers around the education of nuclear engineers, health physicists, research scientists and the general education of the students and community about nuclear energy and radioisotopes.

The long-term contribution that the K-State TRIGA provides comes from the many contributions to society made by graduate engineers and scientists to the country. Numerous novel ideas have been developed over the past thirty years by students and scientists at K-State TRIGA. Some of these ideas have turned into commercial products and successful businesses. The K-State TRIGA serves as radiation science incubator of ideas and products. These products and services have an intrinsic societal value.

The continued operation of the K-State TRIGA is not an irreversible commitment. Changes in programs, extent of operations, and potential decommissioning are all equally possible at any time in the future.

8. ANALYSIS

The K-State TRIGA is an important education facility. It is an integral part of the Kansas State University plan for education, research and service commitment. It is an essential tool to all scientists. It has no significant adverse environmental impact. Radiation exposures to non-K-State TRIGA personnel are not significant when related to the variation in natural radiation in the same area.

The K-State TRIGA is already in operation. New capitalization funds are not necessary. It is the most prudent use of taxpayers money to continue operation of the nuclear reactor. At this point in time, initial capital investment costs have been paid off. All technology, science, education and services rendered now are at minimal cost. Thus the resultant benefit/cost ratio is very high.
The K-State TRIGA provides numerous technological spin-off's of products and services to the community. Graduates of the Kansas State University program are making significant contributions to the resolution of societal energy development problems and contribute products and services for the community.

The K-State TRIGA is the type of reactor potentially best suited for the evaluation of a new type of irradiation therapy known as neutron capture therapy. This technology has the potential for treatment of certain types of brain tumors that heretofore resisted all other forms of therapy.

9. LONG TERM EFFECTS ON THE ENVIRONMENT

At the end of its useful life, the K-State TRIGA site will be returned to general university use. The small additional increase in fuel bum-up will not be a significant factor. When finished, the fuel rods will be sent to a DOE facility where the unspent uranium will be recovered and the radioactive byproducts recovered for commercial use or packaged and shipped for disposal through commercial radioactive waste disposal brokers.

The long-term effects on the environment from renewing the operating license for the K-State TRIGA are insignificant.