AFRRI

ENVIRONMENTAL REPORT
FOR THE
AFRRI-TRIGA REACTOR FACILITY LICENSE R-84

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PREPARED BY

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FOR

DEFENS_ :UCLEAR AGENCY
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ENVIRONMENTAL REPORT FOR THE AFRRI-TRIGA REACTOR

Submitted to:

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Note: This Environmental Report is submitted in addition to the Environmental Impact Appraisal Data already provided. Extensive reference must also be made to the Safety Analysis Report dated 12 May 1981.

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FOR THE ARMED FORCES RADIOBIOLOGY RESEARCH
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1.0 INTRODUCTION

As required by the National Environmental Policy Act of 1969 (NEPA), the U.S. Nuclear Regulatory Commission must consider environmental aspects of proposed Commission actions. This Environmental Report has been prepared in accordance with 10 CFR Part 51 to aid the Commission in complying with NEPA in connection with the Commission's licensing activities. This Environmental Report is part of the application for NRC relicensing of Facility License No. R-84 for the Armed Forces Radiobiology Research Institute (AFRRI) TRIGA Mark-F research reactor as required by 20 CFR Part 50.30. The Environmental Report considers the environmental effects that can be attributed to the operation of the TRIGA Mark-F reactor as well as other pertinent areas.

2.0 ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

AFRRI is a tri-service military organization under the Defense Nuclear Agency. The mission of AFRRI is to conduct scientific research in the field of radiobiology and related radiation research essential to the support of the Department of Defense (DOD).

2.1 AFRRI SITE

The AFRRI site is located on the grounds of the National Naval Medical Center, Bethesda, Maryland. The Medical Center is located approximately 3 miles north of the Washington, D.C.-Maryland line. The AFRRI site is located on a moderate slope, declining northward toward a narrow creek valley. The terrain surrounding AFRRI is rolling with elevations ranging from 230 to 320 feet above sea level.

2.2 AFRRI COMPLEX

The AFRRI complex includes six separate primary buildings arranged in an interconnected complex. The principal radiation facilities housed within AFRRI are the TRIGA reactor facility, the 50-Mev electron linear accelerator facility, the 500-KCi Cobalt-60 facility, and the Standards Laboratory, which contains a

theratron and X-ray unit. In addition to these facilities, AFRRI also houses research laboratories, a hot cell, a radiochemistry lab, an animal clinical research facility, office space, and related support areas.

2.3 AFRRI REACTOR FACILITY

The reactor facility, which includes the AFRRI-TRIGA Mark-F reactor and its associated equipment, is housed in a single building of reinforced concrete. This building is one of two separate buidings that are designated as Building #42. A description of the reactor building may be found in the Final Safety Analysis Report.[1]

There are no exterior conduits, pipelines, electrical or mechanical structures, or transmission lines attached to the reactor building other than utility service facilities which are similar to those required for the rest of the AFRRI complex. These utility service facilities are similar to those required by other research laboratories.

The reactor building ventilation system is independent of the ventilation systems serving the rest of the AFRRI complex. Ambient air enters the reactor building through two air supply fans. The air circulates through the reactor building, passes through roughing and absolute filters, and is subsequently exhausted to the atmosphere via the AFRRI stack. The ventilation filters provide removal of particulate matter greater than 0.3 microns in diameter and are maintained at a minimum efficiency of 99.9 percent. The AFRRI stack releases the air exhausted from the reactor building ventilation system as well as from other ventilation emission systems in the AFRRI complex. The stack release point is approximately 35 feet above the roof of the reactor building and a minimum of 18 feet above the highest building in the AFRRI complex. The reactor building and ventilation system are further described in the FSAR.[1]

Heat dissipation for the AFRRI-TRIGA reactor is accomplished by the reactor water coolant systems. These systems include the primary cooling system, the secondary cooling system (with a 1.5 MW(t) heat exchanger and wet mechanical draft cooling tower), a water makeup system for the primary cooling system, and a water purification system for the primary cooling system. The cooling towers are located on the roof of the AFRRI complex. The towers, with total dimensions of approximately 18 x 32 x 19 feet, are similar to cooling towers associated with the air conditioning systems of large office buildings. Makeup water for the secondary

cooling system consists of raw industrial water which is readily available from the local water system. The reactor water systems are described further in the FSAR.[1]

Although no radioactive wastes are generated during normal reactor operations, a liquid waste disposal system is available as a means of controlling the release of radioactive liquid waste from the AFRRI complex to the public sanitary sewer system. The liquid radioactive waste is divided into three categories: "very hot," "hot," and "warm." The "very hot" radioactive waste is usually too highly radioactive to be diluted and discharged into the sanitary sewer, hence it must be shipped out in a tank truck for disposal at an NRC-licensed burial ground. The "hot" liquid radioactive waste subsystem collects effluents from the areas at AFRRI in which high level radioactive activation or contamination may occur. Finally, the "warm" liquid radioactive waste subsystem collects effluents from those areas in AFRRI in which low-level radioactive activation or contamination may occur. All three liquid radioactive waste systems utilize holdup tanks. The liquid radioactive waste subsystems are further described in the FSAR.[1]

2.4 AFRRI-TRIGA MARK-F REACTOR

The AFRRI-TRIGA Mark-F Reactor, originally developed and installed by the General Atomics Division of the General Dynamics Corporation, is utilized for biomedical research and radioisotope production in support of AFRRI's radiobiology research mission, as well as irradiations of electrical components for DOD systems. In addition, when scheduling permits, other out-of-house experiments are occasionally performed. For example, in the past, the AFRRI reactor has been used in support of Federal criminal investigations for the FBI, studies to characterize transient radiation effects on electronics for Harry Diamond Laboratory and Westinghouse under DOD contract, and artifact analysis for the Smithsonian Institute and National Gallery of Art.[4]

The principal experimental facilities associated with the AFRRI-TRIGA reactor are Exposure Room 1, Exposure Room 2, the Pneumatic Transfer System, and the In-Core Experiment Tube (CET). Experiments may also be conducted in the reactor tank (with or without beam tubes), but these facilities or modes are not normally used. The AFRRI-TRIGA reactor and its associated exposure facilities are further described in the Final Safety Analysis Report.[1]

The AFRRI reactor operates at steady state power levels up to 1 MW (thermal) and in a pulsing mode with step reactivity insertions up to a maximum of 2.8% $\Delta k/k$.[3] Operation of the reactor will generally never exceed a 5-day week, 8-hour day, or about 2,000 hours per year.[4] Based on historical data,[4] the total reactor burnup has been less than 400.2 MW-hr for the period June 1964 to October 1980. Historical data[4] also indicate that the average annual burnup, since 1968 is 26.5 MW-hr/yr, while the average based upon cumulative burnup since 1967 is 30.77 MW-hr/yr. Using the standard 5-day work week, 8-hour day, and burnup rates suggested for a standard 40-hour work week, on the average, 15.44 hours/week is allocated for operative runtime in support of approved experiments, 9.16 hours/week allocated for setup time in support of approved experiment runs, 11.44 hours/week allocated for maintenance, and approximately 3.96 hours/week for training, administration, etc.[4]

3.0 ENVIRONMENTAL EFFECTS OF AFRRI REACTOR FACILITY

3.1 THERMAL EFFLUENTS

The AFRRI Reactor operates at a maximum thermal power output of 1 MW in the steady state mode. The environmental effects of thermal effluents created at this power level are negligible. During prolonged operations at the upper range of power levels, the secondary cooling system is activated and the waste heat is rejected to the atmosphere through the facility's mechanical draft wet cooling tower, located on the roof of the AFRRI complex. The efficiency of this cooling tower is largely determined by the temperature and humidity of the outside air. In June 1980, the tower was enclosed and the H_2O supply was chemically treated to reduce losses. The tower now operates much like a condensor, with only nominal H_2O losses of approximately 50 gallons per week or about 2,600 gallons per year.[4] Prior to June 1980, H_2O losses were in the order of 125 to 250 gallons per week or about 6,500-13,000 gallons per year.[2] As of June 1980, fog plumes are essentially nonexistent, and prior to that date, plumes were evident but not extensive.[4] The FSAR[1] includes more information about the AFRRI reactor cooling system and thermal effluents.

3.2 RADIOACTIVE GASEOUS EFFLUENTS

Gaseous radioactive effluents released by AFRRI from the reactor and other AFRRI facility operations must conform to the requirements of 10 CFR Parts 20.101 through 20.106.

Radioactive gaseous effluents released due to AFRRI facility operations include: N^{16} and Ar^{41}, generated by the AFRRI-TRIGA Mark-F reactor, and released to the environment from the reactor building ventilation system through the AFRRI stack; N^{13} and O^{15} generated as a result of the 50 MeV electron linear accelerator (LINAC); and I^{125} and Xe^{133} generated as a result of operations in the radioisotope and nuclear medicine laboratories.

Table 1 presents a summary of the gaseous radionuclides released on an annual basis from January 1, 1971, to June 30, 1980, while Table 2 presents the results of dose assessment calculations obtained via the annual radionuclide releases given in Table 1. Xe^{133} and I^{125} environmental doses are less than 10 percent of the Ar^{41}, N^{13}, and O^{15} doses[2], and hence were not evaluated in great detail (Table 2). For more information, see the FSAR.[1]

The maximum permissible annual dose for all radioactive gaseous effluents released to unrestricted areas which could be occupied by individuals is 500 milliroentgens (mR) for gamma radiation as specified in 10 CFR Part 20. However, every effort should be made to maintain radiation exposures and releases of radioactive materials to unrestricted areas to levels that are as low as is reasonably achievable (ALARA). Design objectives for nuclear "power" reactors have been established in 10 CFR Part 50, Appendix I, to meet ALARA. The AFRRI dose assessments for Ar^{41}, which makes up the majority of AFRRI's gaseous radioactive effluents, are a factor of three below the design objective of 10 mR/year for gamma radiation given in Appendix I of 10 CFR Part 50.[1,5]

The radiation monitoring systems associated with reactor operations at AFRRI are provided and maintained as a means of ensuring compliance with radiation limits established under 10 CFR Part 20. The AFRRI monitoring systems consist of remote area monitors (RAM's), continuous air monitors (CAM's), cooling water monitors, AFRRI perimeter monitors, personnel monitors, and stack gas and particulate monitors. The RAM's, placed in various areas of the reactor building utilize scintillation detectors which measure gamma radiation. The CAM's utilized in the reactor room, exposure rooms, and prep area provide continuous air sampling and monitoring (gross beta-gamma activity) primarily of airborne particulate matter. The stack particulate and gas monitoring systems measure the gamma activity emitted by radioactive particulates and the activity of gaseous radioactive nuclides, respectively, that are exhausted through the AFRRI stack. Perimeter monitoring at AFRRI consists of a large number of stations, each

equipped with a thermoluminescent dosimeter (TLD) which detects X-ray and gamma radiation. AFRRI personnel and visitors are assigned personal dosimeters which assess whole body, extremity, and internal doses. The radiation monitoring systems utilized by AFRRI are discussed in greater detail in Section 3.6 of the Safety Analysis Report.[1] Table 3 lists the annual summary from 1971-1979, of the highest radiation doses received by individuals at the AFRRI reactor facility. The highest exposure (whole body, extremity, or internal) received by any individual is well below the limits specified in 10 CFR Part 20.101. Table 4 lists data tabulated for collective doses (person-rem) from 1973 through 1978. Given the active civilian and noncivilian population of AFRRI, the collective individual doses are well below the permissible dose levels specified in 10 CFR Part 20.101.

A survey of in-plant thermoluminescent dosimeters (Table 5) and low background film dosimeters (Table 6), for specific locations within the AFRRI reactor room and facilities, indicate that the net dose and high total readings are in compliance with 10 CFR Part 20.101. Perimeter monitoring results (film dosimeters) in unrestricted areas from 1971 to 1979 (Table 7) show that the radiation field caused by the AFRRI-TRIGA Mark-F Reactor is negligible relative to the allowable exposures given in 10 CFR Part 20.105. A summary of environmental film dosimetry data representing possible reactor-produced radioeffluent doses to the environment from 1971 to 1980 is given in Table 8. Even with individual dosimeter uncertainties of ±8 millirem, the readings are well below the allowable doses given in 10 CFR Part 20.105.

During 1 MW(t) steady state operation, the gamma radiation levels directly above the reactor pool and at the reactor pool chain were measured to be 200 mR/hr and 14 mR/hr, respectively.[1] The amount of N^{16} released to the environment is negligible due to the time involved for N^{16} bubbles generated in core to reach the surface of the reactor pool (∽42 seconds) and the time involved in transporting air from the reactor room to the exhaust stack (∽3-4 minutes) relative to the rapid decay (7.14 second half-life) of N^{16}.

Ar^{41}, the gaseous effluent of primary concern released through the AFRRI stack to the environment, was measured to be slightly less than 19 Curies during all of calendar year 1979. This amount of Ar^{41} was larger than the total Ar^{41} release during any year since 1971 (see Table 1). This maximum in annual Ar^{41} release totals was due to the number of reactor operations and the types of experiments performed during 1979. Based on the present experimental facility operational

configuration and anticipated reactor use, it is expected that the total amount of Ar^{41} released during any year will be no more than that released during 1979 (∼20 Curies)[1] and certainly no more than twice that released during 1979 (∼40 Curies). Based on this conservative value of 40 Curies of Ar^{41} released in one year, the maximum integrated air dose in an unrestricted area would be 1.9 millirads for the entire year.[1]

Similarly, the consequences from the Design Basis Accidents of a fuel element drop accident or a fuel clad failure accident were determined to be minimal.[1] The maximum calculated whole-body dose was less than 2 mrad beyond 25 meters from the AFRRI facility.[2] The maximum calculated thyroid dose was less than 57 mrad beyond 25 meters from the AFRRI facility.[2] Doses from these postulated accidents to individuals beyond the boundary of the National Naval Medical Center site would be significantly less than 1 mrad.[2] These calculated doses are well below the permissible levels given in 10 CFR Part 20.106, and hence the operation of the AFRRI reactor would not represent an undue risk to the health and safety of the operational personnel or the general public.

3.3 LIQUID RADIOACTIVE WASTES

Although there are no liquid radioactive wastes generated by normal reactor operations, a liquid radioactive waste handling and disposal system is provided for temporary holding, primarily to provide a means of controlling the release of radioactive liquid wastes from the AFRRI complex to the public sanitary sewer system. Table 9 lists the total amount of radioactivity released to the sanitary sewer system from 1971 to 1979. The amounts of gross alpha, beta, and gamma activities released are within the requirements of 10 CFR Part 20, Section 20.303. See the FSAR[1] for more information.

3.4 SOLID RADIOACTIVE WASTES

Low-level solid radioactive wastes from reactor operations (1971-1980), including laboratory wastes such as glassware, paper, plastics, scintillation vials, disposable gloves, and radioactive animal carcasses, constitute a volume of one to five 55-gallon drums with less than 1 mCi per year, containing essentially all short-lived, radionuclides (i.e., Na^{24}, Mn^{56}, Cu^{64}).[3] Reactor demineralizer resins and particulate filters are changed at intervals of 6 to 18 months, and are disposed of as solid waste. Typical activities observed in these materials are given in Table 10.

3.5 ENVIRONMENTAL SAMPLING

Environmental samples are taken quarterly of water, soil, and vegetation. All sample results have been below action levels specified in AFRRI Health Physics Procedure 2-5 and, in fact, generally are indistinguishable from normal environmental background activity levels.[5]

4.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

Accidents ranging from failure of experiments to the largest core damage and fission product release considered plausible would result in doses of only a small fraction of 10 CFR Part 20 guidelines and are considered negligible with respect to the environment. (See Chapter 6.0 of the FSAR.[1])

4.1 UNAVOIDABLE EFFECTS OF FACILITY CONSTRUCTION AND OPERATION

The unavoidable effects of construction and operation involve the materials used in construction that cannot be recovered and the fissionable material used in the reactor. No adverse impact on the environment is expected from either of the unavoidable effects.

4.2 LONG-TERM EFFECTS OF FACILITY CONSTRUCTION AND OPERATION

The long-term effects of a research facility such as AFRRI are considered to be beneficial through contributions to scientific and medical knowledge. This is especially true in view of the relatively low capital cost involved and the minimal impact on the environment associated with such facilities.

4.3 COST AND BENEFITS OF FACILITY AND ALTERNATIVES

The value of the AFRRI reactor, associated equipment, and the console, together with all other instrumentation and maintenance tools and supplies, is estimated at $3 million (1972-year dollars).[4] The benefits of this facility are in the field of biomedical research in support of national defense. The facility provides additional data and findings in the scientific and medical fields for international use. Some of the activities conducted at the AFRRI reactor facility could be accomplished using particle accelerators or other radioactive sources; however, these alternatives are more costly and less efficient, and cannot totally replace the existing capabilities associated with this facility. There is no reasonable alternative to the AFRRI reactor for conducting the broad spectrum of research conducted.

REFERENCES

1. AFRRI Reactor Facility Safety Analysis Report, May 1981.
2. Ibid., Chapter 6, "Safety Analysis."
3. Amendment #17 to the Technical Specification, Facility License No. R-84 for AFRRI-TRIGA Mark-F Reactor, Docket No. 50-170.
4. Maj. Ronald R. Smoker, U.S.A., Personal Communcation, "Environmental Impact Analyses," February 13, 1981.
5. AFRRI Environmental Impact Appraisal Data; Defense Nuclear Agency, Armed Forces Radiobiological Research Institute, Bethesda, Maryland.

TABLE I

Summary of Gaseous Radioeffluent, 1 Jan 71 to 30 June 80:
Total Release--Radionuclide(s)

Source of Activity:			Ar-41 Reactor	N-13, 0-15 LINAC	I-125 Other	Xe-133 Other
Released activity (mCi):		1971	26,900	1,460	0	0
"	"	1972	11,040	3,760	<1	120
"	"	1973	11,310	3,850	0	1,380
"	"	1974	16,690	20,740	0	40
"	"	1975	7,190	20,180	<1	340
"	"	1976	2,750	1,040	0	2,100
"	"	1977	2,370	640	<1	1,590
"	"	1978	9,410	15,840	<1	340
"	"	1979	18,930	0	<1	1,280
"	"	1980(½y)	1,940	5	<1	260

TABLE 2

Dose Assessment Based Upon Annual Radionuclide Release

Radio-nuclide		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Ar-41	Ci/s:	8.5E-7	3.5E-7	3.6E-7	5.3E-7	2.3E-7	8.7E-8	7.5E-8	3.0E-7	6.0E-7	1.2E-7
Ar-41	mR/h:	3.5E-6	1.4E-6	1.5E-6	2.2E-6	9.3E-7	3.6E-7	3.1E-7	1.2E-6	2.5E-6	5.1E-7
Ar-41	mrem:	0.031	0.012	0.013	0.019	0.008	0.003	0.003	0.011	0.022	.002
N,O	Ci/s:	4.6E-8	1.2E-7	1.2E-7	6.5E-7	6.4E-7	3.3E-8	2.0E-8	5.0E-7	0	1.6E-10
N,O	mR/h:	2.0E-7	5.2E-7	5.2E-7	2.8E-6	2.8E-6	1.4E-7	8.6E-8	2.2E-6	0	7.E-10
N,O	mrem:	0.002	0.005	0.005	0.024	0.024	0.002	0.001	0.019	0	10^{-5}

TABLE 3

Personnel Monitoring

Annual Summary (Year)	Highest Exposure Whole Body Dose (mrem)	Extremity (mrem)	Internal Thyroid I-125 (nCi)
1971	1,644	--	--
1973	2,261	--	--
1975	568	--	--
1977	473	--	--
1978	384	7,038	30
1979	127	3,779	38

TABLE 4

Collective Doses (REM-Person) from 1973 through 1978

(1) Rad Physics Division

Year	Total Dose (REM-Person)
1973	.042
1974	.337
1975	.344
1976	.733
1977	.852
1978	.972

(2) Nuclear Medicine Division

Year	Total Dose (REM-Person)
1973	11.433
1974	8.324
1975	2.248
1976	1.653
1977	.970
1978	1.775

(3) Sources Division

Year	Total Dose (REM-Person)
1973	.691
1974	.244
1975	.970
1976	.078
1977	.248
1978	.677

TABLE 5

Inplant Thermoluminescent Dosimeters

Year	Location[a]	Net Dose (Background subtracted) (mrem)
1978	B1	30
	3201	20
	1124	20
1979	Area 1101	52

[a]See Section 3 of AFRRI Reactor Safety Analysis Report for location description.

TABLE 6

Low Background Film Dosimeter

Year	Location	High Total Year Readings (mrem)
1978	PN (north end of reactor pool)	170
	K1 (KLYSTRONS)	271
	K2 (Modulator Building)	168
	NMI (Gamma Camera, Room 1491)	450
	NMB (Hood Radiopharmacy, Room 1411)	690
1979	Reactor Building	926[a]
	Nuclear Medicine	1,723[b]
	Modulator Building	196[c]

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[a]North end of reactor pool, reflects large activation workload.

[b]Wall of 1413, adjacent to generator storage.

[c]Extrapolated to outside high dose of 13 mrem.

TABLE 7

Environmental Surveillance
Perimeter Monitoring Results (Film Dosimeters)
in Unrestricted Areas

Annual Summary (Year)	Location[a]	Maximum Net Yearly Dose (mrem)	Total Yearly Average Doses per Station (mrem)
1971	(Co-4)	26	1.4
1973	Co-4	13	1.67
1975	(8-A)	14	2.44
1977	ID	14	3.3
1978	ID	10	1.5
1979	--	13[a]	5.1[b]

[a]See Section 3.0 of AFRRI Reactor Safety Analysis Report for locations of perimeter monitors.

[b]Resulted primarily from a number of high (6 to 8 millirem) readings in one seven-week exposure period; did not correlate with reactor use patterns and appeared to be an artifact.

TABLE 8

Environmental Film Dosimeters: 1971-1980 Summary
(all doses in millirem):

Year	Envir. Dosimeter Avg.*	Highest Dosimeter Reading*
1971	1.4	8
1972	7.7	16
1973	1.7	12
1974	2.2	10
1975	2.4	14
1976	0.3	13
1977	3.3	20
1978	1.5	30
1979	5.1	9
1980(½y)	-2.5	

*All are net readings, with background station doses (located miles from AFRRI) subtracted. Individual dosimeter readings have 2σ uncertainties of 8 millirem

TABLE 9

Liquid Radioactive Waste

		Total Radioactivity Released To Sanitary Sewage System			
Year	Total	Gross Beta mCi	Gross Alpha mCi	Gross Gamma mCi	Tritium mCi
1971	--	143.6 ± 2.8	5.4 ± 1.1	--	--
1973	<0.004 ci	87	~1	828	2.5
1975	<1.2 millicuries	147.9 ± 3.7	0.81 ± 1.7	956 ± 524	--
1977	<4 millicuries	--	--	--	--
1978	<33 millicuries (70% by USUHS)	595.4 ± 11.9	1.11 ± 1.46	3,188 ± 463	--
1979	90 millicuries including USUHS	829 ± 19	0.7 ± 0.8	2,850 ± 1,290	--

TABLE 10

Solid Radioactive Waste

Year	Total Radioactivity Shipped (millicuries activity)
1971	150
1973	93.7
1975	155.4
1977	84.5
1978	615
1979	237.8