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AFRRI TR89-2

# AFRRI TECHNICAL REPORT

## An Analysis of Decommissioning Costs for the AFRRI TRIGA Reactor Facility

M. Forsbacka  
M. Moore

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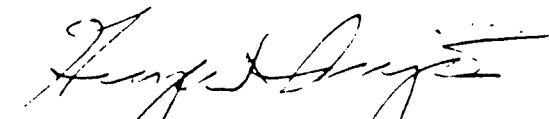
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A handwritten signature in cursive script, appearing to read "George W. Irving, III". The signature is written in dark ink and is positioned above the typed name.

GEORGE W. IRVING, III  
Col, USAF, BSC  
Director

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<p>This report provides a cost analysis for decommissioning the (AFRRI) TRIGA reactor facility. AFRRI is not suggesting that the AFRRI TRIGA reactor facility be decommissioned. This report was prepared in compliance with paragraph 50.33 of Title 10, Code of Federal Regulations, which requires that funding for the decommissioning of reactor facilities be available when licensed activities cease.</p> <p>The planned method of decommissioning is complete decontamination (DECON) of the AFRRI TRIGA reactor site to allow for restoration of the site to full public access. The cost of DECON in 1990 dollars is estimated to be \$3,200,000. The anticipated ancillary costs of facility site demobilization and spent fuel shipment will be an additional \$600,000. Thus, the total cost of terminating reactor operations at AFRRI will be about \$3,800,000. The primary basis for developing this cost estimate was a study of the decommissioning costs of a similar reactor facility performed by Battelle Pacific Northwest</p>				
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Laboratory, as provided in U.S. Nuclear Regulatory Commission publication NUREG/CR-1756. The data in this study were adapted to reflect the decommissioning requirements of the AFRR1 TRIGA reactor facility. (S)

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## Introduction

The U.S. Nuclear Regulatory Commission (USNRC) requires all USNRC-licensed reactor facilities to ensure that funds for the decommissioning of these facilities will be available when licensed activities cease. This requirement is specified by paragraph 50.33 of Title 10, Code of Federal Regulations (CFR), dated November 30, 1983. Because the Armed Forces Radiobiology Research Institute (AFRRI) TRIGA reactor facility is owned and operated by the Federal government, future decommissioning funds are guaranteed through a governmental statement of intent to budget the cost. The budget request should be made sufficiently in advance of decommissioning to prevent the delay of required activities.

The USNRC defines decommissioning of a nuclear reactor facility as the safe removal from service and the reduction of residual radioactivity to a level that permits the release of the property for unrestricted use. A variety of decommissioning methods are available, ranging from permanent entombment of the reactor site to its immediate decontamination. Considering AFRRI's urban location in Bethesda, MD, the best method of decommissioning is immediate decontamination of the reactor facility site to allow for unrestricted public access. This method of decommissioning is referred to as DECON. DECON costs involve only the removal of equipment, structures, and portions of the facility that contain radioactive contaminants. The removal of spent nuclear fuels and demolition of the uncontaminated portions of the facility are considered ancillary costs.

The cost estimates presented in this report are based primarily on a study of the decommissioning costs of a TRIGA reactor facility prepared by the Pacific Northwest Laboratory (PNL) entitled Technology, Safety, and Costs of Decommissioning Reference Nuclear Research and Test Reactors, NUREG/CR-1756.<sup>1</sup> Additional data were obtained from personnel who were involved with decommissioning the Diamond Ordnance Radiation Facility (DORF) in 1979 and local AFRRI experience with the disposal of low-level radioactive waste at Barnwell, SC.

The PNL study gives an extensive breakdown of the decommissioning cost for the Oregon State University TRIGA Reactor (OSTR) Facility. Although the AFRRI TRIGA reactor core is similar to the OSTR, there are fundamental differences in facility layout and use. To adjust for differences between the AFRRI TRIGA and the PNL study's reactor facility, the following areas are examined in this report:

- Estimated conditions at the time of facility shutdown, the radionuclide inventories, and the surface dose rates, compared with those of the OSTR.
- Inflation factors since 1981, when the PNL study was made.
- Major differences in facility layout and design that will impact decommissioning costs.
- Cost of labor differences between the two facilities.
- Cost of energy differences between the two facilities.
- Waste disposal costs and the cost of shipping spent fuel and contaminated rubble to a distant waste depository.



The gross amount of radioactive material to be removed from the AFRRRI TRIGA will, as stated earlier, be greater than that of the OSTR, but the radioactivity concentrations at the time of shutdown will probably be similar. Based on the DORF decommissioning experience, the specific activity of the contaminated materials to be removed as part of DECON should be approximately  $4.2 \mu\text{Ci}/\text{Mg}$ . Complete projected radionuclide inventories can be found in NUREG/CR-1756.

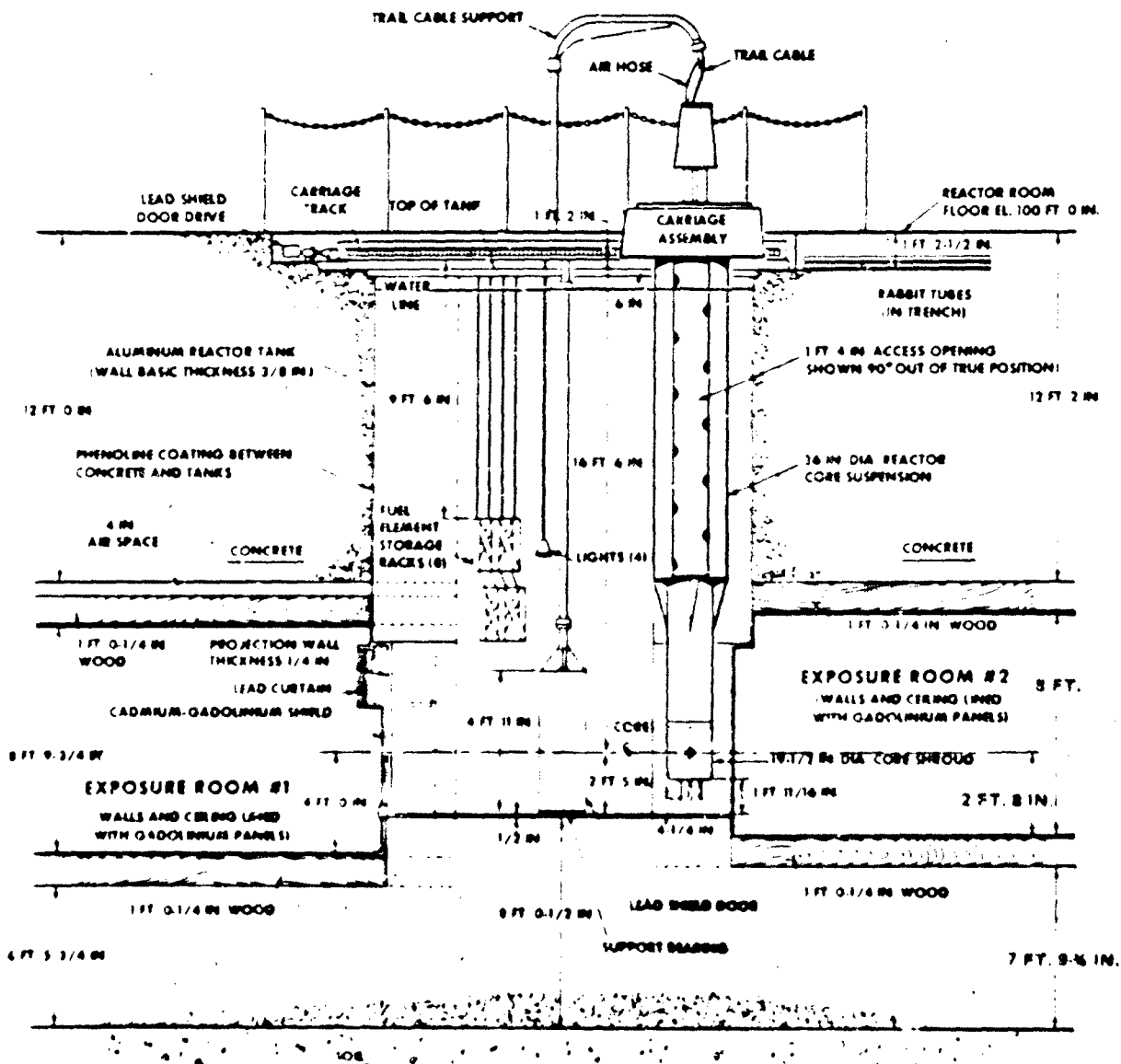


Figure 3. Vertical section view of the Armed Forces Radiobiology Research Institute TRIGA reactor.



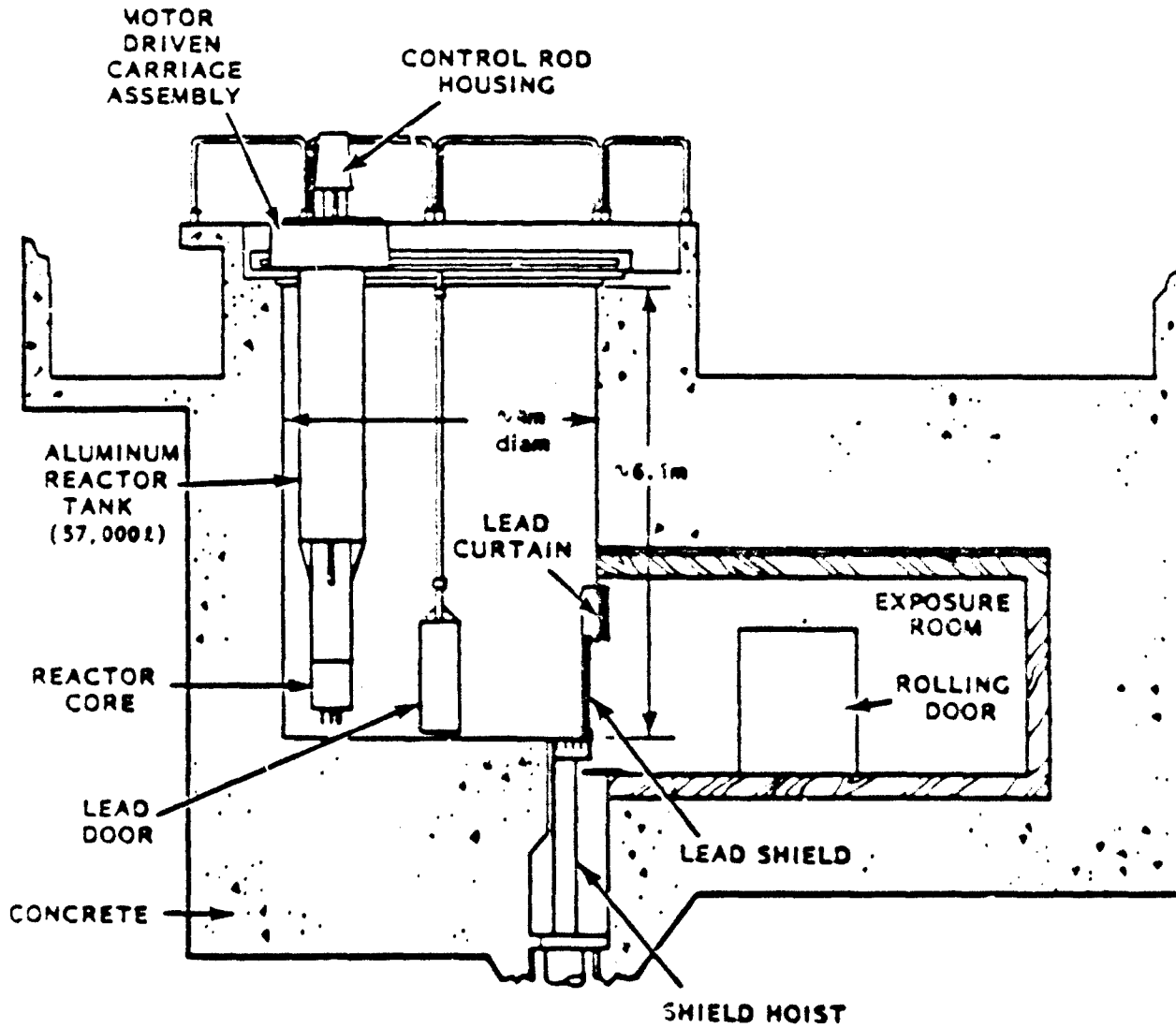


Figure 3. Vertical section view of the Diamond Ordnance Radiation Facility TRIGA reactor.

## Waste Disposal Costs

The cost estimate for waste disposal includes the following factors:

- The amount of contaminated material to be removed and packaged using the methodology of the DORF decommissioning project and the data from NUREG/CR-1756.
- The cost of transporting the waste to a radioactive waste disposal site using the data from NUREG/CR-1756.
- The cost of disposal of low-level radioactive waste based on AFRRI Safety and Health Department's experience with the disposal of low-level radioactive waste at the Barnwell, SC, waste disposal site.

Most of the waste material to be removed from the AFRRI site consists of the activated concrete and wood from the exposure rooms, the contaminated aluminum of the reactor tank, and the reactor core support structure itself. For the purposes of this cost estimate, the volume of concrete to be treated as low-level radioactive waste is the volume of concrete that results from a uniform 1-foot-deep excavation of both exposure rooms. Based on the DORF decommissioning experience, however, the actual volume of contaminated concrete will probably be less than the amount reported in table 1. An overestimate of the amount of contaminated concrete is acceptable because it errs on the side of a more conservative decommissioning budget calculation.

The packaging and transportation costs were developed using data from NUREG/CR-1756. It is assumed that all materials removed during DECON activities could be treated as low-level radioactive waste, so 3.5 m<sup>3</sup> plywood shipping crates costing \$400 (1981 dollars) each would be used. The cost per unit volume of disposing the waste at a radioactive waste depository is taken to be \$2825/m<sup>3</sup> (based on Barnwell charges in 1989 dollars). For the purposes of this report, a worst case scenario of a shipment to a destination in Washington state has been selected. The estimated waste disposal costs, adjusted to 1990 dollars, are reported in table 1.

Table 1. Estimated Waste Disposal Costs for DECON of AFRRI TRIGA Reactor

Waste material	Volume (m <sup>3</sup> )	$\rho$ (Mg/m <sup>3</sup> ) <sup>1</sup>	Mass (mg)	Crates (no)	Shipping	Cost <sup>2</sup>
Contaminated concrete	102.40	2.3	235.5	30	\$44,320.42	\$345,049.43
Contaminated wood	76.82	0.7	53.8	23	10,119.25	235,922.40
Contaminated aluminum	1.86	2.7	5.0	1	945.05	6,589.54
Reactor vessel	N/A	N/A	0.9	1	169.05	1618.26
Total						\$589,179.63

<sup>1</sup>N/A, not applicable.

<sup>1</sup>Mg, megagrams.

<sup>2</sup>Cost = (cost/crate)(# of crates) + shipping costs + disposal costs.

## Labor Costs

The labor cost estimate is also based on information in NUREG/CR-1756. The labor costs shown in table 2 account for overhead costs, such as specialty tools and equipment, specialty contractors, liability insurance, and fees. Because the AFRRI TRIGA facility is larger than the OSTR and the DORF facilities, the labor cost data have been scaled up to reflect increased labor costs (1981 dollars).

Table 2. Estimated Labor Costs for DECON  
of the AFRRI TRIGA Reactor<sup>1</sup>

Staff position	Workyears (no.)	Rate (\$1000/hr)	Cost (\$1000)
<b>Management and support staff</b>			
Decomm superintendent	2.0	89.1	\$178.20
Decomm engineer	2.0	76.0	152.00
Secretary	2.0	24.2	48.40
Clerk	0.5	24.2	12.10
Health physicist	2.0	46.9	93.80
Radioactive shipment specialist	0.5	39.3	19.65
Procurement specialist	0.5	39.3	19.65
Contract and accounting specialist	0.8	47.1	37.68
Security supervisor	0.625	55.9	34.94
Security patrol officer	3.6	25.4	91.44
QA engineer	0.7	46.9	32.83
Control room operator	1.0	34.5	34.50
Consultant	1.0	100.0	100.00
<b>Decomm workers</b>			
Shift engineer	1.0	52.2	52.20
Craftsman	2.0	52.1	64.20
Crew leader	0.5	44.4	22.20
Utility operator	0.342	52.1	10.98
Laborer	6.0	30.9	185.40
Health physics technician	3.0	30.0	90.00
<b>Total</b>	<b>30.067</b>	<b>N/A</b>	<b>\$1,280.17</b>

N/A, not applicable.

<sup>1</sup>Reported as 1981 dollars.

## Energy Costs

The energy costs result from the estimated use of electricity required to carry out DECON activities. The source of the data presented in table 3 is NUREG/CR-1756; values have been scaled up to represent the estimated energy requirements for the AFRRI TRIGA facility. The 1981 cost of energy is taken to be \$0.008 per kilowatthour (kWh).

Table 3. Estimated Energy Costs for DECON of AFRRR TRIGA Reactor<sup>1</sup>

System or equipment	Energy use (kWh)
General system (crane, etc.)	9,000
HVAC	20,000
Lighting	23,000
Control room	5,200
Fire protection	600
Security	5,600
Communications	900
Domestic water	36,300
Reactor water	23,400
Compressed air	15,000
Building heating	302,600
Decommissioning equipment	20,000
Total	461,600
Total energy cost (x \$0.008/kWh)	\$3,692.80

<sup>1</sup> Reported as 1981 dollars.

#### Inflation Factors Since 1981

The effects of inflation must be factored into the overall cost estimate for DECON and decommissioning to arrive at an accurate cost estimate in 1990 dollars. Based on annual Consumer Price Index information provided by the Defense Nuclear Agency/AFRRR Comptroller Department,<sup>3</sup> the inflation adjustment factors shown in table 4 were used.

Table 4. Inflation Adjustment Factors Used in Analysis of DECON Costs

Years	Inflation adjustment factor
1981-86	1.321
1986-87	1.027
1987-88	1.031
1988-89	1.040
1989-90	1.036
1991-90	1.507

## DECON and Decommissioning Costs

The total cost of DECON is the inflation-adjusted sum of the expenses outlined in the previous sections plus a contingency fund, consisting of 25% of the inflation-adjusted sum of expenses. The complete decommissioning of the AFRRI TRIGA facility requires removing the spent fuel elements and demolishing and restoring the AFRRI TRIGA site (table 5).

Table 5. Estimated DECON and Decommissioning Costs for the AFRRI TRIGA Reactor

Cost Category	Cost (\$1000)	
	1981	1990
DECON:		
Waste disposal	\$390.9	\$589.2
Labor	1,280.2	1,929.3
Energy	3.7	5.6
Contingency fund	418.7	631.0
Subtotal	\$2,093.5	\$3,155.1
Ancillary:		
Spent fuel removal and shipment	150.0	226.1
Site demolition and restoration	250.0	376.8
Total	\$2,493.5	\$3,758.0

## Conclusion

This cost estimate is the first step in developing a comprehensive decommissioning plan for the AFRRI TRIGA reactor facility. Five years before the projected end of operations, a preliminary decommissioning plan will be developed as required by Paragraph 50.75(f) of Title 10, CFR. This plan will include the following information:

- A declaration that DECON will be the method of decommissioning.
- Major technical actions that will be required to carry out decommissioning safely.
- Plans for surveying the actual levels of radioactivity in the materials to be removed during decommissioning.
- Plans for disposal of high-level and low-level radioactive waste.
- Plans for site demolition and restoration of the site to full public access.
- A refined cost estimate for DECON and decommissioning.

## References

1. U.S. Nuclear Regulatory Commission, Standard Format and Content for Decommissioning Plans for Nuclear Reactors, Draft Regulatory Guide, Task DG-1005, September 1989.
2. Konzek, G. J., Ludwick, J. D., Kennedy, W. E., Jr., and Smith, R. I. Technology, Safety, and Costs of Decommissioning Reference Nuclear Research and Test Reactors, NUREG/CR-1756, March 1982.
3. Carew, P. H. Instructions for Preparation of RDT&E Amended 1991 Budget Submission, Defense Nuclear Agency Comptroller Memorandum, 12 July 1989.

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