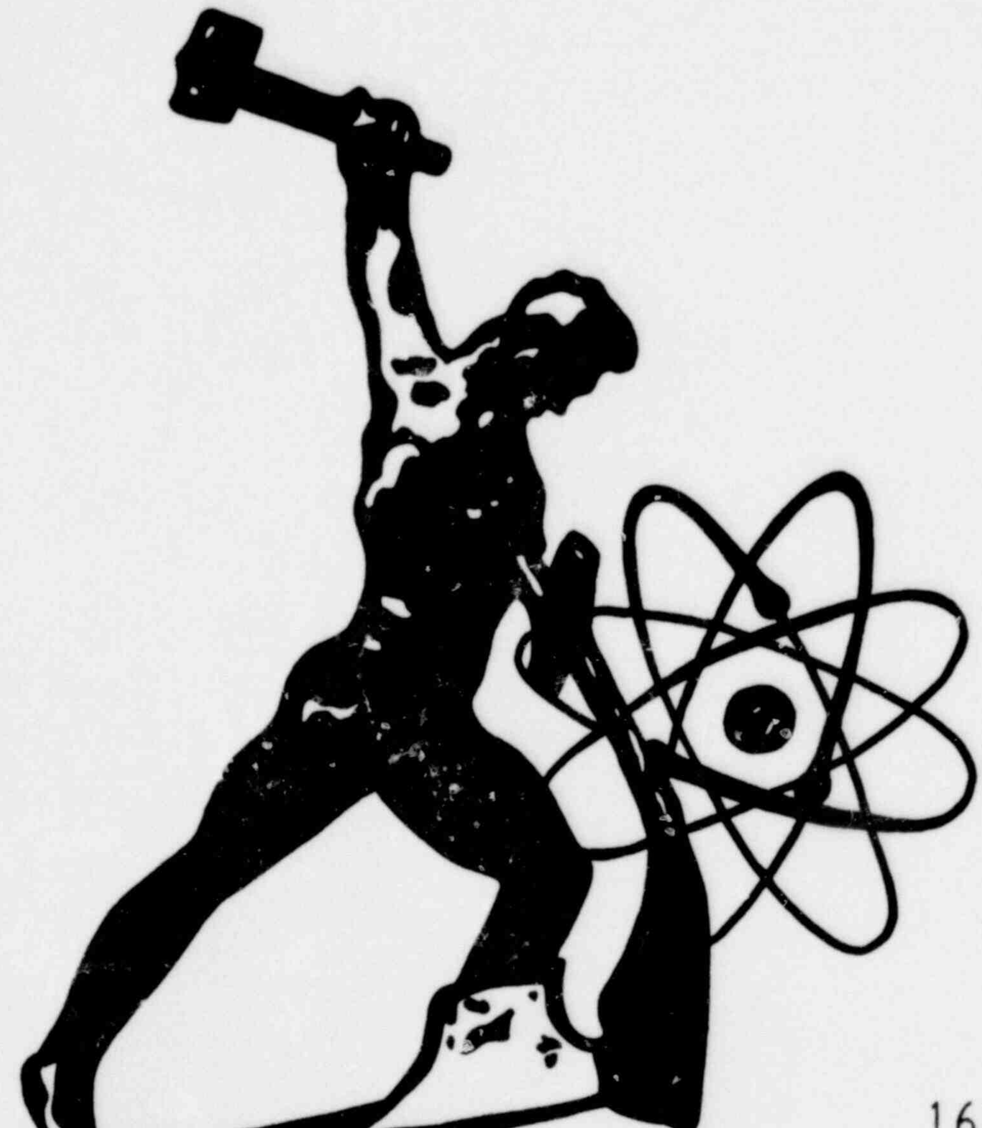
# Environmental Impact Appraisal
# University of Missouri-Rolla Reactor



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# Environmental Impact Appraisal

for

University of Missouri - Rolla
Nuclear Reactor

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## Environmental Impact Appraisal

This section deals with the environmental effects which can be attributed to the operation of the University of Missouri - Rolla Training Reactor since its initial criticality on December 9, 1961. It will also address potential future environmental effects.

A. Facility, Environmental Effects of Construction

The UMR Training Reactor is housed in the Nuclear Reactor Building which is located on the east side of the UMR campus. The nuclear reactor was designed to be the only equipment operated in the building since operation commenced there have been no significant affect on the terrain, vegetation, wildlife, nearby water or aquatic life due to the installation of the reactor or the construction of the Nuclear Reactor Building.

There are no exterior conduits, pipelines, electrical or mechanical structures or transmission lines attached to the nuclear reactor facility other than utility service facilities which are similar to those required in other campus facilities, especially laboratories. Heat dissapation is accomplished by evaporation and conduction from the pool. There is no external cooling system on the UMR Training Reactor.

Make-up water for the cooling system is readily available and is obtained from the City of Rolla water supply. Radioactive gaseous effluents are normally limited to Ar41, for which the building is monitored. There are minimal radioactive liquid effluents associated with the operation of the UMR training reactor. Solid and liquid radioactive wastes are generated through the irradiation of samples to be used primarily on campus either for neutron activiation analysis or for radio-isitopic tracer analysis. These radioactive samples are gathered, packaged and shipped off-site for storage at a Nuclear Regulatory Commission approved site by the campus Radiation Safety Office. The transportation of this waste is done in accordance with existing NRC-DOT regulations in approved shipping containers.

The sanitary waste systems associated with the Nuclear Reactor facility are similar to those at other university reactors. The design excludes the possibility of discharging un-monitored liquids into the sanitary waste system.

B. Environmental Effects of Facility Operation

The UMR Nuclear Reactor has a maximum power output of 200 KWt in the steady-state mode. The environmental effects of thermal effluents of this order of magnitude are negligible. The waste heat is rejected to the atmosphere through the roof of the Nuclear Reactor building. The average water make up to the facility has been $3.15X10^4$ liters per year (See Table 1). This amount of waterloss by evaporation has minimum effect on the environment.

The room in which the reactor is located is continuously monitored for gamma-ray fields and also for radioactive particles in the air. The gamma detector is an GM chamber mounted on the bridge which spans the pool of the reactor bay, directly above the core. The alarm set point of this monitor is normally 10.0 mr/hr. This alarm has never been unexpectedly triggered by a gamma-ray field of this magnitude since it was installed in 1961. The typical reading during full power reactor operations is in the downscale (<2 mr/hr) range. The particulate monitor is a continuous air monitor which samples the air within the reactor pool area. Dust particles are trapped in a filter which is held in place in front of an end-window Geiger-Muller tube. The alarm setpoint of the Constant Air Monitor is 7,000 counts/minute. This alarm has never been triggered due to high concentrations of radioactive particulates in the air. The typical background reading ranges from 50 to 500 counts/minute.

Film badges are located at various positions both inside and outside the reactor room. The film badges are currently placed in three locations:

1) one is located on the reactor bridge one meter above the surface of the pool over reactor core, 2) one is located in the control room and 3) one is located in the lower level experiment floor opposite the thermal column door. Film badges 1 and 3 are within posted radiation areas. The records for these building film badges monitors are given in table 2. The noteable increase in bridge monitor reading occured when the reactor power was increased to 200 KWt During the past two years the facility has reduced it's research use and converted to training. This change in use has reduced the average power and as a result lowered the bridge film badge readings.

In addition to the locations shown on table 2, the UMR Health Physics also monitors four of the campus building adjacent to the UMR Nuclear Reactor Building. Film badge monitors are located in Fulton Hall, Old Metallurgy, Norwood Hall and the Physics building. Since these film badges have been installed there has never been a reading greater than minimum detectable (10 mr/yr).

The radioactive waste discharged from the UMR Training Reactor for the years

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1971 through 1979 is given in table 3. The solid waste is collected by the UMR Health Physicist for disposal when quanity warrents. The solid waste consists of spent resin, (Used in the pool demineralizer pool filters, paper, rubber gloves, plastic vials and other assorted reactor physics laboratory disposables.

The liquid waste produced (as shown in table 3) by the facility is discharged during demineralizer regeneration. This water is isotopically sampled using a Ge-Li/Multichannel Analyzer system prior to discharge. The sampling assumes compliance with 10CFR20 discharge limits. During the past nine years the discharged liquid has averaged 0.92% of the limits of 10CFR20 Table II.

The gas and portialate discharged to the air by the building ventillation system is also shown in table 3. A detailed study was made in 1978 which showed that the concentration of gas was $3.1 \times 10^{-8}$ μci/ml (Ar41) and the concentration of particulate was $1.3 \times 10^{-8}$ μci/ml (Rb88 & Cs138) during full power (200Kw) reactor operations. The gas and particulate then discharged to the environment amounts to $1.1 \times 10^{-8}$ μci/ml. The discharge concentration is approximately 25% of the allowable limits of 10CFR20 table II for the predominant isotope of Ar41. It should be pointed out that these values occur only for full power operation and therefore represent maximum values under normal conditions. This facility is used extensively for training purposes (~95%) which do not require full power operation. During the past two years (1978-1979) full power operation was required for only 50 hours or approximately 1.2% of the total operating time.

Pool water analysis is also done at regular intervals (normally once per month) by the UMR Health Physicist. The results of the sampling is shown in table 4. The rather abrupt change indicated between 1974 and 1975 occurs due a change in sample procedures. Prior to 1975 a boil off to dry sample technique with gas flow proportional counter was used and since that time a one liter liquid sample has been counted using a Ge-Li/Multi Channel Analyzer system. The values shown in table 3 are only averages for a given year and are a function of reactor power history and waiting time after sample collection.

An independent pool water analysis was performed in 1974 by the Environmental Protection Agency and results are consistant with those obtained on the UMR campus. The results show no peaks above background and thus indicate that there are no measurable radioactive isotopes in the samples. The analysis further shows that the pool water is not only within 10CFR20 discharge limits but usually less radioactive than most city water supplies.

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Another area of concern is the generation of high and low-level radioactive wastes. The storage or reprocessing of spent fuel elements is not a major concern at the UMR Nuclear training reactor because our typical annual $U^{235}$ burn-up is approximately 1.1 grams per year or approximately 1.1% of our excess reactivity. During the course of activation analysis experiments and isotope production runs, the facility generates an average of 0.2 $m^3$ of low-level radioactive waste annually (as shown in table 3). The main constituents of this waste are short-lived isotopes such as $Na^{24}$, $Al^{28}$, $Cl^{38}$, $Mn^{56}$, $La^{140}$, $Eu^{152}$ , $Eu^{154}$, $Dy^{165}$, $Au^{198}$. These wastes are shipped to authorized disposal sites in approved containers at interval directed by the UMR Health Physcist.

C. Environmental Effects of Accidents

Accidents ranging from failure of experiments to the largest core damage and fission product release considered possible result in doses of only a small fraction of 10 CFR Part 100 quidelines and are considered negligible with respect to the environment.

D. Unavoidable Effects of Facility Construction and Operation

The unavoidable effects of construction and operation involves 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.

E. Alternatives to Construction and Operation of the Facility

There are no suitable or more economical alternatives which can accomplish both the educational and the research objectives of this facility. These objectives include the training of students in the operation of nuclear reactors, the production of radioisotopes (table 5), its use as a source of neutrons for neutron activation analysis, and also its use as a demonstration tool to familiarize the general public with nuclear reactor operations.

F. Long-Term Effects of Facility Construction and Operation

The long-term effects of a research facility such as the UMR Nuclear training reactor are considered to be beneficial as a result of the contribution to scientific knowledge and training. This is especially true in view of the relatively low capital costs ($250,000) involved and the minimal impact on the environment associated with a facility such as the UMR Training Reactor.

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## G. Costs and Benefits of Facility and Alternatives

The annual operating cost for a facility such as the UMR Training Reactor is on the order of $130,000 with very little environmental impact. The benefits include, but are not limited to: training of Nuclear Power Plant operating personnel, conduction of activation analysis, production of short-lived radio-isotopes, and education of students and public. Some of these activities could be conducted using particle accelerators or radioactive sources, but these alternatives are at once more costly and less efficient. There is no reasonable alternative to a nuclear training reactor of the tupe presently used at the University of Missouri - Rolla Campus for conducting the broad spectrum of activities previously mentioned.

The annual cost of operating the facility are shown in table 6. These costs have been increasing over the ten years shown but are well below the economic inflation experienced by most sections of the country. This fact is demonstrated in the constant 1967 $ column. It suggest that the economic benefits of the facility are increasing with time in service.

The number of nuclear engineering students and visitors for several years is given in table 7. A direct benefit to the general public is vested in the 196 Nuclear Engineering degrees granted during the facilities operating period.

It is possible to have a Nuclear Engineering degree program without a program without a Nuclear Reactor Facility. However, past experience for most disciplines show a much better understanding when experiments and experience accompany a lecture/problem learning system.

Another example of the benefits recovered from a facility of this type is the visitors tours. Approximately 36,000 people have visited the facility and have either been shown by demonstration or by lecture/tour, the purpose of nuclear reactors in our society.

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Table 1

Pool Water Use for UMR - Reactor [gallons]

<u>year</u>

| Month | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 801 | 1184 | 258 | 685 | 296 | 620 | 735 | 387 | 461 |
| Feb | 922 | 1442 | 632 | 658 | 387 | 956 | 374 | 290 | 647 |
| March | 756 | 1114 | 1105 | 795 | 586 | 530 | 1090 | 427 | 332 |
| April | 1680 | 739 | 1114 | 1330 | 315 | 587 | 1173 | 529 | 301 |
| May | 621 | 681 | 1050 | 1360 | 548 | 574 | 664 | 560 | 523 |
| June | 768 | 1303 | 616 | 827 | 443 | 300 | 600 | 361 | 776 |
| July | 938 | 1400 | 910 | 712 | 538 | 870 | 947 | 303 | 357 |
| Aug | 883 | 1041 | 605 | 420 | 668 | 661 | 571 | 456 | 425 |
| Sept | 693 | 722 | 560 | 490 | 640 | 545 | 701 | 392 | 431 |
| Oct | 1007 | 1457 | 410 | 508 | 990 | 533 | 674 | 699 | 421 |
| Nov | 982 | 860 | 442 | 295 | 1486 | 963 | 515 | 497 | 551 |
| Dec | 897 | 310 | 456 | 627 | 399 | 837 | 502 | 522 | 595 |
| Total | 10948 | 12253 | 8158 | 8707 | 7296 | 7706 | 8546 | 5423 | 5820 |
| Average monthly | 912.3 | 1021.1 | * 679.8 | 725.6 | 608.0 | 642.2 | 712.2 | 451.9 | 485.0 |

* Building Air Conditioner Installed

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Table 2

Building Film Badge Records (readings in mr/year)

| | Position | | |
|---|---|---|---|
| Year | 1 | 2 | 3 |
| 1961 | 20 | 40 | |
| 1962 | M | M | |
| 1963 | 5 | M | |
| 1964 | 5 | M | |
| 1965 | M | M | |
| 1966 | M | M | |
| 1967 | 560 | 80 | |
| 1968 | 250 | M | |
| 1969 | 110 | M | |
| 1970 | 360 | M | |
| 1971 | 110 | M | |
| 1972 | 170 | 20 | |
| 1973 | 170 | M | |
| 1974 | 280 | M | |
| 1975 | 180 | M | |
| 1976 | 250 | M | M |
| 1977 | 40 | M | M |
| 1978 | 30 | M | M |

Position 1 Reactor Bridge 1.5 meters above pool surface over reactor core
2 Control Room
3 Lower level experiment room opposite thermal column.

Note: 1. Reading of M means that exposure to badge was less than the lowest measurable limit (~10 mr)

2. Reactor re-licensed for 200 KWt in 1967 origional license was for 10 KWt.

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Table 3

Radioactive Waste Discharge

| Year | Solid | Liquid | Gas & Particulate |
|---|---|---|---|
| 1971 | 7.7mci | 3500gal = 0.2mci | Not available |
| 1972 | 0.0 | 3200gal = 14.0mci | 10,000mci |
| 1973 | 0.0 | 1400gal = 5.0mci | 6,700mci |
| 1974 | 0.0 | 2200gal = 12.8mci | 9,000mci |
| 1975 | 0.0 | 3000gal = 24.22mci | 900mci |
| 1976 | 1.0mci | 3450gal = 7.7mci | 115.19mci |
| 1977 | 0.07mci | 2400gal = 17.2mci | 100.873mci |
| 1978 | 0.01mci | 2700gal = 0.5mci | 22.8mci |
| 1979 | 0.0 | 1500gal = 0.5mci | 19.2mci |
| Total | 8.78mci | 23450gal = 82.12mci | 26857.99mci |
| Average | 0.975mci | 2605gal = 9.12mci | 2984.2mci |

Note (1) Solids consists of spent resin, filters, paper plastic with isotopes of Cr-51, Co-60, Co-58, Fe-59, Mn-54, Na-24, La-140, Ba-140, and Tritium.

(2) Liquids consists of water used for deminilizer regeneration with isotopes of Cr-51, Co-60, Co-58, Fe-59, Mn-54, Na-24, La-140, Ba-140, and Tritium.

(3) Gas and particulates are exausted by fans from the reactor building during operation with isotopes of Kr-88, Rb-88, Xe-138, Cs-138, and Ar-41.

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Table 4

Pool Water Samples

| Year | Activity |
|---|---|
| 1971 | $4.0X10^{-6}$ µci/ml |
| 1972 | $13.7X10^{-6}$ µci/ml |
| 1973 | $13.4X10^{-6}$ µci/ml |
| 1974 | $12.3X10^{-6}$ µci/ml |
| 1975 | $0.20X10^{-6}$µci/ml |
| 1976 | $0.38X10^{-6}$µci/ml |
| 1977 | $0.1X10^{-6}$ µci/ml |
| 1978 | $0.49X10^{-6}$µci/ml |
| 1979 | $0.11X10^{-6}$µci/ml |

Note: The method of calculation was changed in 1975 from boil off and planchet count to a one liter liquid gross count followed by isotope analysis.

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Table 5

By Product Release for Research Purposes

| Year | Activity | Samples on Campus | Samples off Campus |
|---|---|---|---|
| 1971 | 294.8 | 53 | 21 |
| 1972 | 553.0 | 51 | 19 |
| 1973 | 341.0 | 55 | 9 |
| 1974 | 145.00 | 40 | 12 |
| 1975 | 145.02 | 74 | 1 |
| 1976 | 25.89 | 46 | 0 |
| 1977 | 112.8 | 68 | 0 |
| 1978 | 14.3 | 26 | 0 |
| 1979 | 32.7 | 20 | 0 |

Table 6

University Expenditures for Reactor Support

| Year | Total | Total in 1967$ | Salary & Wages | Special Equipment |
|---|---|---|---|---|
| 1969 | $87,424 | 78,057 | $69,544 | None |
| 1970 | 89,515 | 75,222 | 59,910 | None |
| 1971 | 83,056 | 65,916 | 60,121 | None |
| 1972 | 80,796 | 61.116 | 60,431 | None |
| 1973 | 87,343 | 60,153 | 67,380 | 6,587 |
| 1974 | 91,381 | 57,763 | 73,651 | 1,863 |
| 1975 | 90,357 | 54,366 | 73,102 | None |
| 1976 | 89,223 | 51,218 | 69,261 | None |
| 1977 | 81,095 | 44,265 | 67,654 | None |
| 1978 | 108,485 | 56,151 | 93,511 | None |
| 1979 | 130,058 | 63,660 | 108,277 | 4,567 |

Table 7

Students* and Visitors Utilizing the Reactor Facility

| Year | Degrees Granted | | Total Enrolled | Visitors |
|---|---|---|---|---|
| | BS | Grad | | |
| 1962 | 3 | 2 | 3 | Not available |
| 1963 | 3 | 0 | 2 | Not available |
| 1964 | 1 | 0 | 5 | Not available |
| 1965 | 9 | 1 | 6 | Not available |
| 1966 | 4 | 4 | 9 | Not available |
| 1967 | 5 | 6 | 15 | Not available |
| 1968 | 4 | 7 | 26 | 2500 |
| 1969 | 7 | 1 | 74 | 2650 |
| 1970 | 11 | 7 | 79 | 2100 |
| 1971 | 10 | 11 | 70 | 2300 |
| 1972 | 6 | 4 | 82 | 2400 |
| 1973 | 11 | 3 | 84 | 2300 |
| 1974 | 9 | 1 | 77 | 2000 |
| 1975 | 11 | 4 | 101 | 2000 |
| 1976 | 20 | 2 | 104 | 2900 |
| 1977 | 3 | 3 | 76 | 2500 |
| 1978 | 10 | 2 | 83 | 1825 |
| 1979 | 5 | 0 | 88 | 2040 |

* Nuclear Engineering Students at UMR

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