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UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

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JUL 9 1974

Docket No. 50-186

University of Missouri
ATTN: Dr. E. L. Cox
Research Reactor Facility
Columbia, Missouri 65201

Gentlemen:

The Commission has issued the enclosed Amendment No. 2 to Facility License No. R-103. The amendment authorizes the University to: (1) operate the MURR at steady state power level up to 10 MWt, (2) receive, possess and use a 100 curie source of antimony-beryllium, and (3) incorporates revised Technical Specifications as Change No. 10.

A copy of the Federal Register Notice is also enclosed.

Sincerely,

Karl R. Goller

Karl R. Goller, Assistant Director
for Operating Reactors
Directorate of Licensing

Enclosures:
1. Amendment No. 2
2. Federal Register Notice

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

THE CURATORS OF THE UNIVERSITY OF MISSOURI

DOCKET NO. 50-186

AMENDED FACILITY LICENSE

Amendment No. 2
License No. R-103

1. The Atomic Energy Commission ("the Commission") has found that:

A. The application, as amended, complies with the requirements of the Atomic Energy Act of 1954, as amended ("the Act"), and the regulations of the Commission set forth in 10 CFR Chapter I;

B. Construction of the facility has been substantially completed in conformity with Construction Permit No. CPRR-68 and the application, as amended; the provisions of the Act; and the rules and regulations of the Commission;

C. The facility will operate in conformity with the application, as amended; the provisions of the Act; and the rules and regulations of the Commission;

D. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public and (ii) that such activities will be conducted in compliance with the regulations of the Commission;

E. The applicant is technically and financially qualified to engage in the activities authorized by this amendment in accordance with the rules and regulations of the Commission;

F. The University is a nonprofit educational institution and will use the facility for the conduct of educational activities. The University of Missouri is, therefore, exempt from the financial protection requirements of subsection 170a of the Act;

G. The applicable provisions of 10 CFR Part 140 have been satisfied;

H. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

I. The receipt, possession, and use of byproduct and special nuclear materials as authorized by this license will be in accordance with the Commission's regulations in 10 CFR Parts 30 and 70, including Sections 30.33, 70.23, and 70.31.

2. Facility License No. R-103, as amended, is hereby amended in its entirety to read as follows:

A. This license applies to the heterogeneous light water cooled and moderated, pressurized tank, nuclear research reactor (herein "the reactor"), owned by The Curators of the University of Missouri ("the licensee") located at Columbia, Missouri, and described in the application dated March 15, 1961, and amendments thereto, including the amendment dated August 25, 1972, and supplements hereto dated October 5, 1973; January 11, 1974; February 28, 1974; and March 13, 1974 (herein "the application").

B. Subject to the conditions and requirements incorporated herein, the Commission hereby licenses The Curators of the University of Missouri:

(1) Pursuant to Section 104c of the Act and Title 10 CFR Chapter I, Part 50, "Licensing of Production and Utilization Facilities," to possess, use, and operate the reactor in accordance with the procedures and limitations set forth in this license;

(2) Pursuant to the Act and 10 CFR Part 70, "Special Nuclear Material," to receive, possess, and use up to 45 kilograms of contained uranium 235 and up to 80 grams of plutonium-beryllium neutron source for use in connection with operation of the reactor; and

(3) Pursuant to the Act and 10 CFR Part 30, "Rules of General Applicability of Licensing of Byproduct Material," to receive, possess, and use in connection with operation of the reactor a source of 100 curies of antimony-beryllium, and to possess, but not to separate, such byproduct materials as may be produced by operation of the facility.

3. This license shall be deemed to contain and be subject to the conditions specified in Part 20, Section 30.34 of Part 30, Sections 50.54 and 50.59 of Part 50, and Section 70.32 of Part 70 of the Commission's regulations and orders of the Commission now or hereafter in effect, and is subject to the additional conditions specified or incorporated below.

A. Maximum Power Level

The licensee may operate the reactor at steady state power levels up to a maximum of 10 MWt.

B. Technical Specifications

The Technical Specifications contained in the attached Appendix "A" (designated Change No. 10) are hereby incorporated in this license. The licensee shall operate the reactor in accordance with these Technical Specifications. No changes shall be made in the Technical Specifications unless authorized by the Commission as provided in 10 CFR Part 50, Section 50.59.

4. This amended license is effective as of date of issuance and shall expire at midnight on November 21, 2001.

FOR THE ATOMIC ENERGY COMMISSION

Karl R. Goller
Assistant Director for
Operating Reactors
Directorate of Licensing

Attachment:
Appendix "A" (Change No. 10 to
the Technical Specifications)

Date of Issuance: JUL 9 1974

UNITED STATES ATOMIC ENERGY COMMISSION

DOCKET NO. 50-186

THE CURATORS OF THE UNIVERSITY OF MISSOURI

NOTICE OF PROPOSED ISSUANCE OF AMENDMENT TO FACILITY LICENSE

The Atomic Energy Commission ("the Commission") is considering the issuance of an amendment to Facility License No. R-103 to The Curators of the University of Missouri at Columbia, Missouri. The proposed amendment would authorize the University (1) to operate the nuclear research reactor at steady state power levels up to 10 MWt, an increase from 5 MWt, (2) to receive, possess, and use a 100 curie source of antimony-beryllium, and (3) to incorporate revised Technical Specifications in the license. This proposed amendment would revise the license in its entirety to delete the record keeping and reporting requirements from the license because they will be incorporated in the revised Technical Specifications.

The Commission has found that the application for amendment and supplements comply with the requirements of the Atomic Energy Act of 1954, as amended ("the Act"), and the Commission's regulations published in 10 CFR Chapter I. The amendment will be issued after the Commission makes the findings required by the Act and the Commission's regulations which are set forth in the proposed amendment and concludes that the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

The applicant may file a request for a hearing on or before June 24, 1974, and any person whose interest may be affected by this proceeding may

file a petition for leave to intervene. Requests for a hearing and petitions to intervene shall be filed in accordance with the Commission's "Rules of Practice" in 10 CFR Part 2. If a request for a hearing or a petition for leave to intervene is filed within the time prescribed in this notice, the Commission will issue a notice of hearing or an appropriate order.

For further details with respect to this amendment, see (1) the application for amendment dated August 25, 1972, and supplements dated October 5, 1973, January 11, 1974, February 28, 1974, and March 13, 1974, (2) the proposed amendment, (3) the revised Technical Specifications, (4) the related Safety Evaluation by the Directorate of Licensing, and (5) the original Safety Evaluation for operation of the MURR dated July 27, 1966, which are available for public inspection at the Commission's Public Document Room at 1717 H Street, N. W., Washington, D. C. A copy of Items (2), (3), (4), and (5) may be obtained upon request sent to the U. S. Atomic Energy Commission, Washington, D. C. 20545, Attention: Deputy Director for Reactor Projects, Directorate of Licensing.

Dated at Bethesda, Maryland, this 24th day of May 1974.

FOR THE ATOMIC ENERGY COMMISSION

Robert A. Purple, Chief
Operating Reactors Branch #1
Directorate of Licensing

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

SAFETY EVALUATION BY THE DIRECTORATE OF LICENSING

SUPPORTING AMENDMENT NO. 2 TO FACILITY LICENSE NO. R-103

THE CURATORS OF THE UNIVERSITY OF MISSOURI

DOCKET NO. 50-186

INTRODUCTION

By application dated August 25, 1972, and amendments dated October 5, 1973, January 11, 1974, February 28, 1974, and March 13, 1974, the University of Missouri at Columbia requested an amendment to Facility License No. R-103 to permit operation of the MURR at higher power levels and the use of a 100 curie antimony-beryllium source, a change to the Technical Specifications to be consistent with guidance provided in proposed ANS 15.1, and authorization to modify the facility to improve the safety of MURR operations.

The modifications as described in their application were reviewed by the Commission and authorized by letter dated March 21, 1974.

The Missouri University Research Reactor (MURR) is heterogeneous, light water moderated and cooled, reflected with beryllium and graphite, and fueled with enriched (93% U-235) aluminum-uranium plate type elements. The reactor core consists of 8 fuel elements, each occupying a 45° segment of a cylindrical space which is nominally 12 inches O.D. and 9 inches I.D. The volume in the center of the fuel annulus is unpressurized and consists of two regions. The innermost region is a 1.6-inch I.D. "flux trap" which is accessible from the pool surface for insertion and removal of experiments with the reactor shutdown. A water filled region, which is not accessible, separates the "flux trap" from the fuel region. The fuel region is pressurized to approximately 85 psia. The reactor is controlled by varying neutron reflection. A cylindrical shroud of neutron absorbing material in the form of five independently movable rods (four shim safety and one regulating) is inserted between the fuel region and a 3-inch thick beryllium reflector. The rods, the beryllium reflector, and a 9-inch thick graphite reflector surrounding the beryllium are all in an unpressurized pool region outside the reactor pressure vessel. The pool region has provision for experiments in the reflector. Experiments can also be irradiated in beam tubes, pneumatic tubes, or a thermal column.

The MURR has been operated at a power of up to 5 MWt since 1966. It, however, was designed and constructed for eventual operation at 10 MWt with an additional heat exchanger capability that will now be provided. The Commission's review prior to issuance of the construction permit dated October 31, 1961, and again prior to issuance of authorization to operate the MURR at 5 MWt dated July 27, 1966, was based primarily on information relative to 10 MWt operation with authorization given for only 5 MWt because the UMC deferred the installation of the additional heat exchanger equipment. Additional review by the Commission was planned, however, prior to authorization for operation of the MURR at power levels greater than 5 MWt. This review accomplishes that planned action by the Commission.

DISCUSSION

Protection System

Proposed modifications to the reactor protection system will isolate each of two protection system logic units from each other by providing separate inputs (independent sensor systems) to each logic unit. In the present system, each input for a scram signal goes to both logic units in parallel. The new system will reduce the probability of a hot short circuit in the input system causing both logic units to fail to receive a protective action signal. One out of N logic will continue to be used in the new protective system. An open circuit at any input results in a reactor scram as will a loss of power to logic units.

Our review confirms that a single failure will not prevent the system from performing its intended function with the exception that the redundant channels of some of the protective system cabling and electronics are not physically separated and a common external event could effect more than one channel. We agree with the licensee's conclusion, however, that these physical separation deficiencies are adequately compensated for by the close proximity of the reactor operator to protective system cabling and electronics. The operator is in a position to become immediately aware of any external events such as fire which could potentially damage the protective system and can shut down the reactor if protective systems are threatened. The manual scram button in the proposed system initiates a scram on both logic units and also interrupts power to both trip actuator amplifiers and thereby turns off rod magnet current. In our evaluation, we have determined that no single failure could prevent both manual and automatic reactor shutdown.

By letter dated February 28, 1974, the UMC has committed to accomplish an analysis of anticipated transients without scram (ATWS) in accordance with Appendix A of WASH-1270, "Technical Report on ATWS for Water Cooled Power

Reactors." Their analysis and a proposal for accomplishing any necessary modifications to make ATWS consequences acceptable will be provided to the Commission by October 1, 1974. We have determined that the UMC commitment is acceptable for ATWS considerations at the MURR.

Loss of Flow

Loss of flow in the primary system will cause the reactor to be scrammed by any one of four independent flow systems and by flow differential pressure across the core. The reactor would also be scrammed by high inlet or high outlet temperature as a backup to the flow and differential pressure protective systems. If isolation valves on any primary system are actuated by a loss of power to the control circuit or by a loss of air pressure to valve operators, a scram occurs on the loss of power and also when either valve operator leaves its full open position. We have determined that no single failure could prevent the loss of flow protective system from performing its intended function.

Core Convective Coolant System

The proposed installation of a redundant valve system for the core convective coolant system is to eliminate the present single failure potential of the existing system. Each of the two core convective coolant valves is designed to be "fail safe" (fail open on loss of power). The valves are in parallel and both open on loss of flow to allow convective flow through an in-pool heat exchanger to dissipate the reactor decay heat. Each valve is actuated by two independent low flow sensor systems and also by closure of either of the two primary system isolation valves. Our review confirms that the proposed modification will significantly improve the reliability of the convective coolant system in that no single failure will prevent the system from performing its required function. The coolant capacity of the convective coolant system remains unchanged and has been adequately shown in the analysis by the licensee to provide sufficient cooling for the decay heat on a loss of flow situation with steady state power at up to 10 MWt.

Siphon Break System

The modification to the siphon break system will reduce the potential for a release of fission products into the containment building following any accident which damages the fuel. Instead of terminating the open siphon break line near the pool surface, the siphon break line will be provided with siphon break air from a sealed tank.

The siphon break system is designed to prevent uncovering of the core due to siphoning action in the event of a break in the primary system. The licensee has analyzed potential breaks in the primary system and has adequately shown that the anti-siphoning system will prevent the

core from being uncovered by siphoning action from any break in the primary system. Our independent calculations show that there will be a sufficient quantity of air contained in the siphon break system to assure atmospheric pressures as required at the high point of the outlet coolant line if a primary line is draining through a double ended break. The siphon break system is activated in a pipe break incident by low primary system pressure. Two valves in parallel open to supply siphon break air at the high point in the outlet coolant line. Redundant low pressure actuated signals are provided to each of the siphon break valves. We have determined that no single failure will prevent operation of the siphon break function. Air pressure in the siphon break system will be maintained at the required pressure during reactor operation by periodic checks of the system pressure and manual adjustment. Appropriate requirements as discussed with the licensee have been established in the Technical Specifications for the anti-siphon system.

Design Basis Accident

The UMC has chosen a design basis accident (DBA) as the release of fission products from an accidental melting of four fuel plates as a result of blockage of flow. Their analysis shows that exposure to personnel inside and outside containment as a result of this accident would not exceed 10 CFR Part 20 standards for annual exposure to persons in unrestricted areas.

UMC's assumption of the melting of four fuel element plates as a DBA is consistent with the assumed DBA at other similar research reactor facilities and has been determined to be adequately conservative. Exposure calculations are adequately conservative and the resultant exposure from a DBA would be only a small fraction of 10 CFR Part 100 criteria.

Loss-of-Coolant Accident (LOCA)

UMC has analyzed a loss-of-coolant accident caused by a double ended rupture of the largest coolant pipe. Their analysis shows that the core will remain covered (to at least 5 feet above the core) for a rupture of a primary coolant pipe. Their analysis shows that the remaining decay heat following LOCA can be removed adequately by the in-pool heat exchanger without reaching DNB temperatures on any fuel cladding surfaces.

UMC modifications to the convective coolant system and the anti-siphon system are reviewed above. We have determined that no single failure in the protective or engineered safety systems will prevent adequate cooling of the core in the event of a loss of coolant accident.

Release of Argon 41

UMC has reviewed the operation of their facility and has accomplished modifications which will reduce the release of Argon 41 by a factor of

two. The air volume in the thermal column has been reduced and air space above the thermal column has been shielded with a neutron absorbing material. The UMC states that greater than 98% of the remaining Argon 41 production occurs in the three pneumatic tube terminals in the graphite reflector region and the one terminal located in the bulk pool. They state that since 170 c ft/min total of air flow is needed to cool samples in the pneumatic tubes it would be impractical to use argon-free bottled gas or to hold up the exhausted air sufficiently long for appreciable radioactive decay. They maintain that experimental capability will be significantly reduced if other known alternatives are initiated: such as reduction in number of tubes used, the replacement of existing tubes with smaller ones, or the location of tubes to areas of lower neutron flux. UMC calculations and our independent analysis show that potential exposures at the nearest public dwelling as a result of Argon 41 releases are less than 2% of MPC values (averaged on a yearly basis) as specified in 10 CFR Part 20 for unrestricted areas. The University states that they will continue to explore new techniques to further reduce Argon 41 discharges. We have determined that UMC actions to reduce Argon 41 production and proposed plan for further action in the reduction of Argon 41 is an adequate response to our letter of February 22, 1973, and is in compliance with 10 CFR Part 20 requirements.

Technical Specifications

In response to our letter of February 22, 1973, UMC proposed safety limits which were consistent with those as defined in 10 CFR Part 50 and the proposed ANS 15.1. The UMC also withdrew the proposed change to the Technical Specifications which would have allowed experiments with higher radioactive iodine inventory than previously authorized.

Safety limits are defined by UMC as a family of curves with parameters consisting of true values of core flow rate, thermal power, reactor inlet water temperature, and pressurizer pressure. The limits are considered exceeded if, for flow rates greater than 400 gpm the point defined by the reactor power level and core flow rate is at any time above the curve corresponding to the true values of the reactor inlet temperature and primary coolant system pressurizer pressure. Below a 400 gpm core flow rate the safety limit is defined as a maximum fuel cladding temperature of 366°F. Reactor operation is not permitted at 400 gpm or less except during the convective coolant mode for which reactor power is limited to 50 kWt. The reactor will enter the region below 400 gpm also during a normal shutdown or a loss of flow transient in which the decay heat will represent the only reactor power. The criterion used by UMC in establishing the MURR safety limits for all modes of operation of the facility is departure from nucleate boiling. The safety limit curves represent a DNB ratio of 1.2 based on experimentally verified data for MURR type fuel elements. Data was obtained on ATR fuel elements which are similar to MURR elements except that they are about twice as long. ATR results provide some conservatism when used in MURR calculations of DNB conditions because investigators have shown equal or higher burnout heat flux

levels for the shorter MURR channel lengths. The ATR test results also include consideration of hydraulic instabilities relative to incipient bulk boiling. The shorter channel lengths in the MURR are less susceptible by hydraulic instabilities.

The UMC has evaluated LSSS parameters relative to a continuous rod (all rods) withdrawal transient, high pressurizer pressure transient, closing of primary system isolation valves, loss of all electrical power, stopping of primary system pumps, and movement of an unsecured experiment. In each of the above transients, the UMC has shown by conservative analysis that no safety limit would be exceeded by the transient.

Neutron Source of 100 Curies

The analysis provided by the licensee adequately demonstrates that any significant source leakage will be detected by their weekly pool water analysis. They have also shown that pressure buildup in the source during an irradiation to 100 curies of activity is negligible with respect to standard atmospheric pressure. The source unit is not changed. Only the activation level is increased. The source will be accommodated in the same storage and the same irradiation locations as before and used as described herein. The source is doubly encapsulated in stainless steel with the outer container tested to 500 psi external pressure and is, therefore, adequately constructed to prevent release of radioactivity.

The source will be used primarily for subcritical measurements of depleted fuel in preparation for shipment. We have modified the Technical Specifications to require that sources meet the conditions specified for experiments. An appropriate modification to the license has also been made to reflect the use of the source in connection with operation of the reactor rather than exclusively for reactor startup.

CONCLUSION

We conclude that operation of the reactor in the manner proposed can be carried out with reasonable assurance that the health and safety of the public will not be endangered.

Peter B. Erickson
Operating Reactors Branch #1
Directorate of Licensing

Robert A. Purple, Chief
Operating Reactors Branch #1
Directorate of Licensing

Date: May 24, 1974