UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

DOCKET NO. 50-20
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

L I C E N S E

License No. R-37

1. Subject to the conditions and requirements incorporated herein, the Commission hereby licenses Massachusetts Institute of Technology (hereinafter referred to as "MIT"):

   a. Pursuant to Section 104a. and c. of the Atomic Energy Act of 1954 as amended, and Title 10, CFR, Chapter 1, Part 50, "Licensing of Production and Utilization Facilities", to possess and operate as a utilization facility the nuclear research reactor facility (hereinafter "the facility") designated below;

   b. Pursuant to the Act and Title 10, CFR, Chapter 1, Part 70, "Special Nuclear Material", to receive, possess and use 12 kilograms of uranium enriched to approximately 93% in the uranium 235 isotope as fuel for operation of the facility.

   c. Pursuant to the Act and Title 10, CFR, Chapter 1, Part 30, "Licensing of Byproduct Material", to possess, but not to separate, such byproduct material as may be produced in the operation of the facility.

2. This license applies to the facility which is owned by MIT and located in Cambridge, Massachusetts, and described in MIT's application filed on February 20, 1956, and amendments to the application, filed on May 13, 1957, September 16, 1957, November 27, 1957, January 2, 1958, January 9, 1958, January 27, 1958, February 24, 1958, and March 25, 1958, (hereinafter "the application"). The reactor is a one megawatt (thermal) heavy water-cooled and -moderated, heterogeneous, enriched uranium reactor. Experimental facilities are provided for use in neutron diffraction work, horizontal beam experiments, neutron beam therapy experiments, exponential assembly experiments, and neutron irradiation studies.

3. This license shall be deemed to contain and be subject to the conditions specified in Section 50.54 of Part 50 and Section 70.32 of Part 70; is subject to all applicable provisions of the Act and rules, regulations and orders of the Commission now or hereafter in effect; and is subject to the additional conditions specified or incorporated below.

a. Operating Restrictions

(1) MIT shall operate the facility in accordance with the procedures and limitations described in the application.

(2) MIT shall not operate the facility at a power level in excess of 1000 kilowatts (hermal).

(3) No experiment shall be introduced into or permitted to remain in the reactor if more than one per cent excess reactivity would be introduced into the reactor by the withdrawal or loss of that experiment.

(4) The reactor shall not be operated at a power level in excess of that necessary to measure the temperature and void coefficients until MIT has measured these coefficients and found them to be of the sign, and substantially of the magnitude, calculated in its application.

b. Records

In addition to those otherwise required under this license and applicable regulations, MIT shall keep the following records:

(1) Facility operating records, including power levels.

(2) Records showing radioactivity released or discharged into the air or water beyond the effective control of MIT as measured at the point of such release or discharge.

(3) Records of emergency scrams, including reasons for emergency shutdowns.

c. Reports

(1) MIT shall immediately report to the Commission any indication or occurrence of a possible unsafe condition relating to the operation of the facility.

(2) MIT shall, upon completion of the start-up experiments described in its application, submit a report to the Commission describing such experiments and the results thereof.

4. Pursuant to Section 50.60 of the regulations in Title 10, Chapter 1, CFR, Part 50, the Commission has allocated to MIT, for use in the operation of the reactor, 11.63 kilograms of uranium 235 contained in uranium (enriched to approximately 93% in the isotope uranium 235). Estimated schedules of special nuclear material transfers to MIT and returns to the Commission are contained in Appendix "A" which is attached hereto. Shipments by the Commission to MIT in accordance with column 2 in Appendix "A" will be conditioned upon MIT's return to the Commission of material substantially in accordance with column 3 of Appendix "A".

5. This license is effective as of the date of issuance and shall expire at midnight May 7, 1996, unless sooner terminated.

FOR THE ATOMIC ENERGY COMMISSION

H. L. Price
Director
Division of Licensing and Regulation

Date of Issuance:

JUN 9 - 1958

APPENDIX "A"

TO

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FACILITY LICENSE

Estimated Schedule of Transfers of Special Nuclear Material from the Commission to Massachusetts Institute of Technology and to the Commission from MIT:

(1)	(2)	(3)		(4)	(5)
Date of Transfer (Fiscal Year)	Transfers from AEC to MIT Kgs. U-235	Returns by MIT to AEC Kgs. U-235 Recoverable Cold Scrap	Spent Hot Fuel	Net Yearly Distribution Including Cumulative Losses Kgs. U-235	Cumulative Distribution Including Cumulative Losses Kgs. U-235
1957	5.00	-	-	5.00	5.00
1958	1.04	3.04	0.92	(2.92)	2.08
1959	3.33	1.66	1.37	0.30	2.38
1960	2.50	1.25	1.00	0.25	2.63
		In years 1960 through 1996 columns (2) through (4) carry the same quantities. Column (5) increases by 0.25 Kg. each year.			
1996	2.50	1.25	1.00	0.25	11.63
Inventory to be returned	-	-	2.23	(2.23)	9.40
	101.87	50.95	41.52	9.40	

IN THE MATTER OF)
MASSACHUSETTS INSTITUTE OF)
TECHNOLOGY)

Docket No. 50-20

FINDINGS AND CONCLUSIONS

A. Findings

1. On February 20, 1956, the Massachusetts Institute of Technology (hereinafter referred to as MIT) submitted an application for the necessary licenses to construct and operate a research reactor.

2. MIT is a nonprofit, private, educational institution organized under the laws of the State of Massachusetts. MIT is not owned, controlled, or dominated by an alien, foreign corporation, or foreign government.

3. The MIT reactor is a one megawatt (thermal) heavy water-cooled and -moderated, heterogeneous, enriched uranium reactor. The reactor is to be used for the conduct of research. Experimental facilities are provided for use in neutron diffraction work, horizontal beam experiments, neutron beam therapy experiments, exponential assembly experiments, and neutron irradiation studies.

The reactor core and the heavy water moderator are contained in an aluminum pressure vessel. The experimental facilities located outside of the pressure vessel in the graphite reflector, consist of horizontal ports, rotary changing ports, instrument ports, pneumatic tube changers, thimble tubes, thermal columns, and a medical therapy radiation facility. The only experimental facilities located inside of the pressure vessel are six small sample tubes in the heavy water moderator.

The fuel consists of 19 curved plate-type fuel elements, similar to those in the Materials Testing Reactor at Arco, Idaho.

For control and regulation of the reactor, there are six top entry shim-safety rods which penetrate vertically through seals in the pressure vessel into the core region. The control rod drive mechanisms are located between two concrete plugs at the top of the reactor tank.

The pressure vessel for this reactor is an aluminum cylinder 4 feet in diameter and $\frac{1}{4}$ inch thick. This vessel was designed to be in accordance with the ASME Code for Unfired Pressure Vessels to withstand a pressure of 40 psig. The top lid of the pressure vessel is designed to withstand 80 psig. The pressure vessel is surrounded by two feet of graphite. The graphite is enclosed in a boral-lined steel gas-tight container. Outside of this container is a water-cooled thermal shield consisting of a layer of steel and lead. Surrounding the thermal shield is a layer of high density concrete about six feet thick which serves as the biological shield.

The coolant system consists of a primary heavy water loop heat exchanger, a secondary light water loop, and a cooling tower in the secondary loop. The coolant pipes enter at the bottom of the pressure vessel and circulate upward through the core.

4. On May 7, 1956, the AEC issued Construction Permit No. CPRR-5 to MIT for the construction of the reactor for which they are now seeking an operating license.

5. The construction permit CPRR-5 provided that "MIT is financially qualified to construct and operate the reactor in accordance with the regulations contained in Title 10, Chapter 1, Code of Federal Regulations; to assume financial responsibility for the payment of Commission charges for special nuclear material and to undertake and carry out the proposed use of such material for a reasonable period of time." There has been no information developed with respect to the financial qualifications of MIT which significantly changes the facts upon which this conclusion was based.

6. The Massachusetts Institute of Technology has had many years experience in conducting a program of instruction and experimentation in the field of nuclear engineering and related subjects. The MIT staff is well trained in the theoretical aspects of reactor operation and several members of the staff have had operating experience with reactors.

7. The construction permit specified certain additional information required of the applicant prior to the issuance of the operating license. Such information included:

   "(a) A standard operating procedure, including start-up routine and non-routine operation, and shut-down;

   "(b) A description of critical experiments to be performed, including procedures to be followed; and

   "(c) A plan of action for disaster control in event of accident or incident resulting in a radioactive hazard to the public."

   Information on these matters has been supplied and is discussed in Findings Number 8, 9, and 10, respectively.

8. During the initial start-up, the reactor coolant system is to be filled with light water and flow tests are to be conducted using primarily dummy fuel elements. After these tests are completed, the fuel elements are to be removed and the reactor is to be drained, dried and then filled with heavy water. Checks are then to be made to insure that all operating conditions, instrumentation and controls, experimental facilities, and safety systems are in proper order.

   The reactor is to be operated five days per week. At the beginning of each operating period all safety systems are to be checked and, if necessary, a new fuel element is to be loaded. Each time a new loading has been made, an experiment is to be performed to determine the critical position of shim and control rods.

   The applicant has established operating rules for this facility including administrative regulations for routine and emergency procedures, procedures for reviewing reactor experiments, and procedures for determining the qualification and responsibilities of operators.

The proposed operating procedures appear to be adequate to provide reasonable assurance that the reactor can be operated safely.

9. MIT is to conduct a number of initial critical experiments including calibration of shim rods, regulating rod, heavy water level, and neutron absorbers; oscillation frequency experiments; reactivity experiments involving non-uniform loadings, neutron flux and spectral distribution measurements; radiation surveys; fission product poisoning measurements; instrumentation adjustments and calibrations; temperature distribution measurements; temperature and void coefficient measurements; and general performance, inspection, checks and tests with simulation of possible failures. The experiments described and the means for conducting such experiments appear adequate to provide the necessary initial operating data.

10. MIT has established a detailed disaster control plan. This plan provides for the evacuation of people under the immediate control of MIT and for immediate liaison, where necessary, with appropriate State and local officials. This plan appears adequate to provide for emergency situations.

11. The reactor is located in a steel containment building. The building has been designed in accordance with the American Petroleum Institute Recommended Rules for Large Welded Low-Pressure Storage Tanks to withstand an internal pressure of 1 psi. A concrete shadow shield 2 feet thick and 33 feet high surrounds the interior of the containment building.

    The containment building is penetrated by a personnel air-lock, a truck air-lock, an inlet air duct, an aluminum neutron window, a hot-plug storage tank, two hydraulic lifts, an exhaust air duct, an emergency escape air-lock and several pipes and conduits. MIT is providing in both the inlet and outlet lines of the ventilation system for an automatically controlled valve, and a manually operated valve in series.

    The control mechanisms provided at the points of penetrations in the containment building and the nature and frequency of proposed leakage tests appear adequate to provide reasonable assurance that the leakage rate specified will be maintained. The leakage of the building will be measured after all penetrations have been installed and there will be annual tests for leak tightness.

    The construction permit approved the substitution of a single steel door in place of the truck air-lock in the containment building subject to two conditions. These conditions are not relevant, since MIT has constructed the reactor with the truck air-lock. The air-lock is adequate.

12. The MIT reactor is generally similar to the CP-5 research reactor at Argonne National Laboratory and should exhibit similar characteristics. Negative temperature and void coefficients and a long neutron lifetime, which are characteristics of a reactor of this general design concept, provide a high degree of inherent stability.

The temperature and void coefficients are expected to be sufficiently negative to assure safe operation. However, the information on which this finding is based consists of theoretical calculations. The sign and magnitude of these coefficients cannot be definitively established until measurements are made during actual operation of the reactor.

13. The maximum credible accident for this facility consists of the instantaneous insertion of not more than 2.3% excess reactivity. MIT has stated that such an insertion of excess reactivity could be caused by dropping a fuel element into the central fuel element position in the core of the reactor. The initiating mechanisms for this accident would require a combination of circumstances the concurrent occurrence of which are highly improbable.

The instantaneous insertion of 2.3% excess reactivity would place the reactor on a period of approximately 40 milliseconds. Based on the postulated thermal characteristics and temperature coefficient values for the MIT reactor, the temperature reached in the fuel is calculated to be well below the melting point of the fuel. The resulting excursion would be terminated by inherent shutdown characteristics of the core itself before any significant damage would result to the reactor.

Based upon information presently available, the acceptance of this accident as the maximum credible accident is dependent upon a limitation of the amount of excess reactivity which can be inserted by the loss of a single experiment. MIT has calculated that the amount of excess reactivity which could be added to the reactor as a result of flooding all of the experimental facilities with light water would be approximately 1%. Such flooding could credibly occur concurrently with the loss of a single experiment.

14. The greatest possible release of fission products under the conditions of containment specified for this facility from accidental spillage in the handling of the largest experiment to be conducted in this facility would be considerably less than 1.5 r of gamma radiation and an integrated dose of 92 rep to the thyroid from iodine 131 to a person continuously exposed at the site boundary for one hour. While a release of sufficient magnitude to result in such exposures is highly unlikely, these doses would not result in any clinically observable damage to those exposed.

15. MIT has submitted data describing the control and safety instrumentation and the administrative procedures relating to the use of the facility for neutron beam therapy experiments and medical therapy. The instrumentation and procedures appear to provide adequate protection for the health and safety of the public and personnel participating in the use of the facility for these purposes.

16. On January 27, 1958, MIT filed with the Commission, as proof of financial protection pursuant to 10 C.F.R., Part 140, copies of binder No. 14, issued by Mutual Atomic Energy Liability Underwriters, covering this facility in the amount of $2,000,000.

17. The application has been referred to the Advisory Committee on Reactor Safeguards for a report with respect to the hazards of the fadlity. The report of the Committee has been made available to the public.

18. The AEC staff and the Commission's Advisory Committee on Reactor Safeguards believe that the MIT reactor can be operated with an acceptable degree of risk to the health and safety of the public. The advisory Committee recommended that provision be made for an auxiliary system of closing the inlet and outlet lines of the ventilation system. Since the ACRS considered this matter, MIT has stated that it will provide an adequate manually operated valve which is auxiliary to the automatically controlled valve now installed, prior to commencement of the research program.

B. Conclusions

1. The processes to be performed, the operating procedures, the facility and equipment, the use of the facility and other technical specifications provide reasonable assurance that the applicant will comply with the regulations in Chapter 1 of Title 10 of the Code of Federal Regulations, including the regulations in Part 20, and that the health and safety of the public will not be endangered by the operation of this facility, subject to the following conditions:

   (a) No experiment shall be introduced into or permitted to remain in the reactor if more than one per cent excess reactivity would be introduced into the reactor by the withdrawal or loss of that experiment.

   (b) The reactor shall not be operated at a power level in excess of that necessary to measure the temperature and void coefficients until MIT has measured these coefficients and found them to be of the sign, and substantially of the magnitude, calculated in its application.

2. MIT is technically qualified to operate the proposed reactor.

3. MIT is financially qualified to operate the reactor in accordance with the regulations contained in Title 10, Chapter 1, of the Code of Federal Regulations, and to assume financial responsibility for the payment of Commission charges for special nuclear material and to undertake and carry out the proposed use of such material for a reasonable period of time.

4. MIT has submitted proof of financial protection which satisfies the requirements of Commission regulations which are currently in effect.

5. The issuance of a license will not be inimical to the common defense and security or to the health and safety of the public.

FOR THE ATOMIC ENERGY COMMISSION

H. L. Price
Director
Division of Licensing and Regulation

JUN 9 1958

Appendix B

Power History for MITR-I Startup Testing: July 1958 – July 1959

Date	Power Level/Activity
07/21/58	Initial criticality of MITR-I.
07/21/58 - 12/30/58	Intermittent operation at less than 10 kW.
12/31/58	First operation at 10 kW.
12/31/59 - 01/21/59	Intermittent operation at 10 kW.
01/22/59	First operation at 50 kW.
01/22/59 - 02/02/59	Intermittent operation at either 10 kW or 50 kW.
02/03/59	First operation at 100 kW.
02/03/59 - 02/17/59	Intermittent operation at 100 kW.
02/18/59	First operation at 200 kW.
02/19/59	Operation at 100 kW (0.5 hour) and 200 kW (0.5 hour).
02/20/59	First operation at 1 MW (0.75 hour).
02/20/59 - 03/25/59	Intermittent operation at power levels varying from 10 kW to 50 kW. Also, a total of 8.0 hours at 1 MW.
03/30/59 - 04/01/59	Continuous operation at 1 MW for xenon profiling.
04/02/59 - 05/15/59	Intermittent operation at power $\leq$ 500 kW. Also, a total of 13.0 hours at 1 MW.
05/16/59 - 05/27/59	Shutdown for maintenance.
05/28/59 - 05/29/59	Stepwise power escalation to 1 MW.
06/01/59	Use of reactor at authorized power level initiated with reactor operating for one shift per day.
07/01/59	Routine three-shift operation initiated at authorized power level.

Appendix C

Letter dated 23 July 1975 from Mr. George Lear, Chief, Operating Reactors Branch #3, Division of Reactor Licensing (USNRC) to Mr. Lincoln Clark, Jr., Director, MIT Research Reactor (MIT). (Note: Both an environmental impact and a safety analysis were appended to this letter. The first page of the latter is included here, because it documents the date of the construction permit and that of the MITR-I shutdown.)