NUCLEAR REACTOR LABORATORY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

O. K. HARLING
Director

138 Albany Street Cambridge, Mass. 02139
(617) 253- 3843

L. CLARK, JR.
Director of Reactor Operations

February 18, 1977

Mr. James P. O'Reilly, Director
U.S. Nuclear Regulatory Commission
Office of Inspection and Enforcement, Region I
631 Park Avenue
King of Prussia, PA 19406

Subject: Startup Report, License R-37, Docket No. 50-20

Dear Mr. O'Reilly:

In compliance with the requirements of the MIT Research Reactor Technical Specifications, paragraph 7.13.4, MIT submits herewith its written report of the startup of the MITR after completion of the modifications authorized under Construction Permit CPRR-118.

Sincerely,

David D. Lanning

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xc: NRC-DRL -- Mr. G. Lear

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MITR-II Start-up Report

Prepared by MITR Staff
January 1977

MITNE 198

Approved by MITRSC

February 14, 1977

5.10.5 - Scram Check

Acceptance Criteria

Nuclear Safety system operates satisfactorily at full power.

5.11 - Natural Convection Heat Removal

Purpose

To verify that the maximum expected decay heat can be satisfactorily removed by natural convection after a loss of induced flow.

5.11.1 - Natural Convective Heat Removal of Equivalent to Decay Power

Acceptance Criteria

Maximum fuel element surface temperature as calculated from measured surface temperatures shall not exceed that required for incipient boiling.

5.11.2 - Natural Convective Heat Removal During Transient Following Loss of Coolant Flow

(to be done concurrently with Procedure 5.10)

Acceptance Criteria

Maximum fuel element surface temperature, as calculated from measured surface temperature, shall not exceed 300°C.

Results

Procedure 5.11.1 was followed first (below 100 Kw) as planned, in order to check that the natural convection cooling system does operate as predicted and to prove this satisfactory operation before a significant fission product decay heat load was built up by higher power operation. Procedure 5.11.1 was carried out on Core I. The procedure involved stepwise power increases below 100 Kw with primary coolant pump off to measure the coolant and fuel plate temperatures with natural convection cooling. Conservative estimates of the thermal power were used for initial steps and trip settings. After reasonably measurable temperature rises were detected (in the range of 10 to 40 Kw) a better calibration of the systems was attempted based on the natural convection cooling. However, this method had large uncertainties due to efforts such as chimney effects above the core and no direct measurement of the flow rate through the core. Therefore, the sub-committee of the MITR Safeguards Committee approved operation above 100 Kw with a primary pump operating so that a good power calibration could be obtained by operation at approximately 1.0 Mw. The operating power was chosen such that the early natural convection could be used as proof that the decay heat would be adequately removed by natural convection in the event of a shutdown due to loss of primary flow. After the more accurate thermal power calibration of the instrumentation was completed, then procedure 5.11.1 was again followed, stepwise, to a power level of 80 Kw. This was sufficient to extrapolate the measured temperatures up to 100 Kw and prove that natural convective cooling meets the acceptance criteria.

After completion of the natural convection low power tests, the stepwise power tests (Procedure 5.10) were initiated with the combination of 5.11.2 natural convection transient cooling tests after each power step. The data was taken at each step and extrapolated ahead for approval of the next step. The minimum steps required by the procedure were 1.0 Mw, 2.5 Mw and 4.9 Mw; however, in general, the power was raised in 0.5 Mw steps and tests and data interpretation were carried out at each step. Core I data was used as the primary source of information for operation up to 2.5 Mw for Cores II and IV, with some check step tests on Cores II and IV during operation up to 2.5 Mw. Above 2.5 Mw all tests were repeated for Core IV in 0.5 Mw steps up to 4.9 Mw operation. On December 1, 1976, the reactor reached 4.9 Mw. The results of these tests can be summarized as follows:

1. Measured steady state fuel plate temperatures are equal to or less than the predicted values. The maximum hot spot fuel plate temperature (C-13 outside channel 8 inches up) as conservatively inferred from the measured data is 90°C at 6 Mw, 1800 gpm and 60°C core average outlet temperature. This power and these system values are the technical specification, Limiting Safety System Settings, and hence the hot spot is below nucleate boiling under all allowable operating conditions.
2. Temperatures in the D_2O reflector are easily controlled to be well below 55°C. Satisfactory system flow conditions have been established.
3. The measured graphite temperature (in 3GV6) is 175°C after 17 hours at 4.8 Mw and 179°C after 4 days at 4.9 Mw. This is well below the approximately 300°C graphite temperature measured for MITR-I operation.
4. The Medical Water Shutter temperature was measured to stay approximately equal to the primary coolant temperature and was well below the 70°C criteria during 4.9 Mw operation.
5. The D_2O blister tank temperature is measured to be approximately equal to the D_2O reflector temperature and hence is kept well below 60°C during 4.9 Mw operation.
6. Radiation surveys were taken and the acceptance criteria has been satisfied. Dose rate levels and effluent activities are similar to the MITR-I operating conditions with the major exception of the equipment room N-16 dose rates which are lower for MITR-II due to the longer decay time in the core tank and piping.
7. Nuclear Safety channels are linear up to and through 4.9 Mw operation as checked against thermal power calibrations. The automatic control system has been adjusted to operate satisfactorily. Radiation monitor trip settings have been established.

8. The xenon transients of build-up to steady state and transient peaking after shutdown from 4.9 Mw operation have been measured. The steady state value agreed well with predicted reactivity effects; however, the peak xenon after shutdown was considerably lower than estimated by simple one region calculations. This variation from prediction does not cause any operating problem, in fact it is a benefit when xenon override is required. More sophisticated calculations are being made to better understand the details of the shutdown transient.

   Initial reactivity effects of burnup and samarium poisoning have been measured and continued surveillance of core reactivity during 4.9 Mw operation is in progress.

9. A scram check at full power was completed satisfactorily. This was done by lowering the power to about 4 Mw, then resetting the safety system scram below 5.0 Mw and then slowly raising the power until the reactor was scrammed by the safety system trips. The trip occurred at about 4.8 Mw and was in agreement with the preset current reading for the trip point.

10. Natural convection heat transfer has been shown to be satisfactory for removal of decay heat after shutdown due to loss of primary coolant flow at all power level steps up to 4.9 Mw. The maximum fuel plate temperature occur at 25 to 30 seconds after loss of flow and simultaneous scram. After operation at 4.9 Mw, the outlet of the hottest channel (C-13 near outside) is conservatively estimated from the measured data to be 96°C at the peak of the temperature transient and in this case the maximum wall temperature may be a few ~10 to 15°C higher. Since the incipient boiling temperature is near 107°C, the surface may be approaching this temperature. These results are almost in exact agreement with the predicted natural convection cooling results. As discussed on Page 15.15 of the MITR-II Safety Analysis Report MITNE-115, the calculated temperature on loss of flow

after 5 Mw operation were estimated to peak near the boiling condition and the small amount of vapor bubbles is expected to enhance the heat transfer coefficient. The acceptance criteria on natural convective cooling of decay heat from full power operation is therefore satisfactorily met.

Conclusion

The MITR-II pre-operational and start-up tests have been satisfactorily completed. The data have been reviewed by MITR Operations and Radiation Protection Offices. The acceptance criteria have been met and the results of the testing have been discussed with the MIT Reactor Safeguards Committee. On December 20, 1976, the MIT Reactor Safeguards Committee approved continued normal operation at 4.9 Mw for the MITR-II.

Approved: David D. Lanning

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Lincoln Clark, Jr.

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