U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-54/84-01

Docket No. 50-54

License No. R-81 Priority -- Category F

Licensee: Union Carbide Corporation
P. O. Box 324
Tuxedo, New York 10987

Facility Name: Union Carbide Nuclear Reactor

Inspection At: Tuxedo, New York 10987

Inspection Conducted: January 4-6, 1984

Inspectors: for T. C. Elsasser
W. W. Kinney, Project Engineer — 2/3/84 date

for T. C. Elsasser
J. A. Robertson, Reactor Engineer — 2/3/84 date

Approved by: T. C. Elsasser
T. C. Elsasser, Chief, Reactor Projects Section 1B, DPRP — 2/3/84 date

Inspection Summary: Inspection on January 4-6, 1984 (Report No. 50-54/84-01)

Areas Inspected: Routine, unannounced inspection by two region-based inspectors (26 hours) of licensee action on previous inspection findings; facility operation; Fission Product Molybdenum target capsule ruptures; organization; reviews and audits; operator requalification training; surveillance activities; and radiation control.

Results: No violations or deviations were identified.

## DETAILS

1. Persons Contacted

*J. J. McGovern, Business Manager, Radiochemicals
*W. G. Ruzicka, Manager, Nuclear Operations
*C. J. Kornerth, Manager, Health, Safety and Environmental Affairs
*F. J. Morse, Manager, Radiochemical Process Engineering
*L. C. Thelin, Supervisor, Health Physics

The inspector also interviewed the reactor supervisor, another health physics supervisor, reactor operators, and a health physics technician during the inspection.

*Denotes those present at the exit interview.

2. Licensee Action on Previous Inspection Findings

(Closed) Unresolved Item (54/79-01-05): During the February 27-28, 1979, inspection, the inspector questioned the adequacy of the records of power because the recorder charts of neutron power (Log-N, Linear N, Period, and Log Count Rate) were not dated and were not being filed as records of power. During this inspection, the licensee stated that recorder charts showing power levels are dated and filed as records, as required by Technical Specification 6.6, Records, when unscheduled shutdowns and significant unplanned transients occur. Further, the power levels are maintained as a record on the reactor log sheets required by Technical Specification 6.6.1

(Closed) Violation (54/83-01-01): During an eight week time interval from August 5 to September 30, 1982, the licensee did not perform the monthly surveillance channel tests for the coolant flow, core differential temperature, pool temperature and pool level measuring channels. During this inspection the inspector verified that the licensee performs these surveillance channel tests prior to any reactor startup. The checklist for reactor startup within eight hours of shutdown, Reactor Restart Check List, RS-06, was revised so that these channel tests are to be performed prior to each routine reactor restart. Routine reactor restarts are accomplished more frequently then monthly.

3. Facility Operation

The inspectors toured the accessible areas of the facility with a licensee representative. The general level of housekeeping was acceptable.

The inspectors observed the placement of a target capsule fitted with thermocouples in a single pull stringer into the core as part of the heat transfer experiments authorized by the Nuclear Safeguards Committee and the Level 1 Manager. The inspector also observed the completion of the final checks of the Reactor Restart Check List and the reactor startup. The operators performed the work carefully and proficiently.

The heat transfer experiments mentioned above were being performed in a program to define and correct the heat transfer problems associated with the use of the single pull stringer which had been used to hold fueled Fission Product Molybdenum (FPM) target capsules in the core. This subject is discussed further in the next section of this report.

The licensee continues to operate the reactor continuously, 24 hours per day, seven days per week. Each operating shift has two licensed reactor operators on duty. If one of the reactor operators is not a licensed senior reactor operator, a licensed senior reactor operator is on call.

4. Fission Product Molybdenum (FPM) Target Capsule Ruptures

At 10:10 p.m. on October 20, 1983, while operating at 5 MW power, area radiation monitors, continuous air monitors, and the stack particulate monitor alarmed. As a result, the licensee shutdown the reactor, activated the reactor building containment system, and evacuated personnel from the reactor building. After health physics surveys, the licensee re-entered the building early October 21, 1983. The licensee removed two suspect FPM target capsules (fueled experiments) from the reactor and restarted the reactor at 11:30 a.m. Elevated stack particulate monitor readings recurred, and the licensee again shutdown the reactor at 1:30 p.m. The licensee replaced all of the target capsules with dummies and began the systematic replacment of the capsules back into the reactor at 4:45 p.m. At 11:27 p.m. on October 21, 1983, the licensee reinserted a target capsule in the core which immediately ruptured. Sufficient radioactivity was released to cause the actuation of the excursion monitor which caused the automatic sounding of the evacuation alarm and isolation of the reactor containment. After health physics surveys on October 22, 1983, the licensee re-entered the reactor building and placed the ruptured target in a container which was transferred to a hot cell. The reactor was returned to operation at 11:00 a.m. on October 22, 1983. No licensee personnel received greater than 10 mrem exposure or internal depositions as measured by thyroid scans. Airborne radioactive releases to the environment were less than one percent of Technical Specification limits. The capsule rupture consisted of a one and one-half inch long axial separation at the upper end of the capsule.

Two members of the Nuclear Safeguards Committee reported to the facility immediately following initiation of the incident on October 20, 1983. The other two accessible members of the six-member committee were informed of the incident early on October 21, 1983. Three members of the committee met on October 21, 1983, and decided the course of action to be taken. These planned actions included immediate corrective actions, analysis of the failure of the ruptured capsule, and a technical analysis of the capsule manufacturing process.

At 11:40 p.m. on November 16, 1983, while operating at 5 M W power, a second FPM target capsule ruptured. Again, sufficient radioactivity was released to cause the actuation of the excursion monitor which caused the automatic sounding of the evacuation alarm and isolation of the reactor

containment. After health physics surveys and air sampling of the reactor building, the reactor building ventilation was returned to normal at 4:40 a.m. on November 17. At 7:45 a.m. health physics allowed unrestricted access to the reactor building. The ruptured capsule and the E3 "single pull" stringer were removed from the core, encapsulated in a container, and transferred to a hot cell. The capsule rupture consisted of a two inch long axial separation approximately in the center of the capsule. No licensee personnel involved with the incident were contaminated or received a dose exceeding 45 mrem whole body. The total release of airborne radioactivity to the environment was less than 1 percent of Technical Specification limits.

The Nuclear Safeguards Committee held three meetings on November 17-18, 1983, and ultimately recommended that reactor operation using FPM target capsules could be resumed with the capsules in the previously used box design FPM stringers. The reactor was to be brought slowly to power. On November 18-19, the reactor was brought up to 5 MW power with the FPM target capsules in the box design FPM stringers. Reactor operation has continued since that time without any problem with the target capsules.

The second FPM target capsule ruptured in a manner that suggested a cause other than internal pressure. The two inch long axial break in the capsule wall was centered within a patch of color that was distinct from the color of the rest of the capsule. The capsule had been irradiated for only four minutes before failure. The second capsule rupture and the frequent incidence of similar discoloration on other targets indicated to the licensee that some overheating of target capsules may have caused the capsule failures.

The single pull FPM stringer was placed in service during September 1982, and even though the single pull stringer had been in use for slightly more than a year, the licensee decided to revert to the former box stringer design until the heat transfer effectiveness of the single pull stringer could be further analyzed.

The licensee performed heat transfer calculations and checked the fission rates within the targets and concluded that with the proper coolant flow, overheating of the capsule walls was not possible. The licensee further concluded that the most plausible explanation for the failures was that the annular coolant gap between the cylindrical wall of the FPM target capsule and the tube of the single pull stringer surrounding the target had changed. If the coolant channel gap were to change, local boiling could start from reduced flow, and a transient in heat transfer could result.

The licensee gauged irradiated target capsules and found no permanent warpage of the capsules which could have caused the failures. The licensee then gauged all the single pull stringers to determine the extent of any wear to the capsule-positioning dimples in the stringer tubes which could have caused the annular coolant gap around the capsule to change. Several cylindrical gauge tubes with outside-diameters (OD's) that varied from 1.254 inches (the original inside diameter (ID) of the three positioning dimples at the top and bottom of the stringer tubes) up to 1.280 inches

were inserted into each tube of each stringer as go-no-go gauges. This gauging showed that the dimples of 28 of 32 tubes had worn to an ID greater than 1.265, 17 of 32 to an ID greater than 1.270 inches, and 1 of 32 had an ID greater than 1.280 inches. All tubes in the stringer in which the second capsule failed while being irradiated were worn to an ID greater than 1.270 inches but less than 1.280 inches. Under these conditions, the annular coolant gap between the FPM target capsule and the stringer tube could be reduced to less than 10 mils (0.010 inch) in this stringer.

Under these circumstances, the licensee concluded that the probable mechanism of the rupture of the FPM target capsules was as follows:

- The annual coolant channel was distorted to the point where flow in the narrowed portion of the channel was reduced appreciably.

- Local transient film boiling raised the average temperature within the target wall.

- Lateral movement of the target capsule caused rapid local cooling from the film boiling condition resulting in an instantaneous high differential temperature ($\Delta T$) across the target wall.

- The high $\Delta T$ caused excessive thermal stress and subsequent capsule failure.

The licensee has committed to continue the use of the stringers of the box design until suitable corrections to the problems associated with the single pull stringer are found. Upon arriving at suitable corrections allowing the use of the single pull stringer, the licensee committed to submit appropriate Technical Specifications to the NRC regarding the use of the stringer. The Technical Specifications will specify the steps to be taken to assure that proper coolant flow is provided and maintained around all fueled experiment capsules (FPM target capsules) so that these capsules will not rupture because of inadequate heat transfer during irradiation. This will be inspected during a future inspection (54/84-01-01).

5. Organization

The incumbents of organizational levels described in the Technical Specifications are:

| Level | Responsibility | Position | Incumbent |
|---|---|---|---|
| 1 | facility license and site administration | Business Manager, Radiochemicals | *J. J. McGovern |
| 2 | reactor facility management | Manager, Nuclear Operations | *W. G. Ruzicka |
| 3 | daily reactor operations | Reactor Supervisor | *R. A. Strack |

| | | | |
|---|---|---|---|
| 4 | reactor operating staff | Chief, Reactor Operator | *S. E. Lupinski |
| | | Ass't Chief Reactor Operator | *T. R. English |
| | | Day Shift Relief Operator | *G. J. Premus |
| | | Reactor Operators | *J. R. Baird |
| | | | *R. R. Racino |
| | | | **K. D. Morales |
| | | | **P. W. Weber |
| | | | **I. Groun |
| | | | ***S. Sondak |
| | | Reactor Operator Trainees | P. Harp |
| | | | S. Clark |
| | | | J. Whelan |
| | | | R. Saxton |

* Licensed Senior Reactor Operator
** Licensed Reactor Operator
*** Tested by NRC for Reactor Operator License on 12/28/83

In August 1983, the former Manager of Nuclear Operations, M. H. Voth, resigned. W. G. Ruzicka was reassigned from the Reactor Supervisor position to the Manager of Nuclear Operations position, and R. A. Strack was reassigned from the Project Engineer position to the Reactor Supervisor position. The licensee has recently hired J. A. Franzen as the Reactor Project Engineer.

During 1983, three reactor operators and one reactor operator trainee left the reactor. Two auxiliary facility operators not listed above, one a licensed reactor operator and the other a licensed senior reactor operator, are performing reactor operator duties as needed until the trainees become licensed operators.

The radiation protection function is managed by C. J. Konnerth, Manager, Health Safety and Environmental Affairs. Presently, Mr. J. L. Ditton is performing as the Health Physics Supervisor for routine health physics activities. This allows Mr. Thelin to perform more special staff-type health physics studies and activities. The licensee has four full-time health physics technicians.

## 6. Reviews and Audits

The inspector reviewed the minutes of Nuclear Safeguards Committee meetings 101 through 107 which were held during the period of September 14, 1982, through November 18, 1983. The committee also held meetings 108 and 109; however, the formal minutes for these meetings were yet to be prepared and disseminated. According to the mirutes, meetings 103, 105, 106, and 107 were concerned primarily with the ruptured target capsule. The Nuclear Safeguards Committee approved the initial use of the single pull stringer on September 14, 1982. During the general meetings, the committee reviewed and approved procedures, reviewed and approved experiments, reviewed and recommended actions regarding incident reports, and

considered findings made by auditors. The committee also considered the problems of hand exposure to personnel operating the "cryogenic glove box system". According to the licensee, equipment and procedural changes have corrected this hand exposure problem.

The Nuclear Safeguards Committee membership and officers were changed on March 23, 1983.

| Member | Alternate |
|---|---|
| C. Konnerth, Chairman | L. Thelin |
| F. Morse, Secretary | |
| K. George | |
| J. McGovern | D. Grogan |
| D. Gallaher | R. Quackenbush |
| M. Voth | W. Ruzicka |

With M. Voth leaving in August 1983, W. Ruzicka was made a voting member of the committee during meeting 103 on October 27, 1983.

The inspector noted that the new secretary should maintain awareness of the requirement that meeting minutes be disseminated to members of upper management within one month after the meeting.

The inspectors reviewed the records of the audits of facility operations for conformance to Technical Specifications and of the audits of results of actions taken to correct deficiencies in reactor facility equipment, systems, structures, or methods of operation that affect reactor safety. The audits were made in October 1982 and October 1983. The reports showed that the audits were properly performed and pertinent findings were made and reported as required by Technical Specification 6.1.5.4.

Audit Function.

During the 1982 audit of results of corrective actions for deficiencies, the auditor verified that the licensee took the corrective action, as given in their May 19, 1982, letter to the NRC, to assure that stack monitoring instrumentation would be operating during reactor operations as required by Technical Specification 3.3, Radiation Monitoring Systems. This action included: the installation of a remote stack monitoring reset button in the Control Room to supplement the local reset button; installation of a local audible alarm to indicate de-energization of the stack monitor vacuum pump; and more clearly and accurately marked set points on the Control Room repeating stack monitor recorder to allow the operators to better determine when release rates are below setpoint levels and the monitor can be reset.

7. Operator Requalification Training

On the basis of a December 18, 1980, letter from the NRC Operator Licensing Branch, the licensee is using their "Operator Requalification Program For The Union Carbide Research Reactor (R-81)", dated May 1980 for operator requalification.

The program calls for a biennial comprehensive written examination. Due to the amount of time required to prepare, administer, and grade this examination only one test is given and all licensed operators are required to take it within approximately one week, as their duties permit. The next requalification examination is presently scheduled for the end of January 1984.

The inspector reviewed the requalification training records for three operators. The reviewed records included examination grades, document review log, summary of required reactivity manipulations, the log book, and records of observations and evaluations of licensed operators by supervisors. Documentation of retraining was verified by examination scores; however, one minor discrepancy was noted in these records. The examination score of one individual in area I, Radioactive Material Handling, Disposal, and Hazards, required the retraining of the individual in that area. Instead of showing that the individual was retrained in area I, the records showed the individual was retrained in area J, Specific Operating Characteristics. The inspector verified that the individual was actually retrained in Area I, and the licensee corrected the records.

8. Surveillance Activities

The performance of the following surveillance requirements was reviewed.

| Tech Spec | Description | Frequency | Time Period |
|---|---|---|---|
| 4.6.2(2) | Test capability of emergency generator to take reactor electrical load | semiannually | 1981-1983 |
| 4.6.3(1) | Measure the efficiency of the emergency exhaust system charcoal filters and absolute filters and verify flow rate. | annually | 1981-1983 |
| 4.6.3.(2) | Test the operability of the evacuation alarm and containment isolation system, and verify maintenance of negative pressure in containment | semiannually | 1981-1983 |
| 4.10 | Test operability of emergency core spray | semiannually | 1981-1983 |

The inspector verified that the above surveillance tests and measurements were performed at the required frequency. However, the inspector did note the procedure for testing the evacuation alarm and containment isolation system, RS-36, Evacuation Test, stated the test frequency was semiannually plus-or-minus two months, and Technical Specification 4.1, General, requires semiannual tests to be performed within seven months. The licensee

committed to correct the test procedure.

When last performed, the Evacuation Test data was lost. The official data record and the test results were signed as satisfactory with the spaces for recording containment pressure data left blank. The licensee verified by the operating logs that the test had been completed satisfactorily; however the pressure data was not recorded. The licensee committed to reperform this test during the next shutdown in approximately two weeks. (54/84-01-02)

The last test of charcoal filter efficiency performed June 24, 1983, indicated an iodine removal efficiency of 99.23%. However, a recomputation by the inspector using the raw data provided in the official record, indicated that the computed efficiency was 92.77%. Technical Specification 3.4.3, Containment, requires 95% filter efficiency for iodine removal. The licensee stated that the charcoal filters were replaced just prior to this test and the expected efficiency with new filters should have been be 99.23% as recorded. The licensee believes an error was made in recording the data for the upstream concentration of iodine. The licensee committed to reperform this test within approximately 1 week. Subsequent to the inspection, on January 13, 1984, the licensee reperformed the test and obtained a filter efficiency of 99.37%.

9. Radiation Control

The inspector reviewed the licensee health physics manual. The manual defines a good radiation program and provides adequate procedures to implement the program.

The inspector examined the personnel exposure data for 1983, which is now provided in a computer printout. These records showed the highest year-to-date exposure for January 1 through December 4, 1983, for an individual to be 3,790 mrem. During the fourth quarter, this individual had exceeded the 1.25 rem limit given in 10 CFR 20.101(a). The inspector verified that the licensee had met the provisions of 10 CFR 20.101(b) regarding this individual and was in compliance with the provisions of the regulation. The individuals working at the facility generally receive between 2 and 3 rem per year radiation dose.

The inspector examined the hand exposure for the reactor operator who had routinely worked using the cryogenic glove box system mentioned in section 6 of this report. During the first quarter of 1982 this operator received 5072 mrem to his right hand and 2893 mrem to his left hand. During the second quarter, this operator received 5778 to his right hand and 2164 mrem to his left. (The 10 CFR 20.101 limit for individual hand exposure is 18,750 mrem.) During the latter half of 1982, the hand exposure to that individual was lowered significantly mainly because the work was no longer performed primarily by this individual. These hand exposures demonstrated the need to provide equipment, and procedural for this work. As discussed in section 6 of this report, the licensee has made the procedural and equipment changes to correct this problem.

10. Exit Interview

The inspectors met with the licensee representatives (denoted in paragraph 1) at the conclusion of the inspection on January 6, 1984. The inspectors presented the scope and findings of the inspection.