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U.S. Nuclear Regulatory Commission
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SUBJECT **Report for Event Number 57196 "Technical Specification Violation"**
License No. R-120
Docket No. 50-297

As required by Technical Specification (TS) 6.7.1, a written report of Event Report Number 57196 regarding a TS violation that occurred at the North Carolina State University (NCSU) PULSTAR research reactor on 27 June 2024 is attached.

If you have any questions regarding this report or require additional information, please contact Colby Fleming at ncsorrel@ncsu.edu.

I declare under penalty of perjury that the forgoing is true and correct. Executed on 2 July 2024.

Sincerely,

Ayman Hawari

Ayman I. Hawari, Ph.D.
Director, Nuclear Reactor Program
North Carolina State University

Enclosures: Written response to Event Report Number 57196

Report of Event Report Number 57196 regarding a Technical Specification Violation

Event Description

- At 8:30 on 27 June 2024, a satisfactory startup checklist was completed prior to operations with no exceptions noted.
- At 8:50, a check was performed on nuclear instrumentation with reference to the N-16 Channel when the reactor reached 900 kW. All channels agreed with N-16 power reading.
- At 10:00, the reactor operator (RO) took operations logs, scanned the console indications, and noted that the N-16 Power Monitoring Channel percent reactor power meter indication was reading at 95% power consistent with the other power channel indications.
- At 10:30, the RO scanned the console indications and observed the continued agreement between the N-16 Channel an other power indications.
- At 10:33, according to the reactor recorder readout (reviewed after the event), the readout from the N-16 Channel fell from approximately 96% power to approximately 10% power.
- At 10:36, the reactor was operating at 950kW as indicated by the Linear and Safety Channels. The reactor operator observed that the N-16 Power Monitoring Channel percent reactor power meter was indicating a power level of approximately 10%. Following the requirements of operating procedure NRP-OP-105 Immediate Operator Actions, Section 4.2 Abnormal Channel Behavior, the operator shutdown the reactor by ganged insert at 10:36.
- In the moment before initiating reactor shutdown by actuation of the gang rod insert switch, the operator observed that the N-16 Power Monitoring Channel percent reactor power meter indication step increased back up to 95% momentarily, consistent with the other power level channels, before then decreasing on a shutdown period with the gang insert.
- At 10:37, the reactor was logged as shutdown, and the operator informed the DSRO.
- At 10:45, the reactor was successfully secured and a key-off checklist was completed.
- The reactor power recorder data was subsequently reviewed, and it showed that the indications from the Linear, Safety and Log-N power channels were all stable at a nominal power of 950kW in the period leading up to the shutdown at 10:37. Recordings of the N-16 Channel output showed a step signal change from approximately 95% power to 12% power at 10:33:10. From that time until approximately 10:35:30, the N-16 Channel output was between 11.66% and 12.42% power. At approximately 10:35:30, indication returned to agreement with the other power instruments (approximately 95% power) almost simultaneously with the initiation of reactor shutdown by ganged insertion.
- The operability of the N-16 Power Measuring Channel is required under Limiting Conditions for Operation (LCO) per Technical Specification (TS) 3.4(a) for power levels above 500 kW. The percent reactor power meter is part of the channel and was observed to be indicating incorrectly for a brief period with reactor power at 950kW, so per TS 1.2.14 the channel was not operable. This was a violation of TS 3.4(a).
- The NRP Director was informed following the event. The NRC Project Manager, Duane Hardesty, was called at 14:16 and informed. Per TS 1.2.24(d), a notification of a Reportable Event / TS Violation was made by the MEO to the NRC Headquarters Operations Officer at 14:20, and it was logged by the NRC Operations Center as event #57196.

Discussion

Procedures were followed during reactor operation, shutdown, and the subsequent investigation. No SCRAM occurred as the N-16 Channel is not part of the reactor safety system and does not have an automatic shutdown function associated with it. The operator responded correctly to the event and completed the Immediate Operator Actions required by procedure NRP-OP-105 “Response to SCRAMS, Alarms, and

Abnormal Conditions." Notifications were made as required. There was no reactor or radiological safety issue associated with this event.

Immediately following securing the reactor, the DSRO and reactor staff performed channel tests on the N-16 Channel via injection of a test current per NRP-OP-101 Appendix B and found the system to be SAT. After returning the channel tests select switch to "normal" and removing the N-16 electrometer from zero check, a fluctuating negative power level was indicated on the channel display and a correlated negative current was indicated on the electrometer, producing a roughly -10% power indication on the meter display. The electrometer current abruptly returned to zero. The electrometer was turned off and turned on again, and a similar negative signal of approximately -0.3 nA was observed, persisting for several minutes (great than 10 minutes).

The abnormal signal was reliably generated by the switching method described above, which was utilized for further investigation. The abrupt change in detector current was uncharacteristic of capacitive discharge and so continuous discharge across the detector was suspected. The negative current signal was produced in the channel and the detector HV supply was decreased from 500 VDC in increments of 50 VDC while recording the channel current. The first time this was performed, the current abruptly dropped after reaching 300 VDC. The procedure was repeated at a faster rate, starting at 450 VDC, and the anomalous current was observed to persist even when 0 VDC was supplied to the detector. The HV supply was increased to 400 VDC and the channel was switched to "Test" mode and then to "Normal" mode to determine if the signal required a certain level of voltage to initiate, but the anomalous signal was not produced. The channel was switched after changing the supply voltage to 450 VDC and 500 VDC, but the anomalous current was not replicated. No definitive relationship between the detector voltage and anomalous signal was established. The above investigation seems to suggest that the status of the test switch was associated with the anomalous signal, although the nature of this association remains undetermined.

Reviewing the N-16 recorder trace on the radiation recorder, no anomalous readings were observed at any point during the current and previous days of operation.

Corrective Actions

Reactor staff performed diagnostic tests and evaluation of the N-16 Power Monitoring Channel components. Maintenance Log #0900 was opened to document repairs made to the N-16 Channel. In support of power channel diagnostics, the NRP Director authorized the staff to restart the reactor following subsequent completion of the startup checklist and sufficient testing to ensure only the N-16 Channel demonstrated any abnormal behavior. Restart was approved on 27 June 2024 with power limited to levels up to 450 kW in compliance with TS 3.4(a), and the reactor was restarted on 28 July 2024.

Since 27 July 2024, the staff performed multiple inspections, surveillances, and evaluations on the N-16 Channel components. Linearity testing has been performed for the entire channel chain up to 400kW. Extensive monitoring of the channel outputs during operations and over shutdown periods with the current source applied have been performed with the electrometer output recorded. Since 27 July 2024, the erroneous signal has not been reproduced, but on the 27th, the channel investigation was able to reproduce the results multiple times. As a result, continued testing of the electrical components and system setup continue. External support is being solicited from instrumentation vendors to assist with channel component diagnostics and channel isolation testing.

Corrective actions identified to prevent recurrence from this event are as follows:

- Ensure full operability of the N-16 detector.
- Ensure channel grounding does not allow for faulty signals, and the channel is electronically sound.
- Ensure that all N-16 Power Monitoring Channel components have been evaluated, repaired or replaced as necessary, and are operable per TS requirements. To assure operability following evaluation and servicing by an instrumentation support vendor (if necessary), N-16 Power Monitoring Channel surveillance testing shall be completed and channel response with no deficiencies shall be observed for reactor operation at a power level of < 500kW.
- In consultation with and approval from NRC, and consistent with the guidance given in ANSI 15.1-2007, update the definition of 'Reportable Occurrence' in TS Section 1 and add provisions to TS Section 3 'Limiting Condition for Operation', that would allow credit for operator action in responding to and correcting abnormal channel behavior.