

NRC FORM 366 (6-1998)	U.S. NUCLEAR REGULATORY COMMISSION LICENSEE EVENT REPORT (LER) (See reverse for required number of digits/characters for each block)	APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001 Estimated burden per response to comply with this mandatory information collection request: 50 hrs. Reported lessons learned are incorporated into the licensing process and fed back to industry. Forward comments regarding burden estimate to the Records Management Branch (T-6 F33), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, and to the Paperwork Reduction Project (3150-0104), Office of Management and Budget, Washington, DC 20503. If an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.
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TITLE (4)
VOLUNTARY LER: "Incomplete Control Rod Insertion During Trip Insertion Time Testing"

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
09	11	99	99	-- 011	-- 00	10	21	99	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9) N

POWER LEVEL (10) 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

<input type="checkbox"/> 20.2201(b)	<input type="checkbox"/> 20.2203(a)(2)(v)	<input type="checkbox"/> 50.73(a)(2)(i)	<input type="checkbox"/> 50.73(a)(2)(viii)
<input type="checkbox"/> 20.2203(a)(1)	<input type="checkbox"/> 20.2203(a)(3)(i)	<input type="checkbox"/> 50.73(a)(2)(ii)	<input checked="" type="checkbox"/> 50.73(a)(2)(x)
<input type="checkbox"/> 20.2203(a)(2)(i)	<input type="checkbox"/> 20.2203(a)(3)(ii)	<input type="checkbox"/> 50.73(a)(2)(iii)	<input type="checkbox"/> 73.71
<input type="checkbox"/> 20.2203(a)(2)(ii)	<input type="checkbox"/> 20.2203(a)(4)	<input type="checkbox"/> 50.73(a)(2)(iv)	<input checked="" type="checkbox"/> OTHER
<input type="checkbox"/> 20.2203(a)(2)(iii)	<input type="checkbox"/> 50.36(c)(1)	<input type="checkbox"/> 50.73(a)(2)(v)	Specify in Abstract below or in NRC Form 366A
<input type="checkbox"/> 20.2203(a)(2)(iv)	<input type="checkbox"/> 50.36(c)(2)	<input type="checkbox"/> 50.73(a)(2)(vii)	

LICENSEE CONTACT FOR THIS LER (12)

NAME Gregory M. Gurican, TMI Sr. II Licensing Engineer	TELEPHONE NUMBER (Include Area Code) (717) 948-8753
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COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
<input checked="" type="checkbox"/> YES (If yes, complete EXPECTED SUBMISSION DATE).	<input type="checkbox"/> NO				10	22	00

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On September 11, 1999 GPU Nuclear (GPUN) Inc. conducted an elective post-shutdown Control Rod Trip Insertion test on the Control Rod Drive System in support of Maintenance Rule (a)(1) monitoring. Sixty of 61 control rods inserted to the Technical Specification 4.7.1.1 required 3/4 insertion position within the 1.66 second time requirement, one rod did not. One control rod stopped at 26% withdrawn and it was declared inoperable. Technical Specification 3.5.2.2 allows for one inoperable control rod to remain completely out of the core. One additional control rod stopped at approximately 7% withdrawn; however, this control rod did meet the Technical Specification insertion position and time requirements. Additionally all remaining control rods inserted fully into the reactor core. There were no violations of Technical Specification requirements or Safety Analyses during this event and this LER is being submitted voluntarily to the NRC.

The direct cause of the incomplete control rod insertion is distortion or bowing of the fuel assembly guide tubes, which resulted in excessive mechanical drag. The Technical Specification required trip insertion time testing was performed prior to Cycle 13 startup, during which velocity profiles on selected rods were obtained, and no abnormal drag was found to be present. The two fuel assemblies where incomplete rod insertion occurred were discharged from the core. To mitigate this condition, TMI-1 redesigned the Cycle 13 core loading pattern and relaxed the pre-load forces in the hold down springs on specific fuel assemblies. Data gathering and analysis efforts are ongoing and will continue in order to understand the specific cause(s) of guide tube distortion. Long term corrective actions will be developed through the fuel vendor. It should be noted that there have been no prior instances at TMI of a control rod failing to fully insert when the Control Rod Drive Mechanism (CRDM) was de-energized.

There were no adverse safety consequences from this event, and the event did not affect the health and safety of the public. The reactor was maintained in hot shutdown condition at all times during Control Rod Trip Insertion testing. TMI-1 is operated with sufficient negative reactivity to assure that the >1% ΔK/K Shut Down (reactivity) Margin is met with the highest worth control rod in a fully withdrawn position.

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I. Plant Operating Conditions Before The Event:

TMI-1 was in hot shut-down when Control Rod Trip Insertion Time testing was performed and the incomplete control rod insertion occurred. However, the condition being reported in this LER may have been present during the operating cycle (Cycle 12), while the unit was operating at power.

II. Status of Structures, Components, or Systems That Were Inoperable At The Start Of The Event And That Contributed To The Event:

None.

III. Event Description:

On September 11, 1999 TMI-1 conducted a post-shutdown Control Rod Trip Insertion test on the Control Rod Drive System for Maintenance Rule (a)(1) monitoring. All control rods except one (Group 5, Rod 2) inserted to the Technical Specification 4.7.1.1 required 3/4 insertion position within the 1.66 second time requirement. Technical Specification 3.5.2.2 allows for one inoperable control rod to remain completely out of the core. Since Rod 5-2 stopped at 26% withdrawn it was declared inoperable. One additional control rod (Group 2, Rod 2) stopped at approximately 7% withdrawn; however, Rod 2-2 did meet the Technical Specification insertion position and time requirements. Additionally all remaining control rods inserted fully into the reactor core. There were no violations of Technical Specification requirements or Safety Analyses during this event and this LER is being submitted voluntarily to the NRC.

During Trip Insertion Time testing of Control Rod Groups 1 through 4, Group 2 Rod 2 did not fully insert but indicated a control rod position of approximately 7 percent withdrawn. Rod 2-2 met the required trip insertion time of 1.66 seconds. Rod 2-2 was latched and driven into the fully inserted position. During Rod Trip Insertion time testing of Control Rod Groups 5 through 7, the Group 5 Rod 2 [*AA/RCT] did not fully insert but indicated 26 percent withdrawn. Rod 5-2 was latched and driven into the fully inserted position. All rods except 2-2 and 5-2 traveled to the fully inserted position. All control rods, except 5-2, met the trip insertion time requirement with the longest measured insertion time being 1.458 seconds.

Control Rod 5-2 was declared to be inoperable because it did not meet the Technical Specification 4.7.1.1 requirement to drop from fully withdrawn to the 3/4 inserted position within 1.66 seconds. Because Technical Specification 3.5.2.2 allows for one inoperable control rod, this event was determined not to be reportable.

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As a follow-up to the incomplete insertion, a recorder was connected to the position indication signal for Rod 2-2, Rod 5-2 and Rod 5-3. The Trip Insertion Time test was repeated for those three rods. Rod 5-3 was included in the test for comparison to the two rods that had incomplete insertion. Rod 2-2 and Rod 5-2 each stopped at approximately the same position as they had stopped at during the initial test. The rods were latched and driven to the inserted position. Review of the strip chart recorder output of position indication signal versus time indicated that mechanical drag was the cause for the incomplete rod insertion.

After cooldown a partial manual withdrawal of the control rod assemblies using a weight scale was performed to determine whether the mechanical binding was in the Control Rod Assembly (CRA) and Fuel Assembly interface or in the drive train. The weight readings indicated mechanical drag while the CRA was coupled. After uncoupling, the Control Rod Drive Leadscrew moved without any indication of drag. From this it can be concluded that the cause of the problem was not related to the CRDMs.

IV. Identification of Root Cause:

GPUN assembled a root cause evaluation team that included engineering and subject matter experts from other utilities, the fuel vendor, the reactor equipment vendor, and EPRI. The team determined that the probable cause of the incomplete rod insertion was fuel assembly guide tube distortion, which resulted in excessive mechanical drag. This cause was confirmed during subsequent fuel assembly inspections and tests.

Fuel assembly bowing has been observed in previous cycles at TMI-1 as well as other PWRs, and appears to be loosely correlated to fuel burnup. Some fuel assemblies in higher burnup locations do not exhibit a pronounced bow and observable bow was seen on fuel assemblies after the first cycle burn. The bowing in this case was more prominent in a specific area of the core. Visual bow data taken of the fuel assemblies during off loading showed that there was more prominent bowing in the quadrant where the incomplete control rod insertion occurred. It was hypothesized that the fuel assembly hold down force may be combining with fuel assembly axial growth during exposure and lateral stresses induced by coolant flow patterns and interaction with adjacent assemblies resulting in guide tube distortion.

The increased control rod drag is primarily associated with multi-node, "W" and "S," shape fuel bowing. The more severe "W" bows correlate with the drag test data and fuel assembly guide tube plug gage tests.

The two fuel assemblies that had incomplete rod insertion remained in the same core quadrant over two consecutive fuel cycles (as did several other fuel assemblies). In reviewing the videotapes of fuel assembly 7UG at the end of Cycle 11 a "W" shaped bow was observed; fuel assembly 7UG hosted Control Rod 5-2 during Cycle 12. The "W" shaped bow on fuel assembly 7UG appeared more pronounced at the end of Cycle 12. This apparent core location dependency was taken into account in the redesign of the core for Cycle 13.

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The two CRAs were in Mark-B10 fuel assemblies. The Mark-B10 fuel assembly design has a higher hold down force compared to the previous fuel assembly design used at TMI. The hold down springs on a number of fuel assemblies have been relaxed within the recommendations of the fuel vendor in order to limit excess hold down force as a possible causal factor in fuel assembly guide tube bowing.

The root cause team concluded that there might be several causative factors acting together that results in fuel assembly bowing. Further analysis and follow-up data gathering will be needed to be able to identify the specific cause(s) of fuel assembly guide tube distortion.

Direct Cause(s):

The Direct Cause of incomplete control rod insertions was determined to be fuel assembly guide tube distortion. Distortion (or bowing) increases the frictional drag on the control rod. Observations of fuel assembly bow correlate with the Control Rod Trip Insertion time measurements, drag test results and plug gage tests of fuel assembly guide tubes. Additional data gathering and analysis is required before the underlying or root cause(s) of guide tube distortion can be determined conclusively.

Contributing Factors:

1. Observations indicate that core location may be a causal factor in development of fuel assembly bow. Fuel assemblies located in the regions of the core where the occurrence of bow was more prevalent and which were also shuffled within the same quadrant appeared to experience greater bow.
2. High fuel assembly hold down spring forces may have contributed to the occurrence of fuel assembly bow.

V. Previous Events & Extent of Condition:

There have been no previous occurrences of incomplete rod insertion at TMI-1. TMI-1 previously experienced an unrelated problem meeting rod insertion times as a result of corrosion product interference with the CRDM ball-check valve operation. (Reference LER 97-008) That problem was corrected prior to Cycle 12, and the recommended cycle chemistry conditions have been maintained in accordance with EPRI guidelines.

In regard to the extent of condition, at the end of Cycle 12, fuel assembly bowing resulted in one control rod being declared inoperable pursuant to Technical Specification requirements. The affected control rod was able to be driven to the full-in position and all other control rods met their Technical Specification required Trip Insertion times.

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In addition to the inoperable Control Rod 5-2, Control Rod 2-2 experienced incomplete insertion, and nine (9) other control rods had an apparent increase in trip time of > 0.1 seconds, with the maximum insertion time being 1.458 seconds. Fuel inspections and drag data indicate that the nine control rods with increased trip times were also affected by fuel assembly guide tube bow. The increased drag was primarily in the bottom half of travel. Eight of the nine (9) fuel assemblies in locations where an apparent increase in measured control rod insertion time of greater than 0.1 seconds occurred were not reloaded into the Cycle 13 core. The one remaining fuel assembly was loaded into a Cycle 13 core location that does not contain a control rod assembly.

VI. Assessment of Safety Consequences & Implications of the Event:

During Control Rod Trip Insertion testing the reactor was maintained in hot shutdown condition. TMI-1 is designed with sufficient negative reactivity to assure >1% $\Delta K/K$ Shut Down Margin is met with the highest worth Control Rod in the fully withdrawn position. The safety significance of this event was minimal since both Control Rods inserted to a position where most of their respective rod worth would be effective.

Control Rod 5-2 was declared inoperable because it did not reach the 25% position. Subsequent retest with an analog recorder attached indicates that Control Rod 5-2 achieved the 2/3 insertion in approximately 1.44 seconds. The safety analysis assumption is 1.4 seconds to 2/3 insertion. A shutdown margin calculation was performed with Control Rod 5-2 inoperable (i.e., assumed to be fully withdrawn from the core). Presuming that Control Rod 5-2 was inoperable prior to shutdown, the plant continued to be in compliance with the Technical Specifications.

Control Rod 2-2 performed the required safety function of travel to 2/3 inserted as assumed in Safety Analysis and also met the Technical Specification criteria for time to travel from full withdrawn to the 1/4th withdrawn position (25 percent zone switch). Control Rod 2-2 was considered operable and within the Technical Specification requirements.

If the incomplete rod insertion had occurred when the reactor was operating at full power, the safety function would have been met. Even if no credit were taken for the inoperable rod, the safety analysis assumptions would have been met. Additionally, the Technical Specification 3.5.2. Limiting Condition for Operations requires that "an evaluation shall be initiated immediately to verify the existence of 1% ($\Delta k/k$) hot shutdown margin," once a control rod is declared inoperable. This evaluation while required only for power operation was conducted following the incomplete rod insertion which occurred during the Control Rod Trip Time testing.

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VII. Corrective Actions:

The extent of the condition has been addressed by inspection, testing, redesign of the core, and resetting the hold down springs. Fuel assembly bow data and drag data have been obtained on fuel assemblies with control rods that are being returned to the reactor for operation in Cycle 13. The trip insertion time testing that is required by Technical Specifications provides assurance that the control rods met their required function at the beginning of cycle. The Cycle 13 core has been redesigned with consideration given to the bowing already present in the once burned fuel and the impact of potential causal factors associated with their location assignments. Reducing the bow during this cycle will reduce the potential for drag in future cycles when the fuel assembly may host control rods.

Immediate & Short Term Actions:

1. Data collection was performed, as follows: (Completed)
 - a. Fuel Assembly bow data on fuel assemblies being returned to the reactor.
 - b. Insertion drag data for each control rod assembly while inserting it into its host fuel assembly for Cycle 13.
 - c. In-core drag data for 33 selected control rods after hold down force was applied following the reloading of the fuel assemblies into the reactor and installing the reactor head,
 - d. Control Rod Trip Insertion Time testing in accordance with Technical Specifications
 - e. Velocity data for selected control rods during Control Rod Trip Insertion Time testing.
2. The core design for Cycle 13 was changed to account for location dependency of the fuel assemblies. (Complete)
3. The hold down spring force on once burned fuel assemblies operating under control rods has been reset in order to lessen the potential for additional fuel assembly bowing during Cycle 13. The springs on 53 once burned fuel assemblies that will host control rod assemblies were set. The other 8 fuel assemblies hosting control rod assemblies are new fuel assemblies in core locations which did not experience a significant amount of discernable fuel assembly bowing during Cycle 12. (Complete.)
4. Springs on 46 of 48 new fuel assemblies hosting Burnable Poison Rod Assemblies (BPRAs) were reset. The two remaining fuel assemblies are in locations that did not experience much bow in Cycle 12. (Complete.)

Long Term Corrective Actions:

1. TMI will continue its efforts to collect data from other B&W plants and analyze the specific causal factors of guide tube distortion. The need for additional monitoring to assure control rod insertion ability to EOC will be evaluated prior to exceeding 18 months of operation in Cycle 13. This action is being tracked by CAP Corrective Action T1999-0722-5.

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2. Additional long term corrective actions as a result of continued evaluations by the Licensee and the fuel vendor shall be reported in a Supplement to this LER on or before April 22, 2001.

3. While TMI believes that it is unnecessary to shutdown during Cycle 13 to perform Control Rod Trip Insertion Time tests, should a shutdown occur TMI will obtain control rod insertion times. Insertion times will not be obtained if the elapsed time period since the last shutdown is less than four months. The plant process computer collects trip insertion times. Upon an automatic trip, Group 7 trip insertion times may not be from the fully withdrawn position, but this action demonstrates the ability to fully insert. This action is being tracked by CAP Corrective Action T1999-0722-8.

* The Energy Industry Identification System (EIIS), System Identification (SI) and Component Function Identification (CFI) Codes are included in brackets, [SI/CFI] where applicable, as required by 10 CFR 50.73 (b)(2)(ii)(F).