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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project
Unit 1
Docket No. STN 50-498
Results of Fuel Assembly Testing in Response to NRC Bulletin 96-01

References: 1) Letter from T. H. Cloninger to the U. S. Nuclear Regulatory Commission dated April 4, 1996, "Response to NRC Bulletin 96-01 - Control Rod Insertion Problems," (ST-HL-AE-5333)
2) Letter from D. A. Leazar to the U. S. Nuclear Regulatory Commission dated July 3, 1996, "Results of Control Rod Testing in Response to NRC Bulletin 96-01," (ST-HL-AE-5408)

Attached are the South Texas Project results for the Unit 1 testing performed on selected fuel assemblies in the Spent Fuel Pool (SFP) following the Unit 1 sixth refueling outage (1RE06), which were performed in July 1996 (Attachment 1). The testing activities were conducted in response to NRC Bulletin 96-01 and to assist the South Texas Project in determining the root cause of the incomplete rod insertion anomaly.

In addition, Attachment 2 provides a discussion of the South Texas Project investigation and root cause determination of the incomplete Rod Cluster Control Assembly (RCCA) insertion issue.

If you have any questions regarding this subject, please contact Mr. R. F. Dunn at (512) 972-7743 or me at (512) 972-7795.

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Attachments: 1. Summary of Unit 1 July 1996 Fuel Assembly Testing In SFP
2. Incomplete Rod Cluster Control Assembly Insertion Investigation Results and Root Cause Determination

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Attachment 1

Summary of Unit 1 July 1996 Fuel Assembly Testing In SFP

In July 1996, several tests were performed on fuel in the Unit 1 SFP to provide data for determining the root cause for the incomplete rod insertion anomaly. Overall configuration management and work methods were governed by South Texas Project procedures while the actual tests were performed using a Westinghouse procedure that incorporated comments for South Texas Project specific technical requirements. The testing performed is summarized in the paragraphs below.

- Drag tests were conducted by measuring the drag force during withdrawal and insertion of an unirradiated Rod Cluster Control Assembly (RCCA) in the fuel assembly at fixed speed.

- Bow measurements estimated the fuel assembly center distance from true center at each of ten grid locations by using a taught wire pulled up along the assembly length. Measurements were made both by looking from the side and by looking straight at two faces ninety degrees apart of each assembly measured.

- Plug gauge measurements (single tube probe) were made by allowing solid stainless steel cylinders to fall under gravity into the guide tube until they are stopped by either going to the bottom of the guide tube ("G[illegible] or before reaching the bottom of the guide tube due to the guide tube geometry ("NO GO"). The elevations of the NO GOs were recorded Eight plug gauges (four for above the dashpot and four for the dashpot) of differing lengths and diameters were used in a logic sequence to make the required measurements.

- Length measurements were performed using a set of two SFP cells and test equipment. One of the cells contained a length standard (reference cell) and an adjacent cell (test cell) was the location for the fuel assembly being tested. The length standard was measured in the test cell first and then moved to the reference cell. Fuel assemblies were then measured in the test cell and the difference between the fuel assembly length and the length standard was used to estimate fuel assembly growth.

- In a test referred to as visual measurement, fuel pin growth was estimated by recording the gap distance between the fuel pins and the nozzle for each face at both the top and bottom nozzles. The fuel assembly length measurement and nominal pre-irradiated fuel pin length were then used to estimate the fuel pin growth.

- Boroscope inspection used a small fiber-optic probe to visually observe the condition of the surface on the inside diameter of each guide tube inspected. The probe was sufficiently long that the entire length of the guide tube could be observed.

The test scope included all the assemblies that had experienced incomplete insertion and other assemblies selected based upon the fuel assembly type and burnup. The test matrix is given in the following table:

Unit 1 July 1996 Fuel Assembly Test Matrix

Test / Assembly ID	Drag	Length	Bow	Single Tube Probe	Visual	Boroscope	Burnup (GWD/MTU)	Incomplete Insertion in Cycle 6
C20	X	X					27.9	
C28	X	X		X	X		33.3	
C54	X	X		X			31.5	
E10	X	X		X	X		32.3	X(6 steps)
E31	X	X		X	X		32.2	
F01	⊗	X					45.4	
F06	X	X					45.3	
F21	X	X					48.3	
F25	⊗	X					48.5	X(6 steps)
F26	⊗	X	X	X	X	X	49.4	X(12 steps)
F29	X	X					50.0	X(6 steps)
F32	X	X	X	X	X		48.4	
F37	X	X	X	X	X		46.5	
F39	X	X					49.2	
F41	X	X	X		X		49.2	X(6 steps)
F43	X	X					48.6	
F47	X	X					48.6	X(6 steps)
F53	⊗	X					45.9	X(6 steps)
F59	X	X					48.8	X(6 steps)
F60	X	X		X			35.6	X(6 steps)
F62	X	X					48.5	
F64	⊗	X		X			48.5	X(12 steps)
R27	X	X		X	X		43.4	X(6 steps)
R31	X	X		X	X		43.4	

⊗ Drag test not performed because RCCA could not be transferred into the test assembly due to the RCCA not inserting enough under its own weight to be safely unlatched with the RCCA change tool.

General results of the July 1996 test campaign are provided below; detailed results are proprietary, and can be provided upon request with fuel vendor permission.

Drag tests - showed that maximum drag is experienced in the dashpot with no significant drag measured above the dashpot. The highest drag was observed in the lower section of the dashpot (lower dashpot).

Length tests - showed that fuel assembly growth was within normal expectations and well within the design growth.

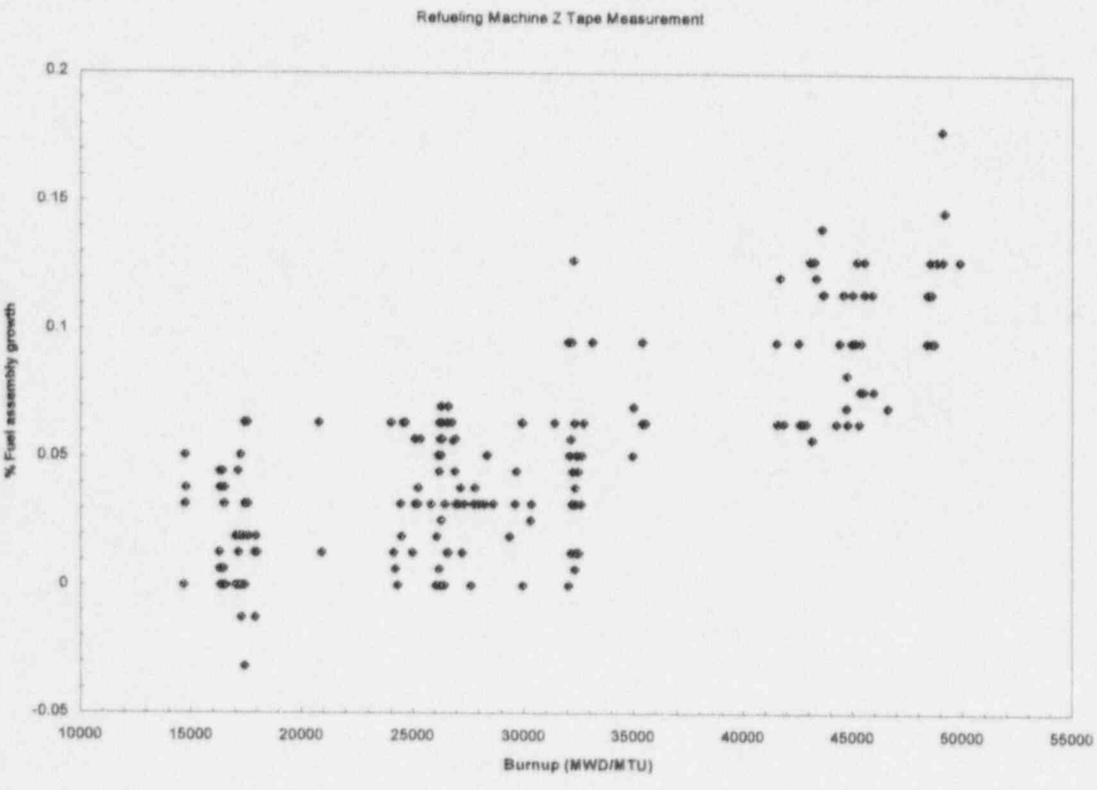
Visual tests - showed that fuel pin growth was within normal expectations and well within the design growth.

Bow measurement - showed larger bow in the dashpot for fuel assemblies that had incomplete insertion.

Boroscope - qualitatively showed that most interference between RCCA and guide tube is in the dashpot.

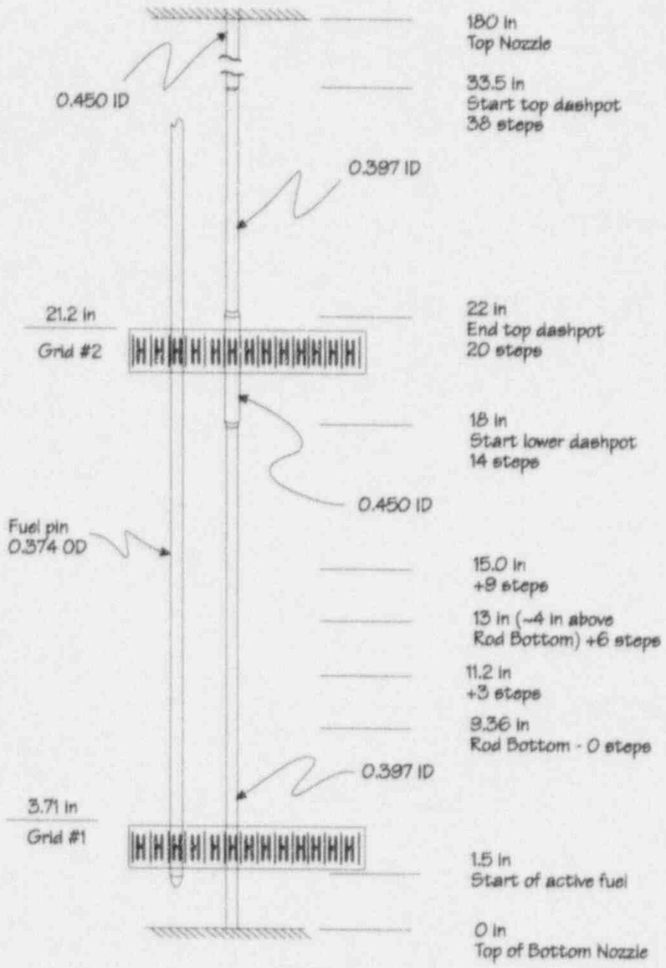
Plug gauge - indicates that most distortion is in the dashpot. The greatest amount of distortion was found in the lower section of the dashpot.

In addition to the tests performed in the SFP, relative fuel assembly lengths of all fuel in the core were measured in the reactor building upender during the 1RE06 outage core offload. These measurements were shown to correlate well with the SFP length measurements made in the July 1996 campaign. As shown in the figure below, the upender measurement shows normal growth for all fuel in the Unit 1 Cycle 6 core. Fuel growth is expected to be less than 0.27% fuel growth, which is the maximum design fuel growth at end of cycle.



In summary, the July 1996 test campaign showed that South Texas Project fuel assemblies are generally prone to increasing guide tube distortion in the dashpot as burnup and core residency time increases with the greatest amount of drag and distortion in the lower dashpot region. This distortion leads to high RCCA drag. The tests show that the distortion is occurring with normal fuel assembly and fuel pin growth. The geometry of the guide tube dashpot is shown in the figure on the following page.

Schematic Diagram of South Texas Project Fuel Dashpot Geometry



Attachment 2

Incomplete Rod Cluster Control Assembly Insertion Investigation Results and Root Cause Determination

Summary

Several major activities directed at two general areas, maintaining and demonstrating margin to the shutdown margin limit and identifying root cause have been completed. These activities have shown substantial margin to the shutdown margin and rod drop time limits have been maintained during operation of both South Texas Project units. The root cause of incomplete RCCA insertion has been identified as excessive fuel assembly guide tube distortion in the dashpot. The reason for the distortion is inadequate resistance to buckling in the fuel assembly design under required loads and burnup. In the future, the South Texas Project plans to limit burnup at rodded locations for current fuel designs and work with the fuel vendor to effect design changes to provide adequate resistance to buckling at design burnups. The following paragraphs provide more detail.

Major Activities

The major activities have been: manufacturing records review, testing support for root cause analysis, demonstration that rod drop time and shutdown margin requirements have been met, and operational support. The manufacturing records review is complete with no anomalies found. The major test milestones completed in the investigation of the event are listed and summarized below:

- Initial testing following the reactor trip directed at showing repeatability, maintaining technical specification rod drop times, measuring the RCCA drive mechanism coil currents, and observing if the RCCAs could be stepped by demand from the rod control system;

- Unit 2 SFP drag tests directed at confirming that the condition is burnup related;

- Unit 1 Cycle 6 mid-cycle rod drop testing performed at hot full flow, Unit 2 Cycle 5 mid-cycle rod drop testing performed at hot full flow, and Unit 1 Cycle 6 end-of-cycle rod drop tests performed at hot full flow, all directed at demonstrating conservative margin in the safety analyses performed in support of operation,

- Unit 1 1RE06 defueled window drag tests directed at demonstrating that C-series assemblies designed to be under RCCAs in Unit 1 Cycle 7 had low drag,

- Unit 1 Cycle 7 beginning-of-cycle cold no flow rod drop test and Unit 1 Cycle 7 beginning-of-cycle hot full flow rod drop test directed at demonstrating adequate insertion capability at beginning of life, and

- Unit 1 SFP tests directed at helping to determine root cause using several different tests.

There have been three major milestones completed in support of operation for Unit 1 and 2 related to this event:

- Analyses have been completed which show that adequate shutdown margin existed for RCCAs stopping at increasing elevations in higher burnup assemblies in Unit 1 Cycle 6,

- An evaluation has been completed which shows that shutdown margin will be met for different RCCA stuck configurations in Unit 1 Cycle 7, and

- An evaluation has been completed which shows that shutdown margin will be met for different RCCA stuck configurations in Unit 2 Cycle 5.

The testing program and operation support activities showed that:

- the shutdown margin was conservative for actual operation in Unit 1 Cycle 6,

- incomplete rod insertion is burnup dependent,

- incomplete rod insertion may be experienced in fuel assemblies with burnup as low as 32 GWD/MTU,

- for the fuel tested, incomplete rod insertion is limited to the lower section of the dashpot region,

- rod drop time to dashpot entry was unaffected by the condition, and

The assemblies experiencing incomplete rod insertion at the South Texas Project are all from Unit 1 Cycle 6. In the following table, the affected assemblies and their core locations are listed followed by dates when RCCA performance was measured. If the RCCA stuck on a certain date, then the incomplete insertion position and the fuel assembly burnup is given for the date. To date, Unit 2 has not experienced incomplete rod insertion.

Assembly ID	Core Location	08/29/95	12/19/95	03/02/96	05/18/96
		Steps above rod bottom/Burnup(GWD/MTU)			
E10	E11	0/23	0/27	0/30	6/32
F25	N09	0/40	6/44	6/46	6/49
F26	F10	0/41	6/44	6/47	12/49
F29	K10	0/42	0/45	6/48	6/50
F41	F06	0/41	0/44	6/47	6/49
F47	C07	0/40	0/44	0/46	6/49
F53	D08	0/38	0/41	6/44	6/46
F59	C09	0/41	6/44	6/47	6/49
F60	K08	0/26	0/30	0/33	6/36
F64	N07	0/40	6/44	6/46	12/49
R27	C05	0/35	0/38	0/41	6/43

As shown in the table, the condition progresses slowly with burnup and is limited to the lower section of the dashpot region (38 steps is the top of the dashpot). Also, the August data points are not from a test, instead, the data points are from a reactor trip where all RCCAs fully inserted.

Root Cause Conclusion

The South Texas Project concludes that the cause of incomplete rod insertion is excessive guide tube distortion in the dashpot due to the in-vessel axial compressive load. When the guide tubes distort, the RCCA rodlets must bend to conform to the shape of the guide tubes. As a consequence of the bending, friction forces are developed between the guide tube and RCCA rodlet walls and the friction force is sufficient to overcome the force of gravity. As shown by measurements and manufacturing records reviews, the fuel assemblies experiencing incomplete rod insertion are built as designed and there are no off-nominal parameters contributing to the excessive distortion observed. Therefore, the most likely cause for the observed excessive guide tube bowing is the result of inadequate resistance to buckling in the fuel assembly design. Contributing factors to the condition are irradiation effects and thermal creep at higher burnup levels. Higher burnup exacerbates fuel assembly bowing because irradiation growth of the guide tubes increases the top nozzle spring force by continuing to compress the spring as the fuel assembly grows axially.

Plan of Action

The South Texas Project will address the observed condition with the following actions:

1) Until other adequate corrective actions are implemented (e.g., fuel design changes), future STP core loading patterns will limit end-of-cycle fuel assembly burnups under all controls rods to less than 30 GWD/MTU to the extent practical. If this is not practical, the number of rodded fuel assemblies exceeding this administrative limit will be minimized, and a safety evaluation performed to ensure shutdown margin and trip reactivity are met when assuming the associated control rods do not fully insert.

2) Verify continued margin of safety in current fuel assembly designs by maintaining a program, throughout Unit 1 Cycle 7 and Unit 2 Cycle 5 operation (current operating fuel cycles), to perform rod drop testing at end of cycle and at each outage of sufficient duration where more than 1250 MWD/MTU burnup has accumulated since the most recent test.

3) Working with the vendor on short term fuel assembly design modifications that use existing approved guide tube material to reduce creep, growth, and corrosion.

4) Pursue new fuel assembly designs with the vendor that will result in designs without specific restrictions on burnup at RCCA locations.

In a previous letter to the Nuclear Regulatory Commission (Reference 2, ST-HL-AE-5408), the South Texas Project committed to evaluating additional testing in Unit 1 during January 1997, when rodded assembly burnups approach the value corresponding to the lowest burnup fuel assembly with the observed incomplete rod insertion condition in Cycle 6 (approximately 32 GWD/MTU). The results of the evaluation indicate there is substantial margin to the shutdown margin limit in Unit 1 Cycle 7 and therefore, there is no need to perform additional testing (beyond the testing described above). The evaluation is primarily based upon:

- the current safety analysis,
- the burnup under Rod Cluster Control Assemblies in Cycle 7 has been designed to remain below 40 GWD/MTU (more than 10 GWD/MTU less than in Cycle 6),
- testing performed to date shows the condition is limited to the dashpot region, and
- testing performed to date showed only two fuel assemblies with incomplete insertion below 40 GWD/MTU.