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

**SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
SUBMITTAL OF POST IRRADIATION EXAMINATION
RESULTS OF FUEL CLADDING FOLLOWING
UNIT 2 CYCLE 7 OPERATION WITH ELEVATED PH**

**REF: Letter logged TXX-02037 from C. L. Terry to the NRC, dated
February 18, 2002**

Gentlemen:

In the above referenced letter, TXU Generation Company LP (TXU Energy) committed to provide the NRC with the post irradiation examination (PIE) results and associated data for fuel corrosion monitoring of fuel at Comanche Peak Unit 2. Attached is a report summarizing the PIE results following Unit 2 Cycle 7 operation with elevated pH and lithium. The data associated with the PIE results is provided on the enclosed compact disk.

This communication contains no new licensing basis commitments regarding CPSES Units 1 and 2.

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TXX-04016

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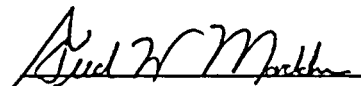
Please contact Mr. J. D. Seawright at (254) 897-0140 (email jseawright@txu.com) should you have any questions.

Sincerely,

TXU Generation Company LP

By: TXU Generation Management Company LLC,
Its General Partner

Mike Blevins

By: 
Fred W. Madden
Nuclear Licensing Manager

JDS/js

Attachment - Elevated pH Program for Comanche Peak Steam Electric Station -
Update Report

Enclosure - Compact Disk of data associated with PIE Results

c - B. S. Mallett, Region IV
W. D. Johnson, Region IV
M. C. Thadani, NRR
Resident Inspectors, CPSES

TXU Energy

**Elevated pH Program for Comanche
Peak Steam Electric Station**

Update Report

January 2004

**TXU Energy
Comanche Peak Unit 2
Elevated pH Program Update – January 2004**

Introduction

Constant-elevated reactor coolant pH chemistry control and its benefit in terms of crud management may potentially be used to reduce plant radiation levels and avoid operational and economic issues associated with PWR axial offset anomaly (AOA). The demonstration of crud management through this principle has been successful in both research and operating experience for plants operating with relatively low reactor coolant boron levels. However, the potential risk of corrosion enhancement to fuel cladding or structural components must be carefully evaluated for modern plants and core designs utilizing higher reactor coolant boron concentrations which thereby require much higher lithium concentrations to achieve elevated pH.

Background

The primary purpose for the investigation of operation at an elevated reactor coolant pH level was to address the increase in plant radiation fields with plant age. The results of on-going attempts to optimize reactor coolant chemistry control programs prompted the initiation of the current program to qualify operation at an at-temperature reactor coolant pH₁ of 7.4 with lithium concentrations up to 6 ppm, which is believed to be the optimum chemistry for crud management.

For many plants, the more recent phenomenon of Axial Offset Anomaly (AOA) is a significant impediment to further optimization of reactor core designs for economic performance. AOA is the result of a combination of factors including fuel rod sub-cooled boiling, crud deposition, and boron hideout inside the crud deposits. Primary chemistry controls have been identified as one potential means of reducing AOA susceptibility. Elevated pH, held constant throughout the fuel cycle, is known to reduce the source, transport, and deposition of corrosion products on nuclear fuel. However, the increased boron requirements for modern core designs require significant increases in lithium concentration to attain desired constant-elevated pH conditions. Therefore, a comprehensive engineering evaluation followed by fuel clad oxide measurements of the possible impact of these lithium increases on fuel clad corrosion susceptibility was necessary.

The assessment of risk for lithium enhanced corrosion of nuclear fuel clad was performed independently by Westinghouse and Framatome ANP for their respective fuel and clad materials to be employed in the demonstration program at Comanche Peak Steam Electric Station. Westinghouse performed evaluations for Zircaloy-4 and ZIRLO™ clad fuel, while Framatome ANP performed evaluations for optimized low tin Zircaloy-4 clad fuel. The two vendor evaluations of fuel related corrosion provided similar conclusions and identified similar parametric factors important to the evaluation. Risk associated with the demonstration, at plant-specific conditions, was judged to be small.

In addition, Westinghouse performed the evaluation for the potential of increased risk of stress corrosion cracking of system structural components. Assessment of risk for increased corrosion susceptibility to structural components identified steam generators as the most susceptible component. The effect of increasing lithium to 6 ppm was judged to be relatively small when compared to factors such as material properties, temperature and stress.

All assessments caution that the results of this evaluation are specific to the proposed core designs for the demonstration and that the potential for lithium enhanced corrosion should be evaluated on a plant and cycle specific basis, prior to instituting an elevated lithium program.

CPSES Demonstration Elevated pH Project

The elevated pH demonstration program at Comanche Peak Steam Electric Station (CPSES) consists of a two phased approach for achieving the desired constant reactor coolant pH_t of 7.4. The demonstration project includes tasks specific to each phase, beginning with the pre-demonstration assessment activities. The phases of the demonstration and post-operation assessments are as follows:

- Assess the influence of operating with a pH_t of 7.4 with a maximum lithium concentration of 6 ppm on fuel cladding oxide growth relative to the plant specific core design, and vendor specific fuel cladding.
- Assess the influence of operating with a pH_t of 7.4 with a maximum lithium concentration of 6 ppm on primary system materials susceptibility to primary water stress corrosion cracking (PWSCC).
- Demonstrate one cycle (U2C7) of operation with a constant pH_t of 7.3 and perform interim evaluation of both operating cycle data and refueling outage (2RFO7) inspection results.
- Demonstrate one cycle (U2C8) of operation with a constant pH_t of 7.4, and perform evaluation of both operating cycle and refueling outage (2RFO8) inspection results.

Demonstration of second cycle (U2C9) operation with a constant pH_t of 7.4 and refueling outage inspections is anticipated to capture results of higher burnup on ZIRLO™ fuel cladding. This activity is not yet included in the project scope.

Two major assessment tasks were performed to evaluate potential impact of the specified chemistry conditions on expected performance of nuclear fuel and reactor coolant system materials. Results of the pre-demonstration task were supportive of the proposed demonstration and no significant issues or risks were identified. Corrosion enhancement of the fuel cladding was not predicted for the proposed power histories, and the expected oxide thickness was well within the fuel cladding corrosion allowances of the respective fuel designs.

The potential for minor increases in susceptibility to PWSCC was identified and particularly for the Comanche Peak Unit 1 steam generator tube materials, which have Alloy 600 MA tubing. Comanche Peak Unit 2 steam generators use Alloy 600 TT tubing, which have proven to be more resistant to PWSCC. The assessment conclusions found, at most, a minor effect of the proposed chemistry changes, which were judged acceptable and low risk.

It was decided to implement the proposed chemistry changes in two steps starting with one operating cycle where the conditions were limited to constant pH_t of 7.3 and a maximum lithium concentration of 5 ppm. Assuming expected results, the chemistry conditions for the next operating cycle would be revised to constant pH_t of 7.4 and a lithium limit of 6 ppm.

Each phase of operation included detailed tasks for chemistry monitoring and fuel surveillance to verify expected conditions, evaluate results and to capture lessons learned. Some of these tasks were directed at secondary objectives and chemistry parameters that were considered relevant indicators of changes in crud behavior.

The impact of elevated constant pH on radiation fields has been a long-term interest to the industry and capturing these effects is a key objective of the demonstration. Due to the decay of radionuclides in existing ex-core deposits, it is expected that trends may not reach a new equilibrium or dose plateau until after three or more cycles at the optimum pH.

Post demonstration fuel surveillances were planned to capture the effect of elevated pH and higher lithium concentrations on corrosion oxide thickness for both Framatome ANP Low Tin Zircaloy-4 and Westinghouse ZIRLOTM fuel clad materials. This plan included evaluation of power histories for both low and high duty assemblies. Full height visual inspections and evaluation of crud deposits is another key objective of the fuel surface examinations.

The demonstration program at CPSES Unit 2 began in the spring of 2002 by increasing the reactor coolant pH_t to 7.3 for Unit 2, Cycle 7 with a maximum lithium concentration of 5 ppm. During the refueling outage following Cycle 6 operation (2RF06), oxide measurements were performed on selected irradiated fuel assemblies which were to be reloaded into Cycle 7 in order to benchmark the oxide thickness of these assemblies prior to implementing the elevated pH program. This report provides a summary of the results of the oxide measurements performed following Cycle 7 (2RF07) with one full cycle of operation of CPSES Unit 2 with an elevated pH_t of 7.3.

Description of Work Scope

Including: Fuel Assembly Identification Numbers
Measuring Equipment and Calibration and Accuracy

Fuel Assembly Identification Numbers

Twelve fuel assemblies from Cycle 7 were included in this inspection. The fuel assembly IDs, the number of cycles of exposure, and the fuel vendor for each assembly are provided below.

JW01, JW05, JW06, JW07	1 st burn	Westinghouse
JJ23, JJ83	1 st burn	Framatome-ANP
HH39	2 nd burn	Framatome-ANP
HH80, HH82, HH83	2 nd burn discharge	Framatome-ANP
GG01, GG19	3 rd burn discharge	Framatome-ANP

Full-face camera inspections were performed on all four faces of each assembly. Fuel cladding corrosion thickness was measured on the outward-facing surface of selected peripheral fuel rods. For ten assemblies, measurements of the fuel rods were performed along all the spans between grid straps. For assemblies HH82 and HH83, only spans 5, 6, and 7 were measured. A high magnification camera recorded visual records of the fuel rod during the measurements.

Measuring Equipment Description, Calibration, and Accuracy

The oxide measuring equipment used is an eddy current system. A Zetec MIZ-23 is used to electronically process signals from an eddy current probe that is positioned against the fuel rod. The MIZ-23 calibration is periodically checked to standard oxide references over a range of 5 to 98 microns. The data should be within plus or minus 3 micron range for successful calibration. During measurements, very thin oxide layers less than 5 microns may sometimes be recorded as negative values. Values of the measured oxide thickness at these levels are insignificant when compared to the more limiting oxide values measured within the grid spans at the top of the fuel assembly.

Crud is typically present in varying degrees on the fuel rod clad surface. If the crud is light and loosely attached, the probe will usually pass through unaffected. However, if the crud is thick and higher-density, the probe will skim over the surface of the crud-affected areas. This will cause the recorded values to have both an oxide thickness component and a crud thickness component. The system used for these measurements has no method for distinguishing between corrosion thickness and crud thickness. Cleaning (by brushing with Scotch-brite pads) and re-measuring the rods may provide some information about the magnitude of any crud component. However, all deposited crud may not be removed and it is difficult to visually determine the effect tenacious crud deposits may be having on the oxide data results.

In an attempt to collect some information on crud levels, brushing was performed on fuel assemblies HH80 and HH83 at span location 6 on one face. The oxide measurements were then repeated after brushing was complete. The comparison of pre- and post-brushing data could provide an indication of crud thickness.

Results

Including: Visual Inspection Results
 Oxide Measurement Results

Visual Inspections

Full-face visual inspections were performed on all assemblies and high magnification visual inspections were performed on select fuel rods. First-burned fuel assemblies showed no evidence of crud in the first four spans. A few cases of dark, localized crud were observed in spans 5 and 6. A thin layer of brown crud, typically observed just below grid 8, was observed in span 7 of all the first-burned assemblies. Localized spots of crud were observed on most grids while grid 8 was covered by a uniform layer of brown crud. An inconsistent, patchy appearance of the clad was observed on the fuel in the first four spans and often occurred just above a grid strap. This appearance is caused in the early stages of oxide formation when the dark gray color of very thin oxide becomes lighter gray as the oxide becomes thicker. This is usually seen when the oxide thickness is less than 10 microns. This will be termed 'transitional oxide' in this report. The common appearance of the transitional oxide just upstream of the grid straps is probably due to the increase in mixing and turbulence caused by the grids, thereby increasing heat transfer, reducing clad temperature, and reducing oxide formation in these areas.

The low-duty, second-burned fuel assembly (HH39) showed no evidence of crud in the first six spans. No localized dark crud was seen on any of the peripheral rods. Span 7 and grid 8 were covered by a thin layer of brown crud. Most of the other grids appeared clean. Transitional oxide was observed in the first three spans.

The high-duty, second-burned fuel assemblies (HH80, HH82, and HH83) showed evidence of crud in spans 4-7. A light, brownish crud was observed on these spans. The crud was observed to be progressively thicker and more uniform higher up the spans. Thicker, dark crud was observed on many rods in spans 5 and 6. Some evidence of crud was observed on all the grids. Most grids had a light layer of brown crud and some also had a few darker spots. Grid 8, like most other assemblies, was covered with dark brown crud. Transitional oxide was observed in the first three spans.

The third-burned fuel assemblies (GG01 and GG19) appeared to be crud-free in spans 1-4. There was a single case of dark crud observed in span 5 and a couple of rods with dark crud in span 6.

Span 7 again exhibited the uniform light brown crud as seen on all other assemblies. There were a few spots of crud observed on most grids and grid 8 was covered with a brown crud layer. Transitional oxide was observed in the first two spans.

Blistering has been observed in the industry in Zircaloy-4 cladding with peak oxide thickness in the range of 60-80 microns. Possible oxide blistering was observed on several rods in both 2RF06 and 2RF07. All cases of blistering were observed in span 6. Assembly HH80, face 1 showed evidence of oxide blisters on rod 10. The maximum measured oxide thickness for rod 10 was 57 microns. This is at the low end of the thickness range for oxide blistering. Possible blisters were also observed on face 2, rods 7, 8, 9, and 10. Rods 8 and 10 had peak oxide values of 69 and 98 microns. Oxide blistering might be expected in this range of thickness. Blisters were also observed on assembly HH83, face 3, rods 2, 9, 10, 13, and 14. Rods 2, 10, 12, and 14 had peak oxide values of 92, 69, 64, and 46 microns, respectively. It is not unusual to observe minor blistering in fuel rods of this burnup, fuel duty, and measured oxide thickness.

Oxide Measurement Summary

All oxide measurement data points were averaged over a one-inch interval, and the listed oxide values are located at the centers of these intervals. Approximately 25 data points were taken in each one-inch interval. A correction factor of -4 microns must be applied to results for the Framatome ANP assemblies as a result of the bias introduced by the different cladding material.

The first-burned Westinghouse assemblies (JW01, JW05, JW06, and JW07) had peak rod oxide thickness values ranging from 7 to 15 microns.

The first-burned Framatome ANP assemblies (JJ23 and JJ83) had peak rod oxide thickness values ranging from 10 to 19 microns.

The low-duty, second-burn assembly (HH39) had peak rod oxide thickness values ranging from 17 to 22 microns.

The high-duty, second-burn assemblies (HH80, HH82, and HH83) had peak rod oxide thickness values ranging from 32 to 98 microns.

The third-burn assemblies (GG01 and GG19) had peak rod oxide thickness values ranging from 26 to 64 microns.

Pre/Post Brush Comparison

Span 6 of HH80 face 2 and HH83 face 3 were brushed and re-measured. For HH80, pre-brushed measurements ranged from 27 to 98 microns. Post-brushed measurements ranged from 26 to 94 microns. For HH83, pre-brushed measurements ranged from 29 to 92 microns. After brushing, measurements ranged from 27 to 90 microns.

In most cases, the data obtained after brushing was not significantly different from the pre-brushed values. For 10 of the 13 rods, values changed less than 5 microns over the entire length of span 6. One rod showed a dramatic change, while two others showed more moderate changes.

Rod 3 on face 2 of HH80 showed a maximum change of about 30 microns. This rod was chosen for measurement because it contained heavy crud directly along the center of the rod. The eddy current probe clearly had to travel over or through this crud. After brushing, the visual record clearly showed that some of this crud had been removed, as indicated by the change in oxide thickness result. Rod 14 on face 3 of HH83 also showed a maximum decrease of 8 microns after brushing. Again, this rod had dark crud directly in the path of the probe. After brushing, most of this crud was removed.

Based on this result, it is concluded that the light, thin layer of crud observed on many rods does not affect the oxide measurements. This crud is loose and thin enough that the eddy current probe runs right through it without significant changes of position. The thicker, dark crud, however, does affect the oxide thickness result. The probe skims over this crud and includes the crud thickness in the oxide value reported.

Comparison to Previous Inspection Results

First-burned assemblies measured during 2RF06 showed some very slight, brownish crud deposition in spans 4 through 6. This crud was present throughout these spans but was an inconsistent, non-uniform covering. Span 7 had a slightly thicker, uniform brown cover of crud. The first-burned assemblies measured during 2RF07 showed evidence of this light brown crud only in spans 6 and 7. However, a thicker, dark crud was observed on several rods in spans 5 and 6. This type of crud was not seen on the first-burned assemblies from 2RF06.

The low duty, second-burned assemblies from 2RF06 showed the same light brown, inconsistent crud on spans 4 through 6. A thicker layer of this brown crud was observed in span 7. Thicker, dark crud was also observed on several rods in spans 5 and 6. The same type of fuel assembly (HH39) from 2RF07 showed only the brown crud in span 7. No dark crud was observed on this assembly.

The high duty, second-burned assemblies from 2RF06 showed light crud accumulation in spans 5 and 6. A similar, but slightly thicker crud layer was observed in span 7. Thick, dark crud was observed on two rods in span 6. Some oxide blistering was noted on several rods in span 6. The high duty assemblies from 2RF07 showed the light crud in spans 4 through 6. It was also present in span 7 as a slightly thicker layer. The thicker, dark crud appeared on many rods in spans 5 and 6. Oxide blistering was also observed on several rods in span 6.

The third-burned assembly from 2RF06 exhibited the light brown crud in spans 4 through 7. As in the other assemblies, this crud was most prevalent in span 7. No thick, dark crud was observed on this assembly. The third-burned assemblies from this cycle showed the light brown crud only in span 7. However, dark crud was observed on one rod in span 5 and two rods in span 6.

Peak oxide values for fuel rods and assemblies measured during 2RF06 and 2RF07 with similar power histories were compared. The first-burned assemblies had fuel rods with peak oxide thickness ranging from 9 to 30 microns during 2RF06 and ranging from 10 to 19 microns during 2RF07. Low duty, second-burned assemblies had fuel rods with peak oxide thickness ranging from 24 to 30 microns during 2RF06 and ranging from 17 to 22 microns during 2RF07. The high duty, second-burned assemblies had fuel rods with peak oxide thickness ranging from 38 to 85 microns during 2RF06 and ranging from 32 to 98 microns during 2RF07. The third-burned assemblies had fuel rods with peak oxide thickness ranging from 22 to 55 microns during 2RF06 and ranging from 26 to 49 microns during 2RF07.

Conclusions and Comments

Results of brushing indicated that most of the light crud present did not have any significant effect on the oxide measurements. However, presence of the thick, dark crud that formed axially along the rods in spans 5 and 6 could cause the oxide thickness result to be exaggerated. Several rods were noted to have this type of crud present on their peripheral faces (and thus in the probe's path). If brushing was not performed on these rods or the brushing was not effective, then the peak values for these rods are likely to be crud-affected.

Overall, there seemed to be less of the uniformly deposited, light brown crud present during 2RF07 than was observed during 2RF06. The thicker, dark crud consistently appeared in spans 5 and 6 for both cycles. However, it was observed only on the low and high duty second-burned assemblies in 2RF06; but was observed on the first-burned, high duty second-burned, and third-burned assemblies in 2RF07. This type of crud also appeared more often in 2RF07. Many rods from the high-duty assemblies were affected in 2RF07, but only a few rods from all assemblies in 2RF06 exhibited this type of crud.

Oxide values remained reasonably consistent from 2RF06 to 2RF07. If anything, there may have been a slight decrease in overall oxide thickness. There was some increase in the variability of measured peak oxide thickness for the high duty assemblies; however, it is considered within the normal variation to be expected. The frequency, magnitude, and location of oxide blistering did not change between 2RF06 and 2RF07.

Oxide thickness values on the Westinghouse fuel assemblies compared favorably to the predictions provided by the Westinghouse corrosion model. Maximum measurements were much less than the upper bound given by the model. Oxide measurements obtained for Framatome ANP assemblies indicate oxide thickness values within the allowable range for the corresponding burnup fuel duties, and the values compared reasonably well with those obtained following Cycle 6 during refueling outage 2RFO6. The comparison indicates that the operation of the Framatome ANP fuel assemblies in an elevated pH environment (pH_i of 7.3 and lithium of up to 5 ppm) did not result in a significant increase in clad oxide thickness. Based on the few changes in crud deposition, oxide thickness, and oxide appearance for both the Framatome ANP and Westinghouse fuel assemblies, operating at an elevated pH_i of 7.4 and lithium concentrations of up to 6 ppm was recommended and is currently being implemented in U2C8.