APPENDIX

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Inspection Report: 50-445/92-52
50-446/92-52

Operating License: NPF-87

Construction Permit: CPPR-127

Licensee: TU Electric
Skyway Tower
400 North Olive Street, L.B. 81
Dallas, Texas 75201

Facility Name: Comanche Peak Steam Electric Station (CPSES), Units 1 and 2

Inspection At: CPSES, Glen Rose, Texas

Inspection Conducted: November 30 through December 7, 1992, and
January 24-25, 1993

Inspectors: I. Barnes, Technical Assistant, Division of Reactor Safety
F. Grubelich, Mechanical Engineer, Office of Nuclear Reactor Regulation

Accompanying Personnel: C. Hrabal, Acting Project Engineer, Division of Reactor Projects

Approved: Arthur T. Howell III for 2-17-93
Samuel J. Collins, Director, Division of Reactor Safety — Date

Inspection Summary

Areas Inspected (Unit 1): No inspection of Unit 1 activities was performed.

Areas Inspected (Unit 2): Routine, announced inspection of the status of Significant Deficiency Analysis Report (SDAR) CP-89-15.

Results (Unit 1): Not applicable.

Results (Unit 2):

- The licensee has implemented equivalent measures to those taken in Unit 1 to assure proper operation of BW/IP International (BW/IP) pressure seal bonnet check valves, and has appropriately responded to additional

problems encountered in Unit 2 with this type of valve and BW/IP bolted bonnet design check valves (Section 1.3).

- The procurement actions for replacement swing arms were comprehensive and well implemented (Section 1.2.1).
- The licensee has used an appropriate methodology to assure vertical and rotational disc-seat alignment in BW/IP pressure seal bonnet check valves (Section 1.2.2).
- Slight disc unseating problems in auxiliary feedwater system BW/IP pressure seal bonnet check valves have been satisfactorily resolved by addition of a beveled counterweight to the disc stud (Section 1.2.3).
- The investigation of the cause of failure of a 4-inch auxiliary feedwater system BW/IP pressure seal bonnet check valve disc stud, which occurred during preoperational test activities, was thorough and reasonable in its assessment. Conservative assumptions and recognized methodology and theory were used in the analyses (Section 1.2.4).
- BW/IP swing check valves have been included in the check valve reliability program, which is designed to identify incipient and existing check valve failures on an ongoing basis (Section 1.2.8).
- The root cause analysis, corrective actions, and assessment of generic implications were appropriate with respect to the reverse flow test failures of two 4-inch bolted bonnet design check valves (Section 1.2.7).

<u>Summary of Inspection Findings:</u>

- SDAR CP-89-15 was closed (Section 1.3).

<u>Attachments:</u>

- Attachment - Persons Contacted and Exit Meeting

DETAILS

1 REVIEW OF CONSTRUCTION DEFICIENCY SIGNIFICANT DEFICIENCY ANALYSIS REPORT (SDAR) CP-89-15: "AUXILIARY FEEDWATER SYSTEM CHECK VALVES" (92700)

The inspectors reviewed the licensee's actions to close SDAR CP-89-15, "Auxiliary Feedwater System Check Valves." The reviews included: (1) verification of implementation in Unit 2 of corresponding corrective actions to those initiated in Unit 1 in response to identified deficiencies, and (2) followup of Unit 2 problems including a disc stud failure and reverse flow test failures of two bolted bonnet design valves.

1.1 Background

This SDAR was initiated in response to failures of Unit 1 BW/IP check valves in the auxiliary feedwater (AFW) system. Specifically, BW/IP check valves have had various hardware and installation problems which precluded them from performing their designed safety function of preventing reverse flow. The SDAR was subsequently increased in scope to address additional problems which were encountered with BW/IP check valves (e.g., swing arm failure). As previously documented in NRC Inspection Report 50-445/90-09; 50-446/90-09, this construction deficiency was reviewed and closed for Unit 1 based on changes to installation procedures, replacement of certain swing arms with investment grade material, correction of alignment problems, and correction of calculation errors. In addition, the check valves were retested after reinstallation by the application of reverse flow tests or through the use of radiography to verify their correct operation.

1.2 Review of Licensee Actions on Unit 2 BW/IP Check Valves

1.2.1 Replacement of Swing Arms

The inspectors reviewed, for problem familiarization purposes, the metallurgical and mechanical property information that was generated during the licensee's investigation of the failure of a Unit 1 nonsafety-related swing arm. This information was contained in Aptech Report, "Failure Analysis and Service Suitability of Check Valve Swing Arms," dated December 1989 and Southwest Research Institute Report, "Evaluation of Commercial Swing Arms," dated March 1991. The inspectors then reviewed the technical and quality requirements which were contained in Purchase Order S00082027S2 for Unit 2 replacement swing arms. It was ascertained from this review that the licensee had prescribed the use of Atlas Foundry in Tacoma, Washington, specified the use of a quality assurance program meeting 10 CFR 50, Appendix B, and ANSI N45.2 (or, alternatively, ASME Code NCA-3800 or NCA-4000), and defined the applicability of 10 CFR 21.

Investment cast swing arms were specified to be furnished in accordance with ASTM Material Specification A747 Grade CB7CU-1 in the H1100 precipitation hardened condition. Supplementary requirements of the material specification

were also imposed with respect to nondestructive examinations (i.e., either magnetic particle or liquid penetrant surface examinations and radiographic ex mination), hardness testing, tensile testing, homogenizing anneal, and marking. The nondestructive examinations were specified to be performed in accordance with Section III of the ASME Code, 1974 Edition through the Summer 1974 Addenda. The vendor was required to furnish certified material test reports, nondestructive examination reports, and heat treatment records.

The inspectors noted that the licensee had been active in performing source inspections at both BW/IP and the manufacturer's facility for this procurement, and had created appropriate verification plans (i.e., VP-90-0766 and VP-90-0772) for performance, respectively, of receipt and source inspections. The inspectors reviewed the receipt and vendor documentation for the replacement swing arms to verify that the materials were consistent with specification requirements for mechanical properties, heat treatment, and nondestructive examination. No problems were observed during this review other than a minor legibility matter with two heat treatment charts. The licensee promptly contacted the vendor to obtain improved quality copies of the two charts.

In general, the inspectors considered that the licensee had specified comprehensive requirements for procurement of replacement swing arms. The measures taken to assure conformance with the procurement requirements were well implemented.

1.2.2 Disc-Seat Alignment

As previously documented in NRC Inspection Report 50-445/90-09; 50-446/90-09, vertical and rotational differences in disc-seat alignment caused backleakage to occur in Unit 1 BW/IP pressure seal bonnet check valves. The inspectors reviewed the licensee's corrective actions to resolve these problems in Unit 2. Vertical disc-seat alignment was accomplished by: (1) determination of the correct bonnet elevation for each valve in accordance with CDF-23451; (2) incorporation of a spacer ring into the design in accordance with TUE Form 91-906 to assure installation of the bonnet at the correct elevation; (3) revision of Maintenance Procedure MSM-CO-8801, Revision 3; and (4) rework of the BW/IP pressure seal bonnet check valves in accordance with Maintenance Procedure MSM-CO-8801. No problems were noted by the inspectors during review of the licensee actions to assure vertical disc-seat alignment.

The licensee had identified that the 25 BW/IP ASME pressure seal bonnet check valves would be modified before fuel load to assure proper rotational disc-seat alignment during any future reassembly operations. The inspectors reviewed the modification which was performed in accordance with TUE Form 91-906, and consisted of the installation by welding of a block and key external alignment device to the valve body and bonnet after completion of testing. The inspectors reviewed a sample of work packages that installed this modification and found them to be complete.

1.2.3 Correction of Low Differential Pressure Problem

Minor leakage through Un t 1 AFW check valves caused the differential pressure (DP) across these valves to decrease to such a level that slight unseating of the disc occurred (TXX-90172). This resulted in high AFW line temperatures. To preclude this problem in Unit 2, counterweights were added to the disc stud in accordance with DCA-94663, Revision 0, to enhance its low DP seating capabilities. Hanging up of counterweights was encountered which was attributed by licensee personnel to the addition of the spacer ring. Backstops were initially added by DCA-94663, Revision 2, to resolve this problem, and were then subsequently removed by DCA-94663, Revision 4, following the stud failure in Check Valve 2AF-0083 (see Section 1.2.4 below). Satisfactory resolution of the problem was achieved by beveling of the counterweights in accordance with DCA-94663, Revision 5. The inspectors reviewed the DCA-94663 revisions and a sample of the related work packages, to assure the adequacy of the modification to correct the low DP problems. The work packages were found to be complete with no problems noted in the review.

1.2.4 2AF-0083 Stud Failure

The failure of a 4-inch BW/IP pressure seal bonnet check valve, 2AF-0083, was identified by reverse flow testing that was performed in association with activities performed by Preoperational Test Procedure 2PT-37-01 on July 3, 1992. The valve is located in the discharge line between the motor-driven AFW Pump 2-01 and Steam Generator No. 2. The function of the valve is to prevent backflow when the pump is not running. Nonintrusive examination and disassembly of Valve 2AF-0083 after the test failure revealed that the disc stud had fractured at its attachment point to the disc. The separated disc was present in the discharge area of the valve body. The licensee repaired the valve and returned it to service after removing a backstop that had been previously added to restrict disc swing arc. In addition, the flow rate through the valve was restricted to 300 gpm pending the results of an investigation into the cause of failure.

The licensee's investigation included a metallurgical examination of the failed parts; reviews of system operation, system and valve design, valve and pump operating history; and assessment of generic implications. The system review included transient analyses under various flow and pump conditions.

The inspectors examined the metallurgical examination report and the details of the investigation contained in Report PTR-32, "BWIP Check Valve 2AF-0083 Failure Investigation," Revision 0.

The metallurgical examination report, which was prepared for the licensee by a contractor, identified that the failure was ductile in nature and was due to a stress overload at a high rate of loading. There was little evidence of ductile stretching or necking down during failure; however, the fracture surfaces showed plastic tearing had occurred.

The inspectors noted from review of Report PTR-32, Revision 0, that in the transient analyses of the design basis, pump starts and stops with a solid water system had been evaluated, with the results indicating that the developed forces were not sufficient to cause the stud failure.

The operational history review of motor-driven AFW Pump 2-01 and Check Valve 2AF-0083 identified the most likely sequence of events, leading to and bounding the time and conditions which caused the valve failure, to be:

- On July 1, 1992, Check Valve 2AF-0083 was exercised during a system fill and vent operation. At the completion of this operation the flow control valve associated with the check valve line would remain in the full open position.
- On July 1, 1992, an inadvertent autostart of motor-driven AFW Pump 2-01 was also recorded.
- On July 3, 1992, Check Valve 2AF-0083 failed the reverse flow test required by Preoperational Test Procedure 2PT-37-01.

The licensee determined from review of the AFW system configuration that a drain down most likely occurred following the system fill and vent operation, as a result of the condensate storage tank being below the check valve level, the associated flow control valve being open, and the steam generator being at atmospheric pressure. The licensee concluded that the failure of Check Valve 2AF-0083 was most likely caused by a system fluid transient which was the result of starting motor-driven AFW Pump 2-01 into a partially drained system.

The inspectors reviewed the failure analyses that were referenced in Report PTR-32, Revision 0. These analyses were prepared by ABB Impell and were contained in Calculation 0218-SQ-0096, Revision 2. It was ascertained from this review that the analyses accounted for the results from the metallurgical examination, pump and valve operating history, and conditions resulting from a transient excessive fluid flow rate. The calculation method consisted of hand calculations based on statics, dynamics, strength of materials, ASME Code load limit analysis, and transient flow theory formulation. The calculation demonstrated that the most credible failure cause was the excessive transient flow rate and resultant backstop/disc stud impact. This failure cause was consistent with the results of the metallurgical examination. The calculation additionally showed that, while the backstop was not the cause of the failure, it was a contributory factor to the degree of damage and level of stress sustained by the stud.

The inspectors concluded that the investigation by the licensee was thorough and provided a reasonable assessment of failure cause. The assumptions used were conservative, and recognized calculation methodology, theory, and formulations had been employed. The corrective actions taken by the licensee for these 4-inch AFW system valves included revision of the AFW operational

procedures to eliminate excessive flow rates, removal of the backstops, beveling of the counterweights, and inclusion of the discharge check valves in the check valve reliability program for ongoing acoustic monitoring. The licensee was additionally considering a long-term design enhancement that would replace the existing threaded disc stud design.

Although the other BW/IP pressure seal bonnet check valves (6 and 8 inch size) in Unit 2 were not considered in the original ABB Impell analyses, an identical set of calculations were subsequently performed on the 6-inch valve. The analyses were performed since these valves were also modified by the addition of backstops and height adjustment spacers. The licensee considered the calculations to be applicable to both size valves. The inspectors ascertained from review of the data that, for the same flow rates, conditions, and assumptions, the stress levels for the increased valve size were below the levels calculated for the 4-inch size and did not indicate a similar failure susceptibility.

1.2.5 2AF-0098 Stud Perpendicularity Problem

The licensee discovered a slightly bent disc stud in 2AF-0098 during an inspection of the valve internals. The valve internals were removed and the disc stud was sent to a laboratory for evaluation. The licensee believed that welding during valve fabrication had caused the stud to bend. In addition, Valve 2AF-0098 had passed its backflow test and the licensee determined the bending was not detrimental to valve operation. The inspectors concurred with this determination based on a review of the licensee's actions to make axial gap criteria part of the existing design in accordance with DCA-91439.

1.2.6 Inadequate Clearance in 3-Inch Diameter Valve Bodies

As documented by the licensee on TUE Form 92-5560, excessive backleakage was identified during the reverse flow testing of the 3-inch check valves associated with the motor-driven AFW pumps' recirculation lines (Valves 2AF-057 and -069). The function of the 3-inch check valves installed in the AFW pump mini-flow lines was to protect the suction of the idle AFW pump from over-pressurization, because suction piping relief valves were not provided in the original design. Subsequent radiographic examinations of the two valves determined that the disc was lodged under the seat ring on Valve 2AF-069 and that the bonnet on Valve 2AF-057 was misaligned to the body. The cause of the interference was due to inadequate clearance in the valve body. The licensee has determined that the 3-inch check valves on the AFW pump recirculation lines serve no safety function and has implemented a design modification through DCA-101801, Revision 0, which removed the valve internals from these two valves as well as Valve 2AF-045, the recirculation valve for the turbine driven AFW pump. The inspector reviewed this DCA and found no problems. The inspectors also verified by review of Flow Diagram M2-0206, Sheet 1, Revision CP2, that the valves did not serve a safety function because of the subsequent installation of suction piping relief valves in addition to a check valve on the suction side of each AFW pump.

1.2.7 Flow Test Failures in 4-Inch BW/IP Bolted Bonnet Design Swing Check Valves

On December 1, 1992, during the inspection, reverse flow test failures occurred in two 4-inch BW/IP bolted bonnet design check valves (i.e., 2CC-0693 and 2CC-0697). These valves are located in the component cooling water return lines from the reactor coolant pump motor coolers. Subsequent radiographic examinations identified that the Check Valve 2CC-0693 disc was lodged in the valve neck in the full open position, while the top edge of the disc in Check Valve 2CC-0697 was lodged under the valve seat lip, preventing full closure. As a result of the prior problem history for BW/IP check valves being predominantly related to the pressure seal bonnet design, the licensee was informed during the exit meeting held on December 7, 1992, that SDAR CP-89-015 would remain open pending completion and submittal of a root cause analysis and planned corrective actions for the two bolted bonnet design check valve test failures.

The licensee submitted the requested root cause analysis and planned corrective actions by letter (TXX-93003) dated January 20, 1993. An inspection of this root cause analysis was conducted during January 24-25, 1993. In addition to review of TXX-93003, the inspectors reviewed TU Electric Engineering Report ER-ME-78, "Investigation and Root Cause Analysis of BWIP Bolted Bonnet Check Valves 2CC-0693 and 2CC-0697," Revision 0.

It was ascertained from this review that Check Valve 2CC-0697 was found to have a step in the outer diameter of the disc face which reduced the outer diameter and formed a sharp edge. Repeated testing demonstrated that the step caused consistent lodging of the disc upper edge under the seat lip. Switching of the disc from Check Valve 2CC-0693 to the body of Check Valve 2CC-0697 resulted in the 2CC-0693 disc easily seating in the 2CC-0697 body. The licensee examined the spare discs in the warehouse, with no further instances of a step noted. In addition, contact with the valve manufacturer indicated that the step was an unusual feature which was not described in the design. Check Valve 2CC-0697 was reworked to remove minor internal body obstructions and replace the disc, with the valve then retesting satisfactorily.

Failure of Check Valve 2CC-0693 to close was determined by the licensee to be related to the presence of two sets of body protrusions which reduced the disc to body clearances along the disc swing path. After rework of the valve to remove the excessive protrusions, the valve failed a retest on January 6, 1993. The retest failure was similar to the condition found in Check Valve 2CC-0697 after its initial test (i.e., the top edge of the valve disc consistently lodged under the seat lip on return of the valve disc to the seat). The failure to close was determined to be related to an excessive gimbal range which allowed the disc edge to approach the valve seat at an elevation and angle that resulted in lodging under the seat lip. Reduction of the gimbal range in the valve was accomplished by reduction of the axial gap, after which the valve retested satisfactorily.

The licensee concluded that the failure mode of the two valves was not random, in that the failure to close was consistent and repeatable. Valves which had previously functioned properly should not be susceptible to similar lodging. In addition, ongoing verification of correct check valve function is provided by closure verification testing following reassembly, inservice testing of safety-related check valves in accordance with ASME Section XI Code requirements, and acoustic monitoring of bolted bonnet check valves (including 2CC-0693 and 2CC-0697) in the check valve reliability program. The inspectors determined that the licensee's root cause analysis, corrective actions, and assessment of generic implications were appropriate, and that the testing and monitoring programs provided ongoing verification of the correct operation of the bolted bonnet check valves.

1.2.8 Check Valve Reliability Program

Utility check valve reliability programs were developed in response to an initiative by the Institute for Nuclear Power Operations. The primary purpose of these programs is to identify incipient and existing check valve failures. The licensee's program was documented initially for Unit 1 in Procedure STA-750, "Check Valve Reliability Program," Revision 1. Revision 2 of this document dated July 24, 1992, included Unit 2 check valves into the program. The inspectors reviewed the procedure and ascertained that it utilized both nonintrusive and disassembly examinations. All valves in the program were assigned a prioritized ranking which was determined by review of valve use, safety function, system and location, operational conditions, and maintenance data. The assigned ranking determined which of three inspection intervals (i.e., once a fuel cycle, once every other fuel cycle, or once every fourth fuel cycle) would be employed. The check valve reliability program was ascertained to include 92 BW/IP check valves in the program population. These 92 valves included all of the motor-driven AFW pump discharge check valves. The inspectors noted no problems with the program and considered it of value in monitoring for degradation.

1.3 <u>Conclusions</u>

- The licensee has implemented equivalent measures to those taken in Unit 1 to assure proper operation of BW/IP pressure seal bonnet check valves, and has appropriately responded to additional problems encountered in Unit 2 with this type of valve and BW/IP bolted bonnet design check valves. Accordingly, SDAR CP-89-15 was closed.

- The licensee developed comprehensive requirements to assure that the replacement swing arms possessed necessary mechanical properties, had been correctly heat treated, and were free of flaws.

- The licensee has used an appropriate methodology to assure vertical and rotational disc-seat alignment in BW/IP pressure seal bonnet check valves. The use of spacer rings and external alignment devices was considered beneficial in regard to facilitating accurate reassembly during future maintenance operations.

- The licensee has satisfactorily resolved slight disc unseating problems in AFW system valves by addition of a beveled counterweight to the disc stud.

- The licensee's investigation of the failure of the disc stud in motor-driven AFW Pump Discharge Check Valve 2AF-0083 was thorough, and was reasonable in its assessment that it was caused by an excessive transient flow rate and resultant backstop/disc stud impact.

- BW/IP check valves have been included in the check valve reliability program, which is designed to identify incipient and existing check valve failures on an ongoing basis. All of the BW/IP motor-driven AFW pump discharge check valves were part of the program population.

- The licensee's root cause analysis, corrective actions, and assessment of generic implications were appropriate with respect to reverse flow test failures in two 4-inch BW/IP bolted bonnet design check valves.

ATTACHMENT

1 PERSONS CONTACTED

1.1 Licensee Personnel

*B. Bhujang, Coordination/Scheduling Engineering Manager
*M. Blevins, Director of Nuclear Overview
*H. Bruner, Senior Vice President
#*W. Cahill, Jr., Group Vice President, Nuclear Engineering and Operations
D. Daly, Startup Manager
J. Donahue, Operations Manager, Unit 2
*D. Fiorelli, Senior Engineer
*C. Graham, Startup/Maintenance Planning
W. Guldemond, Manager, Independent Safety Engineering Group
C. Harrington, Mechanical Equipment Engineering Supervisor
*S. Harrison, Manager, Unit 2 Project Engineering Manager
*T. Heatherly, Licensing Engineer
*T. Hope, Unit 2 Licensing Manager
J. Kelley, Plant Manager
D. Kross, Operations Manager, Unit 2
*F. Madden, Mechanical Engineering Manager
D. Moore, Manager, Operations Transition
*J. Muffet, Design Engineering Manager
*S. Palmer, Stipulation Manager
C. Rau, Project Manager, Unit 2
*J. Roberts, Unit 2 Deputy Project Engineering Manager
*B. Snellgrove, Operations Quality Control Mechanical Supervisor
*J. Snyder, Startup Manager
R. Spence, Construction Quality Control
*D. Stewart, Senior Engineer
*W. Taylor, Executive Vice President, Production
*C. Terry, Vice President
*R. Walker, Manager of Regulatory Affairs for Nuclear Engineering Organization
D. Webster, Manager, Construction
J. Wren, Construction Quality Assurance Manager

1.2 NRC Personnel

*S. Black, Director, Project Directorate IV-2, Office of Nuclear Reactor Regulation (NRR)
#*D. Graves, Senior Resident Inspector, Unit 2, Division of Reactor Projects (DRP)
*T. Gwynn, Deputy Director, DRP
R. Latta, Resident Inspector, Unit 2, DRP
*R. Schaaf, Project Engineer, Project Directorate IV-2, NRR
*G. Werner, Resident Inspector
*L. Yandell, Chief, Project Section B, DRP

1.3 Other Personnel

*R. Adams, News Reporter/Anchor, KCLW Radio
*O. Thero, Consultant, Citizens Association for Sound Energy

* Denotes those present at the exit interview conducted on December 7, 1992.
\# Denotes those present at the telephonic exit interview conducted on January 29, 1993.

2 EXIT MEETING

Exit meetings were conducted on December 7, 1992, and telephonically on January 29, 1993. During these meetings, the principal inspector summarized the scope and findings of the inspection. The licensee did not identify as proprietary any of the materials provided to or reviewed by the inspectors during the inspection.