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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
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SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
AUXILIARY FEEDWATER SYSTEM CHECK VALVES
SDAR CP-89-015 (FINAL REPORT FOR UNIT 1)
(INTERIM REPORT FOR UNIT 2)

Gentlemen:

On May 19, 1989, TU Electric verbally notified the NRC of a deficiency involving backleakage through Auxiliary Feedwater (AFW) System check valves supplied by BW/IP International, Inc. On June 19, 1989, an interim report was submitted via TXX-89424. On June 26, 1989, TU Electric verbally notified the NRC of a deficiency involving the manufacturing of BW/IP supplied check valve swing arms. On July 25, 1989, an interim report was submitted via TXX-89517. On October 26, 1989, TU Electric submitted a final report for the swing arm deficiency and a interim report for the backleakage events via TXX-89778 and stated that the scope of SDAR CP-89-015 would be expanded to include the swing arm deficiency described in SDAR CP-89-019. Additionally, TU Electric separately submitted a detailed report to the NRC concerning backleakage events on August 18, 1989, via TXX-89596, and responded to NRC questions on that report on October 14, 1989, via TXX-89744.

DESCRIPTION OF PROBLEM

Backflow Events

Events involving check valve backleakage occurred on April 5, April 19, April 23, and May 5, 1989. All events occurred during Hot Functional Testing of Unit 1. The April 23 and May 5 events involved backflow of high temperature water from the steam generators through the AFW System into the Condensate Storage Tank. Subsequent investigation of these two events revealed that three different mechanisms occurred simultaneously which created the backflow paths. First, isolation valves were operated in parallel instead of sequentially. Second, several check valves were mechanically hung open. Third, as designed, Feedwater Isolation Bypass Valves (FIBV) unseated when steam generator pressure downstream of the valves exceeded the upstream pressure by more than containment design pressure. Additionally, during the

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May 5 event, operators did not immediately identify a partially open isolation valve (1AF-055), which was thought to be closed. This delayed stopping the backflow. Backflow occurred for approximately fifteen to twenty minutes on April 23, and for approximately sixty-six minutes on May 5. These two events did not damage system piping or containment penetrations. However, two flow transmitters did require recalibration and one pipe support was damaged and subsequently replaced.

The events on April 5 and 19 did not involve backflow of high temperature water through the AFW system. However, these events did reveal failures of BW/IP check valves.

Swing Arm Deficiency

During operation of the Station Service Water System, screen wash pump flow fluctuations were noted. A radiograph of Unit 1 check valve 1SW-048 revealed that the disc had become disengaged from the assembly. Upon disassembly of the check valve, it was confirmed that the valve swing arm was broken. Separately, a casting flaw was identified on the inside diameter of the swing arm clevis to swing arm pivot pin hole for Unit 2 Containment Spray System check valve 2CT-0148 during a maintenance inspection.

ROOT CAUSE

Check Valve Backleakage

The check valves involved in the four backflow events are BW/IP pressure seal design. A total of fifty-six check valves of this design are installed in CPSES Unit 1 and 2. TU Electric determined through radiography that the valves involved in the April 5, April 23 and May 5 events hung open because of an elevation difference between the disc and seat which caused the disc to become wedged beneath the seat lip. This elevation difference was created during previous reassembly activities when mechanics bottomed the valve internals within the valve body as specified by incorrect reassembly instructions. This is viewed as the primary cause of valve failure. The valve involved in the April 19 event was not radiographed prior to disassembly. Therefore, it was not positively concluded that it was hung open at the time; however, its excessive leakage rate is indicative of a hung open condition.

TU Electric also determined that excessive disc axial play may have contributed to the excessive leakage. This condition also affects another model check valve supplied by BW/IP. This model uses a bolted bonnet versus a pressure seal design. One hundred and one BW/IP bolted bonnet valves are installed in CPSES Unit 1 and 2.

Following rework to address elevation and axial play issues, four BW/IP pressure seal check valves failed backflow test requirements due to rotational misalignment between the seat and disc. This condition is germane only to the pressure seal check valve model.

The above failure mechanisms were caused by incorrect or inadequate field reassembly instructions and/or unspecified acceptance criteria.

Two other problems were identified during the valve rework phase. First, a three inch bolted bonnet design check valve failed a local leak rate test. After internal inspection, it was determined that insufficient clearance existed between the perimeter of the disc and the lower side of the hinge pin boss. This condition prevented the check valve from seating. The root cause of this failure was determined to be an improperly profiled weld repair on the swing arm on the lower side of the hinge pin boss. This was substantiated by radiography, inspection of valve internals, and the valve's history of failed local leak rate tests. The three inch bolted bonnet design is the only design where the disc is close enough to the hinge pin boss that a weld build up could cause this type of failure.

Second, a four inch bolted bonnet check valve failed the prescribed backleakage test. A radiographic reinspection was used to determine that the disc was lodged under the seat. A review of the valve internals and new enhanced swing arm revealed that the new BW/IP swing arms allowed for more angular play than had been previously seen in the swing arm/disc assembly.

Feedwater Bypass Isolation Valve

The Feedwater Isolation Bypass valves unseated during the event because they are not required to remain seated at reverse differential pressures in excess of the containment design pressure of 50 psig. These valves normally isolate feedwater flow in the forward direction and provide for containment isolation, and are not intended to prevent the type of backflow observed during the April 23 and May 5 events.

1AF-055

During the May 5 event, 1AF-055 was not fully closed. This prolonged the backflow event. Initially, mechanical binding was believed to be the cause of not fully closing the valve. An NCR was written to inspect the valve's internal parts for evidence of damage. This inspection did identify some disc/seat pitting, but it is believed that this condition would not have caused binding.

Subsequently the reach rod assembly was reworked to correct a dislodged roll pin and replace a bracket bolt. It is believed that these conditions would not have caused reach rod binding. During a subsequent survey, the reach rod assembly worked properly and did not bind. Therefore, no definitive cause could be established as to why 1AF-055 was not fully closed on May 5.

Operator Error

The root cause of operator errors was discussed in our response to Notice of Violation 445/8924-V-01 via TXX-89430, dated June 26, 1989; TXX-89596, dated August 18, 1989; TXX-89744, dated October 14, 1989, and during the Public Meeting held on November 17, 1989. As stated in these responses and at the Public Meeting, the errors occurred because of a misunderstanding of administrative controls for sequential valve operation.

Swing Arm Deficiency

The failure of the swing arm in check valve 1SW-048 was initiated by surface defects formed during the casting process. The defects propagated between dentrites which were not broken up due to inadequate heat treatment. Residual stresses and poor material properties in combination with the corrosive environment of the Station Service Water System contributed to the failure as evidenced by corrosion on portions of the fracture surface. The flaw in check valve 2CT-0148 swing arm is attributed to inadequate casting.

SAFETY IMPLICATIONS

Backflow Events

The potential safety significance of the backflow events was evaluated by calculating the potential radiological effects of the hung open AFW check valves coincident with human error for normal operating conditions. The failure to fully close the pump test line isolation valve, 1AF-055, was included in this evaluation. A conservative dose evaluation was performed assuming that the volume of water that backflowed to the Condensate Storage Tank during both events contained the maximum technical specification allowable activity for steam generators and that this activity was released directly to the environment. The doses to the whole body and thyroid of an individual at the exclusion area boundary were estimated to be 5.57E-12 Rem and 3.03E-09 Rem, respectively. These are extremely low when compared with the dose of 0.5 Rem per calendar year to the whole body allowed per 10CFR20.105, "Permissible Levels of Radiation in Unrestricted Areas." Therefore, if the backflow events had occurred during operation of Unit 1, the radiation release would have been insignificant.

Evaluation of Unit 1 and Common BW/IP Check Valves

Unit 1 and Common Systems which use BW/IP check valves were evaluated to determine the safety significance of an actual or potential disc hang-up which could result in backflow. Eighty (80) BW/IP check valves are used in thirteen (13) systems which could affect the operation of CPSES Unit 1. Ten (10) systems use forty seven (47) BW/IP bolted bonnet check valves. Three systems utilize five (5) BW/IP bolted bonnet and twenty-eight (28) BW/IP pressure seal bonnet check valves.

The evaluation included all design basis events, including the single error of an operator. Credit was taken for ASME Section XI testing plans in place prior to the backflow events. The primary cause of disc hang-up was attributed to the unique pressure seal bonnet design coincident with incorrect reassembly instructions. Therefore, the bonnet design was also considered and documented in the evaluation. Ten (10) of the thirteen (13) systems do not include any BW/IP check valves with the pressure seal bonnet design.

It was concluded that undetected failure of seventy-two (72) of the valves due to disc hang up either is not credible or has no safety significance. However, eight (8) pressure seal valves in the AFW system required a more detailed evaluation to address safety significance. These valves were found hung open after the backflow events.

An evaluation of the effect of the hung open check valves on the accident analyses and containment analyses was performed. It was concluded that the AFW system would have been able to perform the required safety functions for the design basis accidents analyzed in FSAR Chapters 6 and 15.

An evaluation of the effect of the hung open check valves on the high energy line break analyses was also performed. It was concluded that environmental qualification envelopes for the motor driven auxiliary feedwater pumps and safety related ventilation could be exceeded in the event of an Auxiliary Feedwater line break outside containment. This event is only possible at low power levels or during hot standby due to procedurally specified system alignments during other plant conditions. However, in this case, operator action, in accordance with existing procedures, would be sufficient to maintain the plant in a safe condition. Details of the aforementioned safety evaluation are contained in Engineering Report ER-ME-043 which is available onsite for review.

It was concluded that, in the unlikely event of an AFW pipe break at low power levels, the BW/IP check valve condition could have adversely affected the safe operation of the plant. Therefore, this condition has been conservatively determined to be reportable pursuant to 10CFR50.55(e).

<u>Swing Arm Deficiency</u>

The failure of the swing arm in 1SW-048 is not safety significant since this valve serves no safety function. Results of inspections and metallurgical examinations indicate that other Unit 1 and Common BW/IP check valve swing arms had exhibited some of the adverse attributes that led to the failure of the swing arm in valve 1SW-048. However, engineering evaluation of the inspection and metallurgical results has determined that the attributes rejected by the inspection and examination criteria developed to ascertain the acceptability of the BW/IP check valve swing arms would not have caused, or resulted in, additional swing arm failures.

The safety significance of potential Unit 2 BW/IP check valve swing arm casting defects has not been specifically evaluated. This will be done prior to Unit 2 fuel load.

CORRECTIVE ACTIONS

Check Valves

As previously stated, various dimensions are critical within both BW/IP check valve designs including vertical alignment of the disc to seat, disc axial play, and rotational alignment of the disc to seat. The BW/IP technical manuals and maintenance procedures have been revised to include acceptance criteria and specific guidance to preclude vertical and rotational misalignment and excessive axial play. BW/IP check valves in Unit 1 and Common systems have been opened, inspected and/or modified to meet new acceptance criteria as applicable. The bolted bonnet valves were not inspected for vertical or rotational misalignment because their design assures proper alignment whereas the pressure seal design does not. However, the three inch bolted bonnet valves which may have unacceptable clearance between the disc perimeter and the lower side of the hinge pin boss were evaluated. These valves were evaluated in one of three ways: 1) The valve's testing history was reviewed; or, 2) A review of valve radiographs indicated that clearances were sufficient; or, 3) The weld was eliminated by replacing the swing arm. In addition, all four inch bolted bonnet valves that received enhanced swing arms were reinspected and modified to ensure a working valve. An NCR was written to evaluate and disposition any BW/IP disc/stud assemblies that are not in accordance with the latest BW/IP design. This NCR prevents use of these outdated parts in the field.

Most of the post-maintenance backflow testing for Unit 1 and Common BW/IP check valves has been completed. Thirteen valves have not yet been backflow tested in Unit 1 and Common. These tests will be performed prior to entry into Mode 2.

The condition of Unit 2 BW/IP bolted bonnet and pressure seal check valves will be evaluated, dispositioned and corrected, as necessary, prior to Unit 2 fuel load.

Piping and Support Evaluation

During the April 23 and May 5 events, hot water flowed back from various steam generators through the AFW system piping. The temperatures experienced in various sections of the piping exceeded design temperatures and some stress allowables were exceeded. Several actions were taken to investigate the potential piping and support damage. First, design engineering personnel performed walkdowns of affected areas to identify any obvious damage. No obvious piping damage was found after either event. However, one damaged support was identified. Second, Calculation 16345-ME-(S)-079 was performed to determine the effect of the thermal transients due to the backleakage events. The results of this calculation were forwarded to the Engineering Mechanics Group for piping and support analysis.

The results of the pipe stress analysis identified locations which did not satisfy ASME III NC/ND-3600 requirements. The affected section of piping is in the vicinity of strut, AF-1-096-023-S33R, which was found bent due to stresses induced by the reverse flow event. Nondestructive Testing (NDT) was performed on the piping at locations where stresses exceeded the established acceptance criteria. NDT revealed that no plastic deformation of piping resulted in damage and minimum pipe wall thickness was maintained.

The evaluation of pipe supports concluded that the reverse flow events had not affected the capability of pipe or supports to perform their design safety function, except for the one support which was bent and subsequently replaced.

Containment Penetrations

Once the April 23 and May 5 events had been terminated and the AFW pumps were feeding the steam generators, the hot water in the AFW system was flushed through the feedwater preheater bypass containment (cold) penetration. A conservative analysis was performed for the structural impact on the preheater bypass feedwater containment penetrations assuming the penetrations experienced a temperature of 550° F. The analysis indicated the possibility of concrete spalling and crushing at the outside face of the concrete wall.

Visual observation of the outside concrete face found no evidence of the predicted concrete distress. The visual observation did find cracks radiating out from the penetrations which are associated with normal concrete shrinkage and those which developed within acceptable limits during the structural acceptance test.

Based on the field observations and the short time at temperature, it was concluded that the penetrations were not adversely impacted by the pressures, temperatures, and loads associated with the events. Therefore, no hardware actions need to be taken.

1AF-055 Evaluation

An NCR was initiated to inspect 1AF-055 valve internals. The inspection revealed no damage which would cause valve binding. In addition, the valve's reach rod assembly was checked and found to operate satisfactory. Therefore, no hardware corrective actions need to be taken.

Instrument Evaluation

An NCR was initiated to determine whether four flow transmitters had lost calibration due to the effects of high temperature. During calibration, the "as found" data for two flow transmitters was unsatisfactory. The two transmitters were successfully recalibrated.

Feedwater Isolation Bypass Valve (FIBV) Evaluation

Valve leakage testing was performed on the four FIBV's. Testing results showed that the FIBV's would have isolated against design containment pressure as required, but did not seat against the higher steam generator pressure experienced during the events. Engineering and Operations have reviewed the adequacy of the FIBV's as designed and installed. While these valves will perform their containment isolation function, administrative controls have been added to procedurally require that the FIBV's be isolated when the main feedwater pumps are not supplying flow during normal startup and shutdown. Additionally, a review was conducted to determine whether similar valves exist in other safety-related systems and whether additional protection should be provided by requiring associated isolation valves to remain closed during particular plant conditions. No other valves were identified where additional protection was necessary. These corrective actions will be applied to applicable Unit 2 valves prior to Unit 2 fuel load.

Operator Errors

Corrective actions for operator errors were discussed in our Response to Notice of Violation 445/8924-V-01 via TXX-89430, dated June 26, 1989; TXX-89596, dated August 18, 1989 and during the Public Meeting held on November 17, 1989. These letters and the meeting identified a number of actions focused on procedural compliance.

Swing Arm Deficiency

Unit 1 and Common BW/IP check valve swing arms were examined by nondestructive examination (NDE) methods including visual testing, penetrant testing and replication[1]. Swing arms which failed to meet the acceptance criteria of these examinations were removed from service and replaced with either a swing arm that was examined and found acceptable or with a new investment type cast swing arm. TU Electric representatives from Quality Assurance and Engineering were present at the manufacturing facilities to observe the casting and machining of the replacement swing arms and confirm compliance with the purchase order.

Engineering analysis of the material properties of the swing arms which failed NDE established that the swing arms are suitable for use.

Unit 2 BW/IP check valve swing arms will be examined and reworked or replaced, as appropriate, prior to Unit 2 fuel load.

[1]Replication is a process by which a surface is polished and an acetate tape is applied, peeled off and microscopically examined. This provides a topological examination in which hot cracks can be detected.

OTHER LESSONS LEARNED, CORRECTIVE ACTIONS AND IMPROVEMENTS

As a result of TU Electric's evaluation of these events, we have also identified other lessons learned, corrective actions and improvements. These were discussed in TXX-89596, dated August 18, 1989, and during the Public Meeting on November 17, 1989.

OTHER ACTIONS IN PROGRESS

Kalsi Engineering Report

Prior to the backflow events of April 5, 19, 23 and May 5, 1989, TU Electric had initiated a review by Kalsi Engineering, Inc., for check valve applications. In TXX-89744. TU Electric committed to enclose the report by Kalsi Engineering Inc. which discusses the review of CPSES check valves as recommended by INPO SCER-8603. "Check Valve Failures or Degradation," Kalsi's engineering review was also discussed during the Public Meeting held on November 17, 1989. The enclosure contains the Executive Summary, Introduction, Body, Analysis Results, Conclusions, and Recommendations. Due to size, the appendices (A & B), the analysis sheets, and the data sheets of the Kalsi Report are not included in the enclosure. As discussed with the site NRC staff, the total report is available on site for review.

Sincerely,

William J. Cahill, Jr.

TLH/daj
Enclosure

c - Mr. R. D. Martin, Region IV
Resident Inspectors, CPSES (3)