

AEOD ENGINEERING EVALUATION REPORT*

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EVALUATOR/CONTACT: E. Trager

UNIT:	Sequoyah 2	DATE:	01/12/82
DOCKET NO.:	50-328	NSSS/AE:	West/TVA
LICENSEE:	Tennessee Valley Authority		
UNIT:	Salem 1	DATE:	08/11/83
DOCKET NO.:	50-272	NSSS/AE:	West/PSE&G
LICENSEE:	Public Service Electric & Gas		
UNIT:	Salem 2	DATE:	10/05/83
DOCKET NO.:	50-311	NSSS/AE:	West/PSE&G
LICENSEE:	Public Service Electric & Gas		
UNIT:	San Onofre 3	DATE:	10/31/83
DOCKET NO.:	50-362	NSSS/AE:	CE/Bechtel
LICENSEE:	Southern California Edison Co.		
UNIT:	Ginna	DATE:	12/28/83
DOCKET NO.:	50-244	NSSS/AE:	West/Gilbert
LICENSEE:	Rochester Gas & Electric Corp.		

SUBJECT: EVENTS INVOLVING UNDETECTED UNAVAILABILITY OF THE
TURBINE DRIVEN AFW TRAIN

SUMMARY

In five recent events at operating reactors (1982-1983), the turbine-driven auxiliary feedwater (AFW) pumps were unavailable because the steam supply was isolated, although this condition did not cause an alarm or other indication in the control room. The condition was noted either during routine inspections or as the result of an investigation of failure of the turbine driven AFW pump to respond to an EFAS. A review was undertaken to evaluate the human factors aspects of these events. The review found that the licensees involved had taken actions intended to avoid this type of event, but unanticipated factors combined to make the actions insufficient in preventing them. The events were found to have minor safety significance because (1) in all cases the motor driven AFW pumps were operable and available, and (2) the LCO time period was generally not exceeded. The corrective actions taken by the licensees subsequent to the events appear adequate to prevent recurrence of the events at the licensee facilities. However, because events involving undetected unavailability of the turbine-driven AFW train could be significant at other plants or under other circumstances, it is concluded that perhaps an Information Notice should be issued to publicize the most recent events.

*This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

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INTRODUCTION

LER 50-272/83-84 described an event at Salem 1 in which the turbine-driven auxiliary feedwater (AFW) pump was not available on demand because the trip and throttle (T&T) valve was in the tripped position, and this condition was not indicated in the control room. Following receipt of LER 50-362/83-99, which described a similar event that recently occurred at San Onofre 3, a review was begun to determine whether this was a generic problem. During the review, three other similar recent events (1982 and 1983) were identified that occurred at Sequoyah 2, Salem 2 and at Ginna. The Resident Inspectors at the involved sites were contacted to obtain additional information on the events, when possible.

DISCUSSION

All of the five events involved inoperability of the turbine driven AFW pump because the turbine was isolated from the steam supply. Table 1 summarizes information on the events and Appendix A contains more detailed descriptions of the events.

On January 12, 1982, the turbine-driven auxiliary feedwater pump at Sequoyah 2 failed to start on a safety injection actuation. Investigation revealed the electronic overspeed trip latch function to the stop valve had not been relatched following an earlier overspeed trip, therefore, the valve would not open when actuated by operations personnel. The valve is normally relatched from the control room, but the operator had apparently not held the valve hand switch for the necessary 10 seconds and there was no indication in the control room that the valve had been reset. In August 1982, an industry study was published concerning this and three earlier (1980) events of this type. Apparent preventive actions were called for in the areas of design (install control room indication of failure to relatch and/or install clear local indication of the status of the mechanism); operations (if there is no positive control room indication that the valve is relatched, have an auxiliary operator verify and document the relatched condition); and training (train licensed and nonlicensed operators in proper remote and local verification of valve reset).

On August 11, 1983, Salem 1 found the turbine-driven AFW pump T&T valve tripped. It had been inadvertently tripped on August 3, 1983, during maintenance and testing. The tripped condition was not indicated because the valve position limit switch was out of adjustment. The licensee initiated a change request to have positive indication of the "latched" condition and began to have the valve position visually checked on a daily basis. Apparent corrective actions included (1) regular adjustment and testing of limit switches, and (2) local verification after resetting trip valves. Note that Salem 1 had control room indication of a tripped condition but not of a "latched" condition.

On October 5, 1983, the control room operator at Salem 2 observed the trip indicator for the No. 23 AFW pump was illuminated. Investigation found the valve had not been reset following routine surveillance that had been performed one hour earlier. Local valve position indication was installed to improve operator performance. The licensee is planning to install control room indication of the "latched" condition.

On October 31, 1983, at San Onofre 3, the turbine-driven AFW pump failed to start on demand. The pump turbine steam admission valve was found to be in the tripped condition. The licensee is conducting a program to evaluate the cause of the tripped condition. Pending completion of the program, local visual verification will be made once per shift to see that the valve is not tripped.

On December 28, 1983, at Ginna, the AFW pump turbine steam stop valve was found in the tripped condition, although this condition was not indicated in the control room. The valve had been tripped by a contractor employee. This was not noticed because insulation debris in the valve linkages prevented actuation of the limit switch. This problem was corrected by cleaning and lubricating the external valve linkages.

A Resident Inspector at Sequoyah was contacted on May 17, 1984, concerning the Sequoyah 2 event and actions that have been taken to prevent recurrence. He indicated the licensee has done the following:

1. Installed an engraved plate near the remote (control room) valve reset hand switch that includes the reminder to "hold for 10 seconds."
2. Revised procedures to require local visual verification of relatching after a trip.
3. Installed a large, paint-on-plexiglas sign near the valve that includes an illustration of the valve and detailed relatching instructions.
4. Designated the T&T valve as critical and included it on the valve checklist that is completed as part of shift turnover. That is, an auxiliary operator checks and documents the valve is reset once per shift.

The licensee did not install positive control room indication of the valve reset condition. However, the other corrective actions appear to be adequate. Furthermore, it is the opinion of some that the control room may already have too many indicators.

FINDINGS

1. Following the Sequoyah 2 event four additional events occurred during the 1982-1983 time period primarily because of unanticipated factors. Specifically:
 - Salem 1 - Valve not properly reset nor verified, and limit switch out of adjustment.
 - Salem 2 - Valve not properly reset nor verified, and unclear local indication of valve status.
 - San Onofre 3 - Intermittent instrument failures, and ability to reset overspeed trip while failing to reset valve.
 - Ginna - Insulation debris in valve linkage resulted in failure to actuate limit switch, and contractor worker tripped valve.
2. Although overall AFW system availability was not a significant safety problem in these events, lack of correct indication of AFW system availability might be significant at other plants or under other circumstances.

In three of the cases, maintenance appears to be a significant contributing factor. Three of the events (the Sequoyah and Salem 1 and 2 events) are examples of failure to return safety systems to service in operable condition including the failure to verify.

CONCLUSIONS

In the events that occurred subsequent to the Sequoyah 2 event, the electric motor driven AFW pumps remained operable. However, because such events (involving undetected unavailability of the turbine-driven AFW train) might be significant at other plants or under other circumstances, some further action should be taken to publicize these recent events. An Information Notice might be the appropriate vehicle. Because the motor-driven AFW pumps were always available and because the LCO time limits were generally not exceeded during these events, these events do not indicate any significant safety problem.

TABLE 1

STEAM DRIVEN AFW PUMP UNAVAILABILITY EVENTS

Name	How Detected	LCO Permits Pump Unavailability	Time out of Service	Cause and Contributing Factors	Verification
Sequoyah 2 10/12/82	Pump failed to start following a SIAs	3 days (72 hours)	Unknown	CR operator did not correctly operate remote reset mechanism and there was no control room indication of this.	No
Sequoyah 1 10/11/83	Turbine driven pump failed to start following activation signal	3 days	8 days	1) Operator depressed "trip" rather than "stop" push-button when removing the pump from service. 2) Valve not properly relatched following maintenance & testing. 3) Limit switch out of adjustment.	No
Sequoyah 2 10/5/83	Operator noted indicator light in control room	3 days	16 hours	Valve not properly relatched following routine surveillance testing one hour earlier.	No
Sequoyah 3 10/31/83	Pump failed to start following EFAS	3 days	25 hours	Apparent intermittent instrument failure (inadequate indication of the latched condition).	No (Not Applicable Apparent Instrument Failure)
Sequoyah 12/28/83	Operator observed the tripped condition during a routine walk through.	7 days	12 hours	1) Valve was tripped by contractor worker in the area. 2) Valve movement was apparently restricted because of insulation debris and did not activate limit switch.	No (Not Applicable Tripped by Contractor Worker)

APPENDIX A

TURBINE DRIVEN AFW SYSTEM UNAVAILABILITY EVENTS

Sequoyah 2

Docket No.: 50-328

Event Date: 01/12/82

(Ref: LER #82-002 dated 02/05/82)

The turbine-driven auxiliary feedwater pump failed to start on a safety injection actuation and was declared inoperable. Investigation revealed the electronic overspeed trip latch function to the stop valve had not been reset. Therefore, the valve remained closed and blocked steam flow to the pump. There was no visual indication in the control room to give verification that the latch was reset. The reset latch is normally actuated by the operator by holding the valve hand switch at least 10 seconds to make sure the latch mechanism is actuated. Unit 2 was equipped with an automatic reset latch capability but this had been disconnected since 03/29/81 to enable steam flow for warming purposes during preop testing. The Unit 2 control board had a "flag" beside the switch to tell the operator to hold for 10 seconds. However, the operator must not have held the switch long enough to activate the latch. The investigation concluded that the root cause for the event was a design deficiency in the lack of control room indication.

LER #82-002 stated that procedures would be revised to require local visual inspection to verify actual relatching of the mechanism and that the licensee would study the feasibility of installing a visual indicator in the control room to indicate that the motor operator is latched. An August 1982 industry study refers to LER 82-002 and three other LERs that described four events in which the throttle and trip (T&T) valves were thought to have been reset and ready to operate when in fact they were in the tripped position. The study recommended design, operations and training changes to prevent recurrence.

Salem 1

Docket No.: 50-272

Event Date: 08/11/83

(Ref: LER #83-34 dated 8/22/83)

The turbine driven auxiliary feedwater (AFW) pump failed to start following a low-low steam generator level signal because the pump turbine trip valve was in the tripped position. Although it could not be substantiated, the valve had apparently been tripped and left in that position following

maintenance and testing activities on August 3, 1983. It appeared that when the pump was removed from service, the control room "trip" pushbutton was inadvertently depressed instead of the "stop" pushbutton, resulting in activation of the trip valve. In addition, the valve trip position limit switch was out of adjustment causing the "trip" indication in the control room to be inoperable. A design change request was initiated to provide a positive control room indication of a trip valve "latched" condition. Until this change is complete, the trip valve will be verified to be in the latched position by daily observation (change was not completed as of 5/9/84).

This AFW unavailability was also described in an October 1983 industry study that concerned trips and loss of cooling water events due to fouling of traveling screens. Indicated corrective actions included: (1) regular adjustment and testing of the limit switches to ensure operability (where limit switches are used to provide the control room with the status of trip valves), and (2) local verification of position after resetting the trip valve.

Salem 2

Docket No.: 50-311

Event Date: 10/05/83

(Ref: LER #83-056 dated 11/03/83)

At approximately 1800 hours, October 5, 1983, during routine power operation (100%), the Control Room Operator noticed that the trip indication light for No. 23 Auxiliary Feedwater Pump (steam driven pump) was illuminated. Subsequent investigation revealed that the valve was in the tripped position, and had apparently been left in that position following completion of routine pump surveillance testing at 1700 hours, October 5, 1983. When the problem was identified, the No. 23 Auxiliary Feedwater Pump trip valve was latched. Technical Specification 3.7.1.2a was entered retroactive to the time of the occurrence. The pump was declared operable at 0900 hours, October 6, 1983, and Action Statement 3.7.1.2a was terminated. The redundant electrical driven pumps were operable throughout the occurrence, and the pump was restored to operability within the time period specified in the action requirements.

Investigation of the incident revealed that the operator who relatched the pump trip valve at the time of the previous surveillance had turned the valve handwheel to set the valve linkage but had not completed the latching operation by turning the handwheel back to the starting position. This resulted in the valve remaining in the tripped position. No local mechanical position indication existed on the valve, thus detailed knowledge of the valve operating linkage was required to insure that the valve was in the proper position.

The operator involved in the incident was counseled concerning proper operation of the trip valve. To improve operator performance, local mechanical valve position indication was installed, and plasticoid tags were attached to the valve providing instructions for valve operation. Finally, on-shift training in operation of the trip valve was conducted for all personnel who were required to operate the valve.

San Onofre 3

Docket No.: 50-362

Event Date: 10/31/83

(Ref: LER #83-099 dated 11/22/83)

On October 31, 1983, at 1925 hours, Unit 3 was manually tripped from 62% reactor power in response to a loss of main feedwater. An Emergency Feedwater Actuation Signal (EFAS) was received when the unit was tripped, however, the Steam Driven Auxiliary Feedwater Pump 3P-140 failed to start. Both electric driven Auxiliary Feedwater Pumps started and remained operable during this event. The operator investigated the failure of pump 3P-140, found the pump turbine in a tripped condition and manually reset the pump turbine's steam admission valve. The pump started at about 1936.

The pump had previously been satisfactorily tested on October 30, 1983, at 1820. Although Control Room instrumentation was available to signal when the pump turbine tripped on turbine overspeed, troubleshooting of the instrumentation subsequent to the plant trip on October 31, 1983, indicated that there were intermittent failures of the instrumentation to signal when the pump turbine was tripped. These intermittent failures were investigated. The cause of the pump trip was unknown. An engineering program to evaluate the cause of the tripped condition of the pump has been conducted. Pending completion of the program, visual verification that the 3P-140 overspeed trip mechanism is not in the tripped position will be required by procedure once per shift and completion of this verification is on a check-off list.

The San Onofre AFW pump turbine steam admission valve is normally closed and opens when a EFAS signal is received. When the AFW pump turbine trips on overspeed, the condition is alarmed in the control room. However, it is possible to relatch the trip mechanism in such a way that the overspeed trip is reset but the valve is not and the condition is not indicated in the control room.

Because San Onofre has no PORVs, the AFW system is more important. In fact, the licensee is required by license condition to submit a special monthly report specifically on the AFW system. However, the current situation is considered acceptable because:

- (1) Technical Specifications permit the steam driven AFW pump to be out of service for up to 72 hours, and local visual verification that the turbine is not tripped is being performed once per shift. The licensee indicated (on 5/15/84) that the evaluation program is continuing and changes are being made to remove causes of tripping. The number of incidents (of valves being in the tripped position) has been very low.
- (2) The plant has two 100% capacity motor-driven AFW pumps.

Girna

Docket No.: 50-244

Event Date: 12/28/83

(Ref: NRC Op Center Record for 12/28/83)

With the reactor at 100% power, the plant entered a 7-day LCO Action Statement when it was discovered that the turbine driven Auxiliary Feedwater Pump was inoperable. The cause was that the throttle on the pump had been tripped. The licensee felt that a contract person working in the area of the pump bumped the lever into the tripped position earlier in the day. The limit switch did not make contact resulting in no control room indication of the pump being tripped. The valve was reset.

Although an LER was not required for this incident, the licensee sent a letter concerning it to Region I on January 27, 1984. The letter and further discussion with the licensee indicated the following:

- . There was good local valve position indication (that is how the condition was discovered).
- . There was control room indication for an open/latched condition (red light) or closed (green light) condition.
- . The problem was that the tripped condition of the valve was not indicated in the control room, i.e., the valve was tripped but the red light in the control room indicated a "latched" condition (open). The licensee investigation found that the valve operated sluggishly because of insulation debris in the external valve linkages and that the valve limit switch had not been activated because of the limited valve stroke. Note that although there are two lights there is only one limit switch, i.e., there is no redundancy. The red light remains on while the valve is closing until it is almost fully closed. When the valve is fully closed the green light comes on and the red light goes out. Also note the valve is designed to shut with steam flow and steam was not present. The licensee cleaned and lubricated the external valve linkages and tested the valve trip and trip indicators.

The licensee felt the valve had been unintentionally tripped by insulation workers working in scaffolding above the trip lever. To avoid this problem in the future the licensee improved housekeeping, issued a warning to personnel working in the area, and installed a warning sign near the trip lever. The licensee evaluated whether the frequency for preventive maintenance on the valve (including lubrication) should be increased from annually to quarterly, but later determined the other corrective actions should prevent recurrence.