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SUBJECT: LER 91-008-00:on 911114,lighting induced electrical fault on A phase main transformer caused generator trip,turbine trip & reactor power cutback.Caused by problem w/calculator software.Evaluated lightning protection sys.W/911213 ltr.

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NOTES:Standardized plant. 05000530

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JAMES M. LEVINE
VICE PRESIDENT
NUCLEAR PRODUCTION

192-00762-JML/TRB/RKR
December 13, 1991

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Mail Station P1-37
Washington, D.C. 20555

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 3
Docket No. STN 50-530 (License No. NPF-74)
Licensee Event Report 91-008-00
File: 91-020-404

Attached please find Licensee Event Report (LER) 91-008-00 prepared and submitted pursuant to 10CFR50.73. In accordance with 10CFR50.73(d), a copy of this LER is being forwarded to the Regional Administrator, NRC Region V.

If you have any questions, please contact T. R. Bradish, Compliance Manager, at (602) 393-2521.

Very truly yours,

James M Levine

JML/TRB/RKR/nk

Attachment

cc: W. F. Conway (all with attachment)
J. B. Martin
D. H. Coe
INPO Records Center

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LICENSEE EVENT REPORT (LER)

FACILITY NAME	DOCKET NUMBER	PAGE
Palo Verde Unit 3	0 5 0 0 0 5 3 0	1 OF 0 8

TITLE: Reactor Trip Due to Lightning Induced Electrical Fault

EVENT DATE			LER NUMBER			REPORT DATE			OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
1 1	1 4	9 1	9 1	0 0 8	0 0	1 2	1 3	9 1	N/A	0 5 0 0 0
									N/A	0 5 0 0 0

OPERATING MODE	1
POWER LEVEL	1 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check one or more of the following)*

[ ] 20.402(b)	[ ] 20.405(c)	[X] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[ ] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[ ] OTHER *(Specify in Abstract below and in Text)*
[ ] 20.405(a)(1)(iii)	[ ] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[ ] 50.73(a)(2)(ii)	[ ] 50.73(a)(2)(viii)(B)	
[ ] 20.405(a)(1)(v)	[ ] 50.73(a)(2)(iii)	[ ] 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER

NAME	TELEPHONE NUMBER	
	AREA CODE	
Thomas R. Bradish, Compliance Manager	6 0 2	3 9 3 - 2 5 2 1

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
C	E L	C O N	W 1 2 0	Y					

SUPPLEMENTAL REPORT EXPECTED		EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR
[ ] YES *(If yes, complete EXPECTED SUBMISSION DATE)*	[X] NO				

ABSTRACT *(Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines)*

At approximately 1449 MST on November 14, 1991, Palo Verde Unit 3 was in Mode 1 (POWER OPERATION) at approximately 100 percent power when a lightning induced electrical fault on the A phase main transformer caused a generator trip, turbine trip, and reactor power cutback (RPCB). Approximately 35 seconds following these events, the reactor tripped on low Departure from Nucleate Boiling Ratio (DNBR) signals. The plant was stabilized in Mode 3 (HOT STANDBY) at normal operating temperature and pressure. The Control Room shift supervisor classified the event as an uncomplicated reactor trip in accordance with the emergency plan implementing procedure. No other safety system responses occurred and none were required. The post trip review found that the low DNBR reactor trip was due to a control element assembly (CEA) subgroup deviation. During the post trip investigation, APS engineering discovered that a problem with the control element assembly calculator (CEAC) software design may have delayed the reactor trip for up to 16 seconds when a second CPC time delay was initiated. At the time of the second time delay, one CEA subgroup was thought to be misaligned greater than the allowed limit in the CPCs.

The cause of the second time delay was that the CEAC software design did not anticipate that there would be CEA slips lasting less than 0.5 seconds.

There have been no previous similar events reported pursuant to 10CFR50.73.

I. DESCRIPTION OF WHAT OCCURRED:

A. Initial Conditions:

At approximately 1449 MST on November 14, 1991, Palo Verde Unit 3 was in Mode 1 (POWER OPERATION) at approximately 100 percent power.

B. Reportable Event Description (Including Dates and Approximate Times of Major Occurrences):

Event Classification: An event that resulted in automatic actuation of the Reactor Protection System (RPS)(JC).

At approximately 1449 MST, on November 14, 1991, Palo Verde Unit 3 was operating at approximately 100 percent power and a severe thunderstorm was in progress in the local area, when a lightning induced electrical fault on the high voltage bushing (CON)(EL) of the A phase main transformer (XFMR)(EL) caused a generator (GEN)(TB) trip and subsequent turbine (TRB)(TA) trip. In response to this large load rejection, the selected, in-service steam bypass control valves (SBCV)(PCV)(SB) quick opened and a reactor power cutback (RPCB) (JD) occurred per design. The RPCB dropped control element assembly (CEA)(ROD)(AA) Regulating Group 5 into the core reducing reactor power to approximately 70 percent. Concurrently, CEA Regulating Group 4 was automatically inserted into the core to further reduce reactor power and control reactor coolant system (RCS)(AB) temperature. Approximately 22 seconds after the electrical fault, a Control Room operator (utility, licensed) took manual control of CEA Regulating Group 4. Approximately 35 seconds after the electrical fault, the core protection calculators (CPC)(JC) sensed a CEA subgroup deviation, applied the appropriate penalty to the DNBR calculations and determined that the calculated DNBR was below the low DNBR limit. The reactor protection system (RPS)(JC) then initiated a reactor (RCT)(AC) trip on low DNBR. The plant was stabilized in Mode 3 (HOT STANDBY) at normal operating temperature and pressure. The Control Room shift supervisor (utility, licensed) classified the event as an uncomplicated reactor trip in accordance with the emergency plan implementing procedure. No other safety system responses occurred and none were required.

C. Status of structures, systems, or components that were inoperable at the start of the event that contributed to the event:

Not applicable - no structures, systems, or components were inoperable at the start of the event which contributed to this event.

Prior to this event, one of the control element assembly calculators (CEAC)(JC) was declared inoperable when it would not reset and troubleshooting was in progress. Channel A Core Protection Calculator (CPC)(JC) was inoperable due to receipt of spurious trips and pretrips and had been placed in trip. Channel B CPC had been placed in bypass for monthly surveillance testing. A review of these conditions determined that they did not contribute to this event.

D. Cause of each component or system failure, if known:

The A phase Main Transformer bushing failed when a lightning induced electrical potential increase caused the bushing to flashover to ground (i.e., the top of the bushing was grounded to the outside of the transformer). No other component or system failures were involved.

E. Failure mode, mechanism, and effect of each failed component, if known:

The lightning induced transformer bushing failure occurred when the bushing flashed over to ground. This resulted in an electrical fault on the A phase main transformer causing a main generator protective trip and subsequent turbine trip. The loss of load resulted in the selected, in-service steam bypass control valves quick opening and a reactor power cutback per design as described in Section I.B.

F. For failures of components with multiple functions, list of systems or secondary functions that were also affected:

Not applicable - no failures of components with multiple functions were involved.

G. For a failure that rendered a train of a safety system inoperable, estimated time elapsed from the discovery of the failure until the train was returned to service:

Not applicable - no failures that rendered a train of a safety system inoperable were involved.

H. Method of discovery of each component or system failure or procedural error:

The lightning induced transformer bushing failure was discovered during inspection and troubleshooting after this event. There were no other component or system failures, or procedural errors which contributed to this event.

I. Cause of Event:

The control element assembly calculators (CEAC) and core protection calculators (CPC) are part of the reactor protection system. The CEACs monitor the position of all control element assemblies (CEA). Each CEAC provides an input into each CPC channel. There are four (4) CPC channels. Each CPC channel monitors the CEA position in one (1) quadrant of the core. The CPCs use CEA position information as an input to determine the core radial peaking distribution and the core minimum DNBR. Each CPC channel also uses the CEA configuration information as an input to determine if the current core CEA configuration is permitted. The CPCs will impose a large penalty factor on the radial peaking distribution in the event of:

1) A subgroup deviation where the position of one of the subgroups deviates from the group position by more than 9.9 inches.

2) An out of sequence configuration involving a regulating group being inserted out of sequence (e.g., group 4 CEAs being below group 5).

The penalty factors for subgroup deviations are typically large because they are based on the most limiting subgroup deviation (drop of a complete subgroup from a fully withdrawn condition). In the event of a subgroup deviation, the large penalty factors generally result in the CPCs conservatively calculating a DNBR that is less than the low DNBR setpoint. If two (2) or more of the four (4) CPC channels calculate a DNBR that is less than the low DNBR setpoint, a reactor trip will occur.

When a reactor power cutback (RPCB) occurs the designated RPCB CEA groups are automatically dropped into the core. The designated RPCB CEA groups are Regulating Groups 4 and 5. Regulating Group 4 consists of subgroups 5 and 22. The CEACs initially assume a RPCB is in progress when any of the designated RPCB CEAs appear to be dropping into the core. When the CEACs sense that a potential RPCB is underway, a RPCB signal is sent to the CPCs. This signal causes the CPCs to not use the position information for CEA Regulatory Groups 4 and 5 for a short time (approximately 16 seconds) for the purpose of updating the radial peaking factor, or determining if a subgroup deviation or out of sequence CEA configuration exists. The time delay is required during a RPCB since the concurrent drop of both RPCB CEA groups could result in a subgroup deviation during CEA free fall and an unnecessary reactor trip. During a RPCB all other CPC calculations are functional (except those based directly on CEA Regulatory Groups 4 and 5 position) and would cause a reactor trip if a condition

occurred (other than a CEA deviation in Regulatory Groups 4 and 5) which required protective action.

If any of the CEAs in the designated RPCB groups fall into the core at a rate consistent with a free falling CEA, the CEACs determine that there is a potential RPCB and initiate the time delay in the CPCs. The CEACs are designed to wait 0.5 seconds after any of the RPCB CEAs are determined to be dropping into the core before performing additional checks to ensure that all CEAs in the group are also free falling. In this way, the CEACs can distinguish between the drop of a single CEA and the drop of an entire CEA group. During a RPCB, the 0.5 second delay allows for all CEAs in the RPCB group(s) to start moving before the validity of the assumed RPCB is evaluated. This is necessary since there is a finite amount of time required before all CEAs in a group will begin falling when the drop of a group is initiated. After the 0.5 second delay, if only part of the CEA group is moving then the time delay is reset to 0.0 seconds. However if no CEA movement is detected, the 16 second time delay will remain in effect. Therefore, if any of the CEAs in Regulating Groups 4 or 5 are detected to be dropping into the core and after 0.5 seconds only part of the group is dropping, the CEACs will determine that this condition is not a valid RPCB and the CPC time delay will be reset to 0.0 seconds. Conversely, if a slip of a valid RPCB CEA or subgroup were to occur for less than 0.5 seconds, then the CEACs would not reset the CPC time delay. If the CEACs detect movement of a CEA not assigned to a RPCB CEA group, it resets the time delay to 0.0 seconds. The CEAC software design did not anticipate that there would be CEA slips lasting less than 0.5 seconds.

During this event, the CEACs correctly determined that a RPCB was underway when Regulating Group 5 dropped into the core following the turbine trip. After 16 seconds the CPC time delay was reset to 0.0 seconds as designed. However it is postulated that a few seconds after the CPC time delay reset, one of the subgroups in Regulating Group 4 slipped approximately 11 inches. Therefore the CEAC assumed that a second RPCB was underway since a Regulating Group 4 CEA was dropping. A second CPC time delay was then initiated. During the first 0.5 second period, the CEAC continued to monitor the CEA positions and determined that there was no longer any RPCB related CEA movement. Therefore, the 16 second time delay remained in effect. Approximately sixteen seconds later (approximately 35 seconds after the initial RPCB), the CPC time delay was reset to 0.0. The CPCs sensed the subgroup deviation and applied the required penalty factors to the DNBR calculation. The CPCs conservatively calculated a DNBR less than the DNBR setpoint and initiated a reactor protection system trip.

The reactor trip described in Section I.B was caused by a low DNBR reactor protection system trip. The post trip review determined that the CPC calculated low DNBR was due to a CEA subgroup slipping and deviating approximately 11 inches from its CEA group. The cause of the CEA subgroup slipping could not be determined (SALP Cause Code X: Other). Extensive investigation and troubleshooting could not identify the cause of the CEA subgroup slip. The reactor trip would have been expected after the RPCB due to the CEA subgroup deviation.

The cause of the second time delay was that the CEAC software design did not anticipate that there would be CEA slips lasting less than 0.5 seconds (SALP Cause Code B: Design, Manufacturing, Installation Error). A review of the CEAC software by APS engineering and ABB Combustion Engineering (CE) verified that this scenario would produce the results the plant experienced. APS engineering recreated this event by simulating this event in one (1) CEAC and one (1) CPC channel in Unit 3. CE also verified these results on their development system.

There were no procedural errors which contributed to this event. There were no personnel errors which contributed to this event.

J. Safety System Response:

Other than the reactor protection system actuation described in Section I.B, there were no other safety system responses and none were necessary.

K. Failed Component Information:

The failed transformer bushing was manufactured by Westinghouse and part number 233D503G02.

II. ASSESSMENT OF THE SAFETY CONSEQUENCES AND IMPLICATIONS OF THIS EVENT:

The steam bypass control system (SBCS)(JI) controls the positioning of the SBCVs, through which steam is bypassed around the turbine into the condenser (SG). The SBCS is designed to increase plant availability by making full use of SBCV capacity to remove excess RCS thermal energy following turbine load rejections. This avoids unnecessary reactor trips and prevents the opening of pressurizer safety valves (PSV)(RV)(AB) or main steam safety valves (MSSV)(RV)(SB).

The RPCB system works in conjunction with the SBCS to avoid unnecessary reactor trips and prevent the opening of PSVs or MSSVs. The RPCB system allows for rapid reduction in reactor power at a rate faster than the normal CEA insertion. When the RPCB system senses a large load

rejection it provides a step reduction in reactor power. The step reduction in reactor power is accomplished by dropping one or more preselected CEA regulating groups into the core. Technical Specification (TS) 3.1.3.6 allows the insertion limits and the withdrawal sequence to be exceeded for up to two (2) hours following a RPCB.

The 16 second time delay imposed when a RPCB is initiated is based on a RPCB with a failure of the turbine to runback. This assumes that the secondary system is still demanding the pre-RPCB steam demand with the resultant RCS cooldown. The time delay ensures that the CPCs will generate a reactor trip before DNBR limits are reached. The second time delay could occur if the subgroup slip lasted for less than 0.5 seconds.

APS engineering analyzed this event and determined that the CEA subgroup deviation of approximately 11 inches along with the second time delay did not cause any violations of the specified acceptable fuel design limits (SAFDL). The analysis of this event determined that the effect of the actual subgroup deviation on the core power distribution was minimal.

APS has completed a preliminary evaluation of the safety consequences of this event under the most adverse postulated conditions for the software anomaly described in Section I.I. Any subgroup slipping for greater than 0.5 seconds would have reset the time delay to 0.0 seconds causing the CPCs to evaluate the deviation and insert penalty factors as appropriate. A subgroup slip lasting 0.5 seconds would result in a subgroup deviation of approximately 25 inches or less. With a deviation of 25 inches, the effect on the core power distribution would not be significantly different than the approximately 11 inch deviation in this event. The final evaluation is expected to be completed by May 1992. If the results of the final evaluation are significantly different than the preliminary evaluation, the final evaluation will be discussed in a supplement to this report.

The reactor trip at the end of the second time delay for the approximately 11 inch subgroup deviation described in Section I.I was both precautionary and generic. Any subgroup deviation greater than the allowed limit of 9.9 inches results in the CPCs applying a large, conservative penalty factor to the DNBR calculation which results in a reactor trip. Even though the CPCs were unable to detect the CEA subgroup slip during the second time delay, all remaining CEAC and CPC protective capabilities were functional and would have tripped the reactor if CEACs or CPCs sensed a condition, other than conditions based strictly on CEA subgroup or group position, that required protective action.

Other than the second time delay described in Section I.I, the plant performed as expected in response to the event described in Section I.B.

TEXT

APS engineering reviewed this event and determined that no safety limits were exceeded and that the event was bounded by current safety analyses. The event did not result in any challenges to the fission product barriers or result in any releases of radioactive materials. Therefore, there were no safety consequences or implications as a result of this event. This event did not adversely affect safe operation or the health and safety of the public.

III. CORRECTIVE ACTION:

A. Immediate:

1. Palo Verde Unit 3 was stabilized in Mode 3 (HOT STANDBY) at normal operating temperature and pressure. An investigation of this event was initiated in accordance with the PVNGS Incident Investigation Program.

2. The CPC and CEAC time delay was reset to 0.0 seconds in Units 1 and 3. The time delay will be reset to 0.0 seconds in Unit 2 prior to startup from the current refueling outage. This will ensure that all subgroup deviations (including the subgroups in Regulatory Group 4) greater than 9.9 inches will result in a reactor trip.

B. Action to Prevent Recurrence:

1. The adequacy of the lightning protection system is being evaluated by APS engineering. This evaluation is expected to be completed by April 1992. An action plan and schedule will then be developed for any recommended improvements resulting from this study.

2. APS engineering is evaluating the CEAC software to justify reinstating the time delay and to determine if any CEAC software modifications are required. The time delay will remain at 0.0 seconds until this evaluation is completed.

IV. PREVIOUS SIMILAR EVENTS:

No other previous events have been reported pursuant to 10CFR50.73.