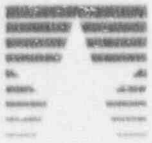

TU ELECTRIC

Log # TXX-901040
File # 10200
Ref. # 50.73(a)(2)(i)

December 19, 1990

William J. Cahill, Jr.
Executive Vice President

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NO. 50-446
PLANT SHUTDOWN REQUIRED BY TECHNICAL SPECIFICATIONS
LICENSEE EVENT REPORT 90-041-00

Gentlemen:

Enclosed is Licensee Event Report 90-041-00 for Comanche Peak Steam Electric Station Unit 1, "Technical Specification Shutdown Due to Protection Set Inverter."

Sincerely,

William J. Cahill, Jr.

DEN/daj

Enclosure

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

IE22
1/1

NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE RECORDS AND REPORTS MANAGEMENT BRANCH (P-530), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC. 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC. 20503.

LICENSEE EVENT REPORT (LER)

Facility Name (1)	Docket Number (2)	Page (3)
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	1 OF 0 9

Title (4)

TECHNICAL SPECIFICATION SHUTDOWN DUE TO FAILED PROTECTION SET INVERTER

Event Date (5)			LER Number (6)			Report Date (7)			Other Facilities Involved (8)	
Month	Day	Year	Year	Sequential Number	Revision Number	Month	Day	Year	Facility Names	Docket Numbers
1 1	1 9	9 0	9 0 -	0 4 1 -	0 0	1 2	1 9	9 0	N/A	0 5 0 0 0
									N/A	0 5 0 0 0

Operating Mode (9): 1

Power Level (10): 0 4 5

This report is submitted pursuant to the requirements of 10 CFR §: (Check one or more of the following) (11)

- 20.402(b)
- 20.405(a)(1)(i)
- 20.405(a)(1)(ii)
- 20.405(a)(1)(iii)
- 20.405(a)(1)(iv)
- 20.405(a)(1)(v)
- 20.405(c)
- 50.36(c)(1)
- 50.36(c)(2)
- [X] 50.73(a)(2)(i)
- 50.73(a)(2)(ii)
- 50.73(a)(2)(iii)
- 50.73(a)(2)(iv)
- 50.73(a)(2)(v)
- 50.73(a)(2)(vii)
- 50.73(a)(2)(viii)(A)
- 50.73(a)(2)(viii)(B)
- 50.73(a)(2)(x)
- 73.71(b)
- 73.71(c)
- Other (Specify in Abstract below and in Text, NRC Form 366A)

Licensee Contact For This LER (12)

Name		Telephone Number Area Code
T. A. HOPE	COMPLIANCE SUPERVISOR	8 1 7 8 9 7 1 - 1 6 3 7 0

Complete One Line For Each Component Failure Described in This Report (13)

Cause	System	Component	Manufacturer	Reportable To NPRDS	Cause	System	Component	Manufacturer	Reportable To NPRDS
X	E I F	I N V I T	W 1 1 2 0	Yes					

Supplemental Report Expected (14)

- [ ] Yes (If yes, complete Expected Submission Date)
- [X] No

Expected Submission Date (15): Month | Day | Year

Abstract (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On November 18, 1990, Comanche Peak Steam Electric Station Unit 1 was in Mode 1, Power Operation, operating at 45 percent reactor power. Protection Set Inverter IV1PC3 tripped, causing a loss of power to 118 VAC Instrumentation Distribution Panel 1PC3. The Technical Specification Action Statement was entered which required the inverter to be operating within 24 hours or a plant shutdown and cooldown would be required. Initial troubleshooting did not reveal the root cause, so Unit 1 was shutdown in accordance with the Action Statement. Troubleshooting did reveal a failed silicon controlled rectifier, failed resistors and a loose wire. Root causes were determined to be AC voltage transients, inadequate termination on the loose wire, and failure to completely identify all damaged components from previous inverter failures. Corrective actions include revising procedures, creating an inverter troubleshooting guide, changing wire termination methods and powering Reactor Protection Inverters from only a DC source.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

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EXPIRES: 4/30/92
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LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

Facility Name (1)	Docket Number (2)	LER Number (6)			Page (3)		
		Year	Sequential Number	Revision Number			
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	- 0 1 4 1	- 0 1 0	0 1 2	OF	0 1 9

Text (If more space is required, use additional NRC Form 366A's) (17)

I. DESCRIPTION OF THE REPORTABLE EVENT

A. REPORTABLE EVENT CLASSIFICATION

The completion of any nuclear plant shutdown required by the plant's Technical Specifications.

B. PLANT OPERATING CONDITIONS PRIOR TO THE EVENT

At 0243, November 18, 1990, Comanche Peak Steam Electric Station Unit 1 was in Mode 1, Power Operation, operating at 45 percent reactor power. Protection Set inverter, IV1PC3 (EIIS:(EF)(INVT)) was supplying power to 1PC3 (EIIS:(EF)(BU)) from 480 volts AC (VAC) input power 1EB3-1.

C. STATUS OF STRUCTURES, SYSTEMS, OR COMPONENTS THAT WERE INOPERABLE AT THE START OF THE EVENT AND THAT CONTRIBUTED TO THE EVENT

There were no inoperable structures, systems or components that contributed to the event.

D. NARRATIVE SUMMARY OF THE EVENT, INCLUDING DATES AND APPROXIMATE TIMES

At 0243, November 18, 1990, with the plant in Mode 1, Protection Set Inverter IV1PC3 tripped, causing a loss of power to 118 VAC Instrumentation Distribution Panel 1PC3. Action Statements for Technical Specification 3.8.3.1 were entered. At 0249, 1PC3 was reenergized from its bypass distribution source which satisfied Action Statement 3.8.3.1.b. Action Statement 3.8.3.1.c required energizing 1PC3 from inverter IV1PC3within 24 hours or commence a shutdown and cooldown. At 0253, Electrical Maintenance (utility, non-licensed) was called to investigate and determined fuse 1FU had blown with 480 VAC breaker 1CB (EIIS:(ED)(BKR)) tripped. By 0700, initial troubleshooting found a wire loose (wire X2). The wire was

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

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EXPIRES: 4/30/92
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LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

Facility Name (1)	Docket Number (2)	LER Number (6)			Page (3)		
		Year	Sequential Number	Revision Number			
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	- 0 1 4 1	- 0 1 0	0 1 3	OF	0 1 9

Text (If more space is required, use additional NRC Form 366A's) (17)

correctly installed, and at 1900, a temporary modification to install monitoring equipment for DC voltage inside the inverter was completed. At 1955 an attempt was made to energize the inverter, but fuse 1FU blew within a second. By 2100, further troubleshooting found two open resistors (resistors 10R and 1R). At 2200 the resistors were replaced, but fuse 1FU blew again when the inverter was energized. The decision was made to commence plant shutdown and cooldown, and at 0200, November 19,1990, a Notification of Unusual Event was made and a plant shutdown was commenced at approximately 10 percent reactor power per hour. Mode 3, Hot Standby, was entered at 0754. The failure was determined to be the Silicon Controlled Rectifier (SCR)/Diode Bridge assembly, but the specific component within the assembly could not be isolated; therefore, the entire assembly was replaced by utilizing the assembly from Unit 2 inverter IV2PC2 (EIIS:(EF)(INVT)). Inverter IV1PC3 was returned to service and placed on a load bank at 0953. The temporary modification was monitoring DC internal voltage and bridge output voltage. At 1700, plant operations management was briefed on the findings, inverter status and root cause analysis. Management was informed that the probable cause of the inverter failure was a 480 VAC voltage transient caused by switching in the 480 VAC line. These transients were recorded during the monitoring of inverter IV1PC1 (EIIS:(EF)(INVT)) as a corrective action from Licensee Event Report (LER) 90-002-00, "Reactor Trip and Flux Doubling Actuation due to Inverter Failure." These inverters can take AC or DC input to generate the 118 VAC instrumentation power; therefore, it was decided to run the inverters from a DC only source. At 1742, the load bank was removed, 1PC3 was powered by IV1PC3 at 1938, and the inverter was declared operable at 2200. The Notification of Unusual Event was terminated at 2342, November 19,1990. Further troubleshooting of the original IV1PC3 assembly was inconclusive and the assembly was installed in inverter IV2PC2, where it ran for about 4 hours until it blew an internal DC fuse at 0430 on November 20, 1990. Further troubleshooting determined that thyristor 1SCR was the failed component. 1SCR is one of two thyristors that make up the SCR/Diode Bridge assembly. By 1730, 1SCR was replaced, the inverter was energized and placed in continuous service with a 20 amp load bank.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92
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Facility Name (1)	Docket Number (2)	LER Number (6)							Page (3)		
		Year		Sequential Number		Revision Number					
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	-	0 1 4 1	-	0 0			0 1 4	OF	0 1 9

Text (If more space is required, use additional NRC Form 366A's) (17)

E. THE METHOD OF DISCOVERY OF EACH COMPONENT OR SYSTEM FAILURE OR PROCEDURAL ERROR

The inverter failure was determined by the Unit 1 Reactor Operator (utility, licensed) from Main Control Board (MCB) inverter trouble alarm and affected instrument channels failing. The failed components in the inverter were discovered by Electrical Maintenance during troubleshooting as described above.

II. COMPONENT OR SYSTEM FAILURES

A. FAILURE MODE, MECHANISM, AND EFFECT OF EACH FAILED COMPONENT and CAUSE OF EACH COMPONENT OR SYSTEM FAILURE

1. 480 VAC Breaker 1CB tripped during the event. The breaker can trip on overcurrent or high voltage on the internal DC bus for inverter IV1PC3. Previous monitoring of inverters recorded switching transients on the 480 VAC system that exceeded a duration of 25 milliseconds, greater than that required to trip 1CB on high voltage. It was determined that 1CB tripped due to the high voltage transient on the 480 VAC line possibly due to switching transients elsewhere on the line.

2. Fuse 1FU opened repeatedly during the event. Fuse 1FU is sized to protect SCRs from short circuit current. Resistance load for the SCR/Diode Bridge assembly in IV1PC3 approaches zero when the operation of both SCRs is not per design with a 60 hertz square wave output from the assembly. The improper operation of either SCR (in this case 1SCR) or both SCRs results in fuse 1FU opening.

3. Wire X2 was found loose in the gate circuit for thyristor 1SCR. The connection is a mechanical compression type which over a period of time can loosen due to vibration or thermal expansion and contraction of dissimilar metals. If X2 was an open circuit, 1SCR would not turn on and 2SCR would not turn off, then fuse 1FU would open. All connections in IV1PC3 were checked and no others were found loose.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92
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Facility Name (1)	Docket Number (2)	LER Number (6)			Page (3)
		Year	Sequential Number	Revision Number	
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	- 0 1 4 1	- 0 0	0 5 OF 0 9

Text (If more space is required, use additional NRC Form 366A's) (17)

4. Resistor 10R was found open during troubleshooting. Resistor 10R is in the current path for the transient voltage protection for thyristor 2SCR. The circuit is to prevent the SCR from turning on due to a voltage transient by providing a parallel path for the energy of the transient to flow through. On March 29, 1989, capacitor 10C in this circuit shorted. The inverter manufacturer indicated that the resistor in series with the capacitor in the transient circuit will open or be damaged if the capacitor shorts. When capacitor 10C failed, resistor 10R resistance was tested satisfactory, but the resistor was damaged or weakened due to that previous event. A voltage transient was part of this event as revealed by Breaker 1CB tripping. It is believed that the weakened resistor 10R was opened by the voltage transients.

5. Precharge Circuit Resistor 1R was found open during troubleshooting. On March 24, 1989, IV1PC3 was energized and fuse 1FU opened immediately. Troubleshooting found 1SCR to be a short circuit. During energization of the inverter circuitry for the previous event, damage did occur to resistor 1R. Further damage occurred to cause resistor 1R to open on November 18, 1990, when IV1PC3 was energized twice prior to finding the resistor open with 1FU opening immediately each time. The inverter manufacturer confirmed that energization of the inverter with a short circuit damages precharge resistor 1R.

6. Thyristor 1SCR was found to have a short circuit between gate leads, but would also operate properly. The problem was first isolated to the SCR/Diode Bridge assembly while in IV1PC3. Using standard test methods to determine whether the SCR was shorted or open did not reveal the anomaly. The assembly was installed in Unit 2 inverter IV2PC2 and operated properly for approximately 4 hours. A non-standard test revealed the anomaly. The anomaly in 1SCR would allow stray induced influences to play a role in turning 1SCR on. A diode D2 on the gate drive board prevents stray influences from operating the SCR. The short between the gate leads of the SCR created a short across diode D2. If 1SCR turned on with 2SCR on, then fuse 1FU would open.

B. FAILED COMPONENT INFORMATION

The inverter was a Westinghouse 7.5 KVA, 118 VAC, single phase, 60 hertz, Fixed Frequency Inverter.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92
ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE RECORDS AND REPORTS MANAGEMENT BRANCH (P-530), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC. 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC. 20503.

C. SYSTEMS OR SECONDARY FUNCTIONS THAT WERE AFFECTED BY FAILURE OF COMPONENTS WITH MULTIPLE FUNCTIONS

Protection Set Inverter IV1PC3 feeds power to 118 VAC Instrumentation Distribution Panel 1PC3. 1PC3 was deenergized for 10 minutes when IV1PC3 was initially lost. 1PC3 was reenergized from 120 VAC non-1E power up to and during reactor shutdown and cooldown. Panel 1PC3 supplies power to:

- Nuclear Instrumentation System Channel III control and instrument power
- Process Protection Set Channel III
- Solid State Protection System Train A power supplies
- Protective Relay Rack Channel III
- Control system functions for turbine control, pressurizer level control and pressurizer pressure control
- Main Control Board power for some indications on MCB 04, 05, 07, 09

III. ANALYSIS OF THE EVENT

A. SAFETY SYSTEM RESPONSES THAT OCCURRED

Main Control Board indication was received that inverter IV1PC3 had failed. No safety system responses occurred.

B. DURATION OF SAFETY SYSTEM TRAIN INOPERABILITY

118 VAC Instrumentation Distribution Panel 1PC3 was deenergized for 10 minutes until it was reenergized on bypass power. Inverter IV1PC3 was inoperable for 43 hours, 17 minutes.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

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LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

Facility Name (1)	Docket Number (2)	LER Number (6)			Page (3)
		Year	Sequential Number	Revision Number	
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	- 0 1 4	- 0 0	0 1 7 OF 0 1 9

Text (If more space is required, use additional NRC Form 366A's) (17)

C. SAFETY CONSEQUENCES AND IMPLICATIONS OF THE EVENT

For the plant operating in Modes 1 through 4, all four reactor protection system inverters are required to be operable. The power output of IV1PC3 is required to be operable. The loss of IV1PC3 required a plant shutdown within 24 hours and cooldown within the following 6 hours. These Technical Specification requirements were met and the plant was cooling down when the inverter was returned to operation. No automatic safety function was initiated or required. Operation was within the requirements of the Unit 1 Technical Specifications during the entire event. At no time during this period did a condition exist that threatened the health or safety of the public.

IV. CAUSE OF THE EVENT and CORRECTIVE ACTIONS

ROOT CAUSE No. 1

A switching transient on the 480 VAC line caused a voltage transient that contributed to a component failure within inverter IV1PC3 and caused breaker 1CB to trip open.

CORRECTIVE ACTION No. 1

Operating procedure "118 VAC Distribution System and Inverters" was revised to allow the inverters to operate on a DC only source. This is in accord with the recommendation made to plant management on November 19, 1990, to eliminate use of the 480 VAC source due to transient voltages that were observed during monitoring of the inverters. The alarm procedure was changed to account for the 480 VAC breaker 1CB being open and a temporary modification was installed to eliminate the trouble alarm for the inverters. A design modification has been initiated to provide a permanent design for elimination of the trouble alarm for the inverters due to the 480 VAC breaker being open. Since IV1PC3 has been on the DC source, no transient voltages have been recorded on the monitoring equipment installed by the temporary modification during troubleshooting.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

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LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

Facility Name (1)	Docket Number (2)	LER Number (6)					Page (3)		
		Year		Sequential Number		Revision Number			
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	-	0 1 4	1	- 0 1 0	0 1 8	OF	0 1 9

Text (If more space is required, use additional NRC Form 366A's) (17)

ROOT CAUSE No. 2

Inadequate termination on wire X2. Wire X2 had a compression fitting that had worked loose over time due to vibration or thermal expansion and contraction of dissimilar metals.

CORRECTIVE ACTION No. 2

Work has been scheduled to have lugs installed on the gate leads for the terminations to the gate drive board in the four inverters. All other gate leads in other inverters were visually inspected and no deficiencies were discovered.

ROOT CAUSE No. 3

Failure to completely identify all damaged components from previous inverter failures. Resistors 1R and 10R were damaged from previous inverter failures but were never identified because the damage could not be detected from resistance tests. Only by analyzing this current inverter failure and discussing the results with the inverter manufacturer could the previous damage be determined.

CORRECTIVE ACTION No. 3

The failure analysis performed in this event has identified other resistors in other inverters that could be potentially damaged and should be replaced. These components will be replaced. A specific troubleshooting procedure for the Westinghouse inverters is being written to incorporate the lessons learned from this event. The lessons learned will be incorporated into current maintenance procedure "Westinghouse 7.5 KVA Inverter Troubleshooting and Rework."

GENERIC CONSIDERATIONS

The root causes determined in this event are generic concerns for the other inverters and the corrective actions determined in this event apply to those inverters.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION

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LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

Facility Name (1)	Docket Number (2)	LER Number (6)			Page (3)		
		Year	Sequential Number	Revision Number			
COMANCHE PEAK - UNIT 1	0 5 0 0 0 4 4 5	9 0	- 0 1 4 1	- 0 1 0	0 1 9	OF	0 1 9

Text (If more space is required, use additional NRC Form 366A's) (17)

V. PREVIOUS SIMILAR EVENTS

LER 90-002-00, "Reactor Trip and Flux Doubling Actuation due to Inverter Failure" was caused by failure of Protection Set Inverter IV1PC1. The root cause of the inverter failure could not be determined in this event, but a corrective action was to install monitoring equipment to record inverter performance. It was during the monitoring of IV1PC1 that enough evidence was collected to suggest that AC switching transients were occuring in the 480 VAC system of long enough duration (greater than 25 milliseconds) to cause potential damage to inverter components and trip the 480 VAC supply breaker 1CB. But it was not until the event of November 18, 1990, that enough evidence was collected along with IV1PC1 data to adequately postulate what was happening to the inverters.

VI. ADDITIONAL INFORMATION

The times listed in the report are approximate and Central Standard Time.