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March 1, 2001

Docket No. 50-461

10CFR50.73

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

Subject: Clinton Power Station
Licensee Event Report No. 2000-002-01

Dear Madam or Sir:

Enclosed is Licensee Event Report (LER) No. 2000-002-01: Out-of-Phase Synchronization Results in Damage to Division 3 Emergency Diesel Generator and Inadequate Design of Static VAR Compensator Freeze Circuit Results in Overvoltage of Class 1E Divisional Bus. This report is being submitted in accordance with the requirements of 10CFR50.73.

Sincerely yours,

J. M. Heffley
Vice President

JRF/blf

cc: NRC Clinton Licensing Project Manager
NRC Resident Office, V-690
NRC Region III, Regional Administrator

IE22

NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION
(6-1998)

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Clinton Power Station	05000461	1 OF 10

TITLE (4)
Out-of-Phase Synchronization Results in Damage to Division 3 Emergency Diesel Generator and Inadequate Design of Static VAR Compensator Freeze Circuit Results in Overvoltage of Class 1E Divisional Bus

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 NAME	DOCKET NUMBER
									None	05000
02	28	2000	2000	- 002 -	01	03	01	01	FACILITY NAME: None	DOCKET NUMBER: 05000

OPERATING	1
POWER LEVEL (10)	100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

	20.2201(b)		20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
	20.2203(a)(1)		20.2203(a)(3)(i)	X	50.73(a)(2)(ii)		50.73(a)(2)(x)
	20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
	20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)		OTHER
	20.2203(a)(2)(iii)		50.36(c)(1)	X	50.73(a)(2)(v)		Specify in Abstract below or in NRC Form 366A
	20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Steve Kowalski, Nuclear Station Engineering Department	(217) 935-8881, Extension 3902

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX

SUPPLEMENTAL REPORT EXPECTED (14)			EXPECTED	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE).	X NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On February 28, 2000, while paralleling the Division 3 Emergency Diesel Generator (EDG) to an offsite source, an out-of-phase synchronization occurred that damaged the Division 3 EDG stator windings. A Static VAR Compensator (SVC) responded to the out of phase synchronization in a way not intended by design, resulting in an overvoltage condition on the Division 3, Class 1E, electrical distribution system. Subsequent evaluation of the overvoltage condition determined the overvoltage condition did not adversely affect components supplied by the Division 3 electrical distribution system.

The out-of-phase synchronization was caused by a combination of synchronization technique weaknesses. The cause for the SVC not responding as intended by design was determine to be a failure to account for an inherent time delay in the SVC freeze circuitry during the design process of the SVC freeze function. Corrective actions for this event include; repair of the Division 3 EDG, improving guidance for paralleling EDGs, installing syncronizing check relays, revising the EDG reverse power relay settings, performing routine preventive maintenance on synchroscopes, and providing training on this event.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	2 OF 10
Clinton Power Station	05000461	2000	- 002	- 01	

TEXT *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

DESCRIPTION OF EVENT

On February 28, 2000, the plant was in Mode 1 (POWER OPERATION) at 100 percent reactor [RCT] power. At approximately 1041 hours, an out-of-phase synchronization and overvoltage condition occurred on the Division 3 (1C1), Class 1E, 4160 volt alternating current (VAC) distribution system [EB]. This event occurred while operations personnel were synchronizing the Division 3 Emergency Diesel Generator (EDG) [EK] to an offsite power source in accordance with CPS surveillance procedure 9080.02, " Diesel Generator 1C Operability - Manual and Quick Start Operability." At approximately 1043 hours, the bus overvoltage condition was terminated by opening the Division 3 EDG output breaker, thus securing parallel operation of the Division 3 EDG with the offsite power source. The Division 3 EDG was subsequently shut down.

The Clinton Power Station (CPS) Class 1E 4160 VAC electric power system consists of three electrically and physically independent distribution divisions, i.e., the 1A1, 1B1 and 1C1 electrical buses. Each of the three distribution divisions can be supplied with electric power from either of two offsite sources via two physically independent circuits or an EDG that serves as a standby power source, independent of the offsite source. The two physically independent offsite source circuits are the 345 kilovolt (kV) circuit through the Reserve Auxiliary Transformer (RAT) and the 138 kV circuit through the Emergency Reserve Auxiliary Transformer (ERAT). A Static VAR Compensator (SVC) is installed on each of the secondary sides of the RAT and ERAT to assist in maintaining acceptable voltages to the 4160 VAC distribution divisions during normal plant operating conditions and / or accident conditions. Each SVC is rated at +28.5/-14.0 MVAR and includes a thyristor-controlled reactor bank rated at 21.5 MVAR, a thyristor switched capacitor bank rated at 21.0 MVAR, and a capacitive harmonic filter bank rated at 7.5 MVAR. (Figure 1 on page 10 contains a simplified diagram of the 4160 VAC electrical power system.)

On February 28, 2000, at approximately 0034 hours, operations personnel commenced performance of CPS surveillance procedure 9080.02. CPS surveillance procedure 9080.02 satisfies Technical Specification (TS) Surveillance Requirement (SR) 3.8.1.3, in that it verifies the Division 3 EDG can operate for greater than or equal to 60 minutes at a load of greater than or equal to 1980 kilowatts (KW).

At approximately 0920 hours, on February 28, 2000, and in accordance with CPS surveillance procedure 9080.02, the offsite power source supplying the Division 3 1C1 electrical bus was transferred from the RAT (which is the normal power supply to the Class 1E buses) to the ERAT (which is the secondary power source). At approximately 0944 hours, the Division 3 EDG was started. At approximately 1016 hours, the Division 3 EDG was declared inoperable

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	3 OF 10
Clinton Power Station	05000461	2000	- 002	- 01	

TEXT *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

in accordance with CPS surveillance procedure 9080.02. This was done in anticipation of placing the Division 3 EDG output breaker control switch in the Pull-To-Lock (PTL) position and setting the Division 3 EDG governor speed droop to 50 percent to support parallel operation of the Division 3 EDG with the offsite power source.

The following TS Limiting Condition for Operation (LCO) Actions were entered when Division 3 EDG was declared Inoperable: LCO 3.8.1, Required Action B.1, which requires verifying correct breaker alignment and indicated power availability for each offsite circuit within 1 hour and once per 8 hours thereafter; LCO 3.8.1, Required Action B.2, which requires declaring required features supported by Division 3 EDG inoperable when the redundant required features are inoperable within 4 hours; LCO 3.8.1, Required Action B.3.1, which requires determining the Division 1 and Division 2 EDGs are not inoperable due to common cause within 24 hours; and LCO 3.8.1, Required Action B.4, which requires restoring the Division 3 EDG to operable status within 72 hours.

At approximately 1041 hours, the Division 3 EDG output breaker was closed, thus commencing parallel operation of the Division 3 EDG with the offsite source (ERAT). The Division 3 EDG power output was immediately adjusted to greater than 200 KW in accordance with CPS surveillance procedure 9080.02. Shortly thereafter a nuclear equipment operator, stationed in the Division 3 EDG room, reported to the Main Control Room (MCR) that he heard a loud thud and a noticeable vibration of the floor when the Division 3 EDG output breaker was closed. During this report, Annunciator 5007-5M, " 4 kV Bus High Voltage," alarmed (this annunciator has a two-minute time delay feature), and the control room operator identified that the 1C1 electrical bus voltage indicated 4332 VAC. With bus voltage indication greater than 4300 VAC (the maximum sustained operation and operability voltage), the control room operator opened the Division 3 EDG output breaker as required by CPS surveillance procedure 9080.02. Immediately following opening of the Division 3 EDG output breaker, 1C1 electrical bus voltage decreased to within its normal operating range. Parallel operation of the Division 3 EDG and the offsite power source lasted for approximately 3.5 minutes.

Per the requirements of CPS procedure 5007.05, " Alarm Panel 5007 Annunciators - Row 5," the Control Room Supervisor (CRS) declared the Division 3 electrical distribution system inoperable for bus voltage being above the analyzed maximum sustained operation and operability voltage of 4300 VAC, per the requirements of CPS procedure 3501.01, " High Voltage Auxiliary Power System." In addition, the CRS declared the Division 3 EDG unavailable, and the following additional TS LCO Actions were entered: LCO 3.8.9, Required Action E.1, which requires declaring the High Pressure Core Spray System (HPCS) [BG] inoperable; LCO 3.5.1, Required Action B.1, which requires verifying by administrative means that Reactor Core Isolation Cooling (RCIC) [BN] is Operable within 1 hour; and LCO 3.5.1, Action B.2, which requires restoring HPCS to an Operable status within 14 days.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	4 OF 10
Clinton Power Station	05000461	2000	- 002	- 01	

TEXT *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

By approximately 1100 hours on February 28, 2000, LCO 3.5.1, Required Action B.1, and LCO 3.8.1, Required Action B.1, were completed.

Condition report 2-00-02-172 was initiated to investigate this event, and Operations requested the Nuclear Station Engineering Department (NSED) to perform an evaluation on the effect that the over voltage condition had on the Division 3 electrical distribution system components. In addition, Operations, in conjunction with NSED, commenced a common mode failure analysis per the requirements of LCO 3.8.1, Required Action B.3.1, to determine if Division 1 and Division 2 EDGs were susceptible to a common mode failure condition.

Station engineers determined that the abnormal noise and vibration reported by the nuclear equipment operator stationed in the Division 3 EDG room, and the associated power oscillations on the 1C1 electrical bus, were the result of an out-of-phase parallel between the Division 3 EDG and the ERAT. Due to the out-of-phase condition, the Division 3 EDG initially began to motorize (reverse power). The motorizing action of the Division 3 EDG resulted in a large current flow which resulted in depressed voltages on the Division 3 electrical distribution system. In response to the decrease in voltage, the ERAT SVC responded by adding more capacitance to the Division 3 electrical distribution system to raise voltage. Subsequently, the SVC " froze" with a large capacitance value connected to the Division 3 electrical distribution system. This condition resulted in an elevated voltage on the 1C1 electrical bus. (As explained later, the SVC response causing the elevated bus voltage was a non-conforming condition outside the design basis of the plant.)

At approximately 2232 hours on February 28, 2000, a common cause failure analysis was completed per the requirements of LCO 3.8.1, Required Action B.3.1. The analysis concluded that there was no credible common mode failure mechanism that would lead to Division 1 and Division 2 EDGs not being able to satisfy their safety function. Parallel operation of a diesel generator with an offsite power source is not a safety function of the EDGs relative to their standby operability requirements for automatically responding to a loss-of-coolant accident (LOCA), a loss of offsite power (LOOP), or a LOCA concurrent with a LOOP; therefore, the event that caused the overvoltage condition on the Division 3 electrical distribution system did not have a common mode failure mechanism relative to Divisions 1 and 2. Station engineers also recommended that, since the observed transient occurred when the EDG was paralleled to the 1C1 electrical bus, EDG surveillances that require parallel operation of an EDG to an offsite source be discontinued until a conclusive determination on the cause of the event was completed. Upon this recommendation, Operations suspended performance of surveillances that require parallel operation of an EDG to an offsite source.

At approximately 1930 hours on February 29, 2000, engineering personnel completed an evaluation of the impact of the overvoltage condition on the 1C1 electrical bus. The evaluation concluded that components supplied from the Division 3 electrical distribution system were not adversely affected by the overvoltage condition due to the short duration

and low magnitude of the overvoltage condition. The 1C1 electrical bus overvoltage condition lasted for approximately 3.5 minutes. Within that time (at or near the onset), bus voltage reached a maximum of 4366 VAC for 0.25 seconds and stabilized at 4339 VAC within two seconds. (Divisions 1A1 and 1B1 electrical busses were not affected by the overvoltage condition as they were aligned to the RAT).

An inspection of the Division 3 EDG was also initiated to determine if the out-of-phase synchronization and overvoltage condition resulted in damage to the Division 3 EDG. The EDG vendor was contacted to determine what inspections should be performed to determine if the Division 3 EDG was damaged. The vendor recommended that the generator, the number 10 main engine bearing, the engine crank shaft dampener and the main engine turbocharger be inspected for damage. In addition, analysis of the Division 3 EDG lubricating oil, sampled shortly after the EDG was secured (while the engine was still hot), was performed. The synchroscope used to parallel the Division 3 EDG to the offsite source was also removed and tested for accuracy.

The results of the inspection found that the generator stator was damaged. Varnish was cracked off the stator end turns and some of the stator end turn wedges were loose. As a result, the generator was replaced. With regard to the diesel engine, no visible damage to the number 10 main engine bearing or the engine crank shaft dampener was found. The results of the engine oil sample analysis found no signs of abnormal bearing wear. Because of the extensive amount of time required to fully inspect the EDG engine turbocharger, a new turbocharger was installed. The results of the synchroscope test determined the synchroscope was degraded (exhibited hesitation during rotation) and the synchroscope was replaced.

During the investigation into the overvoltage condition on the Division 3, 1C1 electrical bus, station engineering determined that the ERAT SVC response to out-of-phase paralleling of the Division 3 EDG was a non-conforming condition outside the design basis of the plant. A small time delay (approximately 50-200 milliseconds) inherent in the electrical interlock circuitry for the freeze signal (as discussed below) allowed the SVC to adversely interact with the EDG during the out of phase transient. This small time delay and its potential effect had not been identified or evaluated for the SVC design.

In 1999, during refuel outage 6, SVCs were installed on the secondary side of the RAT and ERAT to address potential inadequate grid voltage conditions that can occur subsequent to a unit trip following a loss of coolant accident (LOCA). The SVCs enhance both steady state voltage and dynamic voltage response by adding capacitive or inductive reactance to the Class 1E 4160 VAC electric power system. During parallel operations between the RAT and ERAT, RAT and Unit Auxiliary Transformer (UAT), and the RAT or ERAT and an EDG, the voltage control function of each SVC was designed to freeze to prevent interaction between the SVC control and the control function of the other sources.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	6 OF 10
Clinton Power Station	05000461	2000	- 002	- 01	

TEXT *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

The freeze signal is derived from auxiliary contacts on the diesel generator output breakers, the RAT feeder breaker, the ERAT feeder breaker and the UAT feeder breaker. In response to the unexpected SVC response that occurred during a time when the SVC was expected to be frozen, condition report 2-00-03-051 was initiated to address this issue.

An operability evaluation was performed to determine the impact of the non-conforming condition (SVC freeze signal time delay) on the operation of the plant. (At the time of this operability evaluation, station engineers believed that the interaction of the SVC may have significantly increased the voltage transient observed during the initial paralleling of the EDG to the ERAT. Further analysis and modeling has determined that the SVC did not contribute to the transient voltage and real power swings immediately after the Division 3 EDG was paralleled out of phase with the Division 3 electrical distribution system.) The results of the operability determination concluded that the severity of the voltage transient that may potentially occur within the SVC freeze delay time during the initial paralleling of sources is dependent on the degree of voltage, frequency and / or phase mismatch between the sources to be paralleled. Analysis indicated four conditions in which the non-conformance may impact plant operation. The four non-conforming conditions identified included: 1) transfers between the RAT and UATs, 2) transfers between the RAT and ERAT, 3) transfers of an electrical distribution system from its associated EDG to the RAT or ERAT (LOOP recovery), and 4) parallel operation of an EDG with the RAT or ERAT (EDG surveillance testing).

1) The potential of an adverse interaction between the RAT and UATs is minimal. RAT and UAT voltages have the same phase angle and similar voltages since they are connected to the Main Generator and 345 kV offsite power source. Additional guidance was added to CPS Procedure 3501.01, " High Voltage Aux Power System," for this operation. CPS Procedure 3501.01 now requires verification that RAT and UAT voltages are matched prior to transfers.

2) Transfers between the RAT and the ERAT do not have a potential for creating transients due to the non-conforming SVC freeze signal delay. RAT and ERAT frequency are the same because they are both connected to the same offsite electrical distribution grid. Voltage differences between the two sources are minimal because each source is connected to an SVC with overlapping voltage control setpoint bands. In addition, a synchronizing check relay will only allow breaker closure if the angle is within specified limits (less than or equal to 20 degrees with procedural requirements to ensure frequencies are matched). SVC voltage control and the limitations of the synchronizing check relay create specific boundaries for this event and therefore, limit the potential for transients generated by the SVCs; therefore, no immediate action was required.

3) Transfers of an electrical distribution system from its associated EDG to the RAT or ERAT (LOOP recovery) involve potentially varying voltage and frequency since the diesel is an isolated power source; however, the potential of an adverse interaction between an EDG and the RAT SVC or ERAT SVC is minimal due to synchronizing check relay protection. Circuit breaker synchronizing check relay protection is provided for the RAT and ERAT feeder breakers. Synchronizing check relay protection limits the potential for bus disturbances, thus the potential for control interaction

between an EDG and SVC is minimized. The synchronizing check relays limit the operator's ability to parallel an EDG with the RAT or ERAT with a large relative frequency difference. Additionally, the RAT and ERAT synchronizing check relays limit the maximum out-of-phase condition that may exist for breaker closure to 20 degrees. These limits reduce the potential for transients during transfers from an EDG to the RAT or ERAT; therefore, no immediate action was required.

4) Parallel operation of an EDG to an energized electrical distribution system being supplied by either the RAT or ERAT (EDG surveillance testing) also involves potentially varying voltages and frequencies since the EDG is an isolated power source. During this evolution, synchronization check relay protection is not provided. Voltage and frequency are adjustable and matched by the operator prior to closing the EDG output breaker for parallel operation. However, during this evolution, frequency and voltage variances between the sources are controlled by the actions of the operator with no synchronizing check relay protection. (During this event, paralleling of the EDG with the offsite source was performed in accordance with approved operating procedures.)

To immediately address this operational condition, parallel operations of an EDG to the RAT or ERAT were suspended. To allow surveillance testing to recommence, additional actions were taken to minimize the potential for control interaction between the EDG and the ERAT SVC. The Division 3 synchroscope was replaced. In addition, a temporary modification to manually freeze the ERAT SVC was installed for the Divisions 1A1, 1B1 and 1C1 electrical distribution systems. The temporary modification allows operators to manually freeze the ERAT SVC prior to synchronizing an EDG to the ERAT, thus, eliminating the delay. With these actions in place surveillance testing of the EDGs is allowed to resume.

No other automatic safety system responses were necessary to place the plant in a safe and stable condition. No other equipment or components were inoperable at the start of this event to the extent that their inoperable condition contributed to this event.

CAUSE OF EVENT

The damage to the Division 3 EDG was caused by a combination of synchronization technique weaknesses that resulted in paralleling the Division 3 EDG out-of-phase with the Division 3 electrical distribution system. Procedural guidance concerning synchroscope speed prior to paralleling was weak. The procedure specified adjusting EDG speed so the synchroscope is moving slow in the fast direction. During this event it was determined that the synchroscope was rotating at a rate of 4 to 6 seconds per revolution. Rotation at this speed is excessive and contributed to paralleling the Division 3 EDG out-of-phase. In addition, control room operators focus on raising the power output of the EDG immediately after commencing parallel operations to avoid a reverse power trip of the EDG output breaker. This focus distracted the operator from ensuring the EDG was paralleled in phase.

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CAUSE OF EVENT (Continued)

The cause for the elevated Division 3 electrical distribution system voltage after the out of phase parallel of the Division 3 EDG was due to a design error during the development of the SVC freeze signal. The original design of the SVC freeze function was changed prior to installation and the subsequent design did not account for inherent delays in the freeze circuitry.

(Subsequent to the event, a detailed evaluation of the SVC response to the out of phase parallel event was performed. The evaluation determined that the SVC did not exacerbate the transient voltage and power swings immediately after the Division 3 EDG was paralleled out of phase with the Division 3 electrical distribution system and did not contribute to the damage that occurred to the Division 3 EDG.)

CORRECTIVE ACTIONS

The corrective actions for paralleling the Division 3 EDG out of phase with the Division 3 electrical distribution system include:

- The Division 3 EDG was repaired and returned to an operable condition.

- The Division 3 synchroscope was replaced. In addition, a preventive maintenance task has been initiated for periodic calibration of the EDG and Main Generator synchroscopes.

- The procedures for paralleling an EDG to an off-site source are in the process of being revised to provide more guidance on syncroscope speed prior to paralleling.

- The reverse power relays setpoints for the Division 1, 2, and 3 EDGs will be reviewed and revised as appropriate to minimize the potential for unwarranted reverse power trips of an EDG output breaker during paralleling operations.

- Circuit breaker synchronizing check relay protection will be provided for the Division 1, 2, and 3 EDG output breakers. The synchronizing check relays will reduce the potential for paralleling an EDG to the RAT or ERAT with large frequency, voltage or phase differences.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	9 OF 10
Clinton Power Station	05000461	2000	- 002	- 01	

TEXT *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

CORRECTIVE ACTIONS (Continued)

The corrective actions for the delay in the SVC freeze signal include:

- A temporary modification to manually freeze the ERAT SVC for EDG parallel operation was installed for the Division 1A1, 1B1, and 1C1 electrical distribution systems. (These modifications included a provision for ensuring that a LOCA initiation signal will override the manual freeze condition during EDG testing.)

- Lessons learned associated with the improper design of the SVC freeze signal was provided in continuing training for engineering personnel.

(Subsequent to the above actions, an extensive analysis and dynamic modeling was performed on the control interaction of an EDG and the RAT/ERAT SVCs. The results of this analysis demonstrated that parallel operation of an SVC and EDG is stable for all postulated system perturbations. Based on this analysis, the SVC freeze function for parallel operations of an EDG and the RAT/ERAT SVCs will be removed and the design basis of the plant will be updated to reflect this change. Additionally, the temporary modification noted above will be removed.)

ANALYSIS OF EVENT

This event is reportable under the provisions of 10CFR50.73(a)(2)(ii)(B) and 10CFR50.73(a)(2)(v)(D). The inherent time delay in the SVC freeze circuitry is a condition that is outside the design basis of the plant. The damage to the Division 3 EDG is an event or condition that alone could have prevented the fulfillment of the safety function of a system (HPCS) that is needed to mitigate the consequences of an accident.

An assessment of the safety consequences and implications identified that this event had a minimal effect on nuclear safety. Parallel operation of a diesel generator with an offsite power source is not a safety function of the EDGs relative to their standby operability requirements for automatically responding to a loss-of-coolant accident (LOCA), a loss of offsite power (LOOP), or a LOCA concurrent with a LOOP.

ADDITIONAL INFORMATION

The Division 3 EDG is a 16-cylinder engine manufactured by General Motors Electro Motive Division (EMD), model number 16-645-E4. The damaged Division 3 generator was manufactured by Beloit, type TBGZDK. The replacement Division 3 generator is manufactured by Louis-Allis, type TBGZDK.

CPS has not had any reportable events in recent history involving paralleling an EDG out of phase or an overvoltage condition on an electrical distribution bus due to a design error.

For further information regarding this event, contact Steven Kowalski, Station Engineer, at (217) 935-8881, extension 3902.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	10 OF 10
Clinton Power Station	05000461	2000	- 002	- 01	

TEXT *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

Figure 1