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LICENSEE EVENT REPORT (LER)

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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Oconee Nuclear Station, Unit 1	05000 269	1 OF 9

TITLE (4) Design Deficiency Results in the Technical Inoperability of the Oconee Emergency Power Source Due to a Postulated Failure of Keowee Hydro Units

EVENT DATE (5)			LER NUMBER (6)			REPORT NUMBER (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
									Oconee, Unit 2	05000 270
01	11	93	93	-- 01 --	2	07	13	95	Oconee, Unit 3	05000 287

OPERATING MODE (9)	N
POWER LEVEL (10)	000

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

20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
20.405(a)(1)(i)	50.36(c)(1)	X 50.73(a)(2)(v) (D)	73.71(c)
20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	OTHER
20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	(Specify in Abstract below and in Text, NRC Form 366A)
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 (12)

NAME	TELEPHONE NUMBER (Include Area Code)
L. V. Wilkie, Safety Review Manager	(803) 885-3518

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

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 15 single-spaced typewritten lines) (16)

On January 11, 1993, at 2230 hours, Oconee Nuclear Station Units 2 and 3 were operating at 100% Full Power and Unit 1 was shut down for refueling. During the follow-up of a Self Initiated Technical Audit recommendation, Oconee Engineering (OE) identified a scenario that could have impacted the ability of the Keowee Hydro (KH) Station to supply the Oconee emergency power paths. A KH unit generating to the system grid at a high load when an emergency start initiates, would separate from the grid and would over speed. If the speed reaches the trip set point, the unit would trip and excitation to the KH unit would be lost and result in inoperability of the KH unit. The KH control scheme would also result in above normal frequency following load rejection. The root cause of this event is Design Deficiency: Unanticipated Interaction of Systems, (Design Oversight). Immediate corrective action was to administratively prohibit the use of KH units for generation to the system grid. Subsequent OE analysis permitted limited output of a KH unit when supplying the system grid. The root cause of the subsequent non-conservative limit is Analysis deficiency (calculations: mechanical). The limits were reduced as a result of the more conservative analysis.

BACKGROUND

During normal operation, each Oconee unit receives power through an auxiliary transformer (T). During startup, shutdown and following shutdown, the two main feeder buses are supplied from the startup transformer (CT). Emergency transfer from the T to CT transformer is initiated automatically by protective relay action.

The Emergency Power Switching Logic transfers to an available power source during any loss of power situation. It reduces the loads to a level within the capacity of the emergency power source and transfers essential loads to the emergency power source.

The Keowee Hydro (KH) Station consists of two 87.5 MVA hydroelectric generators that supply power to the Duke Power transmission grid. In addition to normal generation, KH is part of the Keowee Emergency Power System [EIIS:EK], which is designed to serve as the emergency on site power source for Oconee Nuclear Station (ONS). Upon loss of power from the Oconee generating units and the 230KV switchyard [EIIS:FK], power can be supplied from the KH units via two separate and independent paths.

One path is an overhead 230 KV transmission line to the 230 KV switchyard yellow bus [EIIS:FK] at Oconee which supplies each unit's start-up transformers. The overhead transmission line is arranged with air circuit breakers (ACB 1 and 2) so that it can be connected to the KH Units.

The second path is an underground feeder cable to the Oconee transformer CT-4 which supplies the redundant standby power buses. This path is sized to carry full engineered safeguard loads of one Oconee unit plus the auxiliary loads required for safe shutdown of the other two Oconee units (20.628 MVA total). The underground feeder is arranged with ACB's 3 and 4 so that it can be connected to either KH unit. This underground feeder is connected, at all times, to one KH unit on a predetermined basis and is energized along with CT-4 whenever the associated KH unit is in service.

Each KH unit is provided with its own automatic emergency start-up equipment. Both units undergo a simultaneous emergency start on a loss of the grid, an engineered safeguards actuation on any of the three Oconee units or an extended loss of voltage on any unit's main feeder bus. On an emergency start-up, the unit connected to the underground feeder supplies that feeder. If there is a grid disturbance, the other unit is automatically connected to the Oconee 230 KV switchyard yellow bus only after the yellow bus is automatically isolated from the grid.

Therefore, in the event of a Loss of Coolant Accident and the simultaneous loss of the grid, emergency power is available from a KH unit through either the underground feeder or the overhead transmission line.

The field, supply, and field flashing breakers are closed to provide DC to the field, which will allow the generator to produce electricity. Anti-pump circuitry prevents breakers from cycling back and forth between closed and tripped when a close and trip signal are both present.

EVENT DESCRIPTION

On May 15, 1992, a Self-Initiated Technical Audit was completed for the Electrical Distribution System at Oconee Nuclear Station. A section of this audit covered Emergency Hydro Generators at Keowee Hydro (KH). A recommendation was made that engineering develop a formal single failure analysis of the KH units operating in parallel with the off site grid to ensure that all possible scenarios are reviewed and properly evaluated with formal calculations.

On January 11, 1993, Oconee Engineering (OE) was continuing the single failure analysis. Engineers A and B were evaluating scenarios where a KH unit could over speed if the unit is generating at full load to the system grid when an emergency start is initiated. The emergency start causes the KH units to separate from the system grid (i.e., load rejection). The KH unit could trip on over speed if lake levels for Lakes Keowee and Hartwell are different enough to produce a high net head and the KH units are generating at full load to the system grid.

Engineers A and B determined that Turbine/Governor control circuitry is such that if the KH units over speed approximately 140% of rated speed, the shutdown solenoid auxiliary relay will de-energize and give a trip permissive to the KH units field breakers. The field breakers have a maintained close signal already present (via the emergency start signal), therefore the field breakers will trip and not re-close due to an anti-pump feature. Excitation to the KH units would be lost and the KH units would not be capable of performing their intended function. Engineering Supervisor A and Engineering Manager A were informed concerning the postulated event. After they concurred that the potential problem could adversely impact the Emergency Hydro Generator capability, the Superintendent of Operations was notified at 2230 hours and administrative controls were established preventing the KH units from supplying the system grid.

On January 12, 1993, the evaluation continued to determine the impact of the scenario on previous KH operation. At 1557 hours, it was determined that the postulated event could have impacted the ability of the KH units to supply the Oconee emergency power paths in the past. This scenario could result in common mode failure of both units. Prior to a previous postulated event on October 12, 1992 (LER 269/92-16), both units routinely had been generating to the grid. Even after the corrective actions (restricting the KH unit dedicated to the underground path from supplying the grid) were completed on the previous event, if only one unit was generating to the grid then that unit would be technically inoperable and the other unit would be subject to postulated single failure.

On January 12, 1993, at 1702 hours, the NRC was notified of the past technical inoperability.

The KH units were restricted from supplying the system grid from January 11, 1993, at 2230 hours until approximately 1600 hours on January 14, 1993. On January 14, 1993, OE completed a conditional operability evaluation and determined that with no more than 66 megawatts (MW) on a unit supplying the system grid and a gross head of no more than 146 feet, the postulated event could not occur. After further evaluation, OE revised the calculation to allow a variable output of between 69 and 75 MW for a corresponding lake level. A modification is being planned to restore full power generation capability to the system grid while not impacting the emergency power capability.

Because the KH units were restricted from supplying the grid after the determination of the postulated scenario, no Limiting Condition for Operation was entered upon discovery of this problem.

On May 16, 1994, during the review of the KH Emergency Power System for the Design Basis Document effort, another scenario was found that could also render the emergency power system inoperable due to overspeeding following separation from the grid. Documentation supporting the adequacy of voltage, when supplied via the KH overhead power path, was a commitment item. In order to address the commitment, an engineering calculation was performed. During the review of the calculation, the scenario was discovered.

The scenario assumes that both KH units are generating to the system grid (above 75 MW) when a design basis event occurs with a loss of offsite power. Upon receipt of the emergency start signal, both KH units will separate themselves from the system grid thus rejecting their load and consequently overspeeding. The present KH control scheme allows the

overhead path to be re-energized (if isolated) by the KH unit connected to the overhead path following a time delay (6.5 seconds for KH unit 1 or 4 seconds for KH unit 2). At the end of this time delay the KH units are still overspeeding, which results in above normal frequency output. The effects of above normal frequency is such that the start-up source undervoltage relays will not reset prior to the emergency power switching logic (EPSL) seeking the underground path as the source for an Oconee Loss Of Coolant Accident unit. With the KH unit connected to the underground experiencing the same transient (load rejection) as the KH unit connected to the overhead, frequency output is such that the electrical supply to certain 4kv safety related motors yields a lower starting torque. Therefore these 4kv safety related loads require longer time to accelerate and therefore, could trip on overcurrent.

If the KH unit connected to the overhead was generating to the system grid in excess of 75MW prior to the event, conditions exist such that, with a low delta head at KH, the time allowed to energize the Oconee main feeder busses could not be met.

Since January 1993, KH has had administrative controls restricting its output to the system grid. Also, since October 1992, the KH connected to the underground path is not allowed to generate to the grid. Oconee Engineering reviewed the time period stated above and found that the delta head across the KH turbine, when operating, was greater than 124 feet (Lake level was not below 792 feet). OE determined that under these conditions, since October 12, 1992, the KH units have been operating in a mode which posed no adverse affect on their ability to serve as the emergency power source for Oconee.

Prior to October 12, 1992, administrative control restricting the operation of KH to the system grid did not exist. Therefore, both KH units could operate to the grid without administrative MW limits. For the periods of time, prior to October 12, 1992, when both KH units were generating to the system grid they were operating in a mode which would adversely affect their ability to serve as the emergency power source for Oconee.

In January 1995, during a review of the calculations for a modification to allow a KH unit to generate to the grid at 100% (87MW), the limits of 69 to 75 MW were questioned by the NRC. A review of the existing calculations for KH limits was performed and the values used were determined to be inappropriate. When appropriate values were used, a more conservative limit was established. The new limit was 68 MW at 132 feet gross head. By applying this limit, the KH units would have been technically inoperable for an additional 31 hours 3 minutes over a span of five days since January 1993.

CONCLUSIONS

The design of the Keowee Hydro (KH) units included safety provisions to ensure their reliability as the emergency power source for Oconee Nuclear Station. Although it was recognized the possibility of an over speed trip existed, it is not apparent that the design considered that the shut down auxiliary relay would activate the anti-pump protection for the field breaker circuitry. Also, the design did not consider the result of above normal frequency on the start-up source relays. Therefore, the root cause of this event is Design Deficiency: Unanticipated Interaction of Systems or Components (Design Oversight).

The root cause of the subsequent non-conservative limit is Design Analysis; Analysis deficiency (calculations: mechanical). The calculation used to increase the operating limits utilized analytical methods which did not contain enough conservatism in the treatment of instrument uncertainties. The section of the Engineering Directives Manual (EDM) for calculating instrument uncertainty was not issued until after the original calculation restricting the KH generation to the grid. However, subsequent revisions to this calculation did not utilize the EDM appropriately. The supplemental planned corrective actions should prevent this type deficiency from occurring.

In the past, all three Oconee units have been in operation while this vulnerability existed, however, no event has occurred which resulted in physical inoperability of a KH unit due to this scenario. On October 19, 1992, a loss of switchyard event occurred at Oconee (LER 270/92-04), which resulted in inoperability of KH units for reasons other than overspeed or high frequency trip actuations. Subsequent to that event, a load rejection test was performed on October 25, 1992, where actual unit load was above the conditional operability limit but below the maximum postulated load analyzed in this event. The KH unit did not over speed enough to trip, therefore the KH unit remained operable. This indicates that the calculations used in this analysis are conservative.

A review of past Problem Investigation Reports for the last two years indicates several problems which potentially result in the inoperability of the KH units. Several of these problems involved design deficiencies from a failure to anticipate interaction of components. LER 269/92-19 identified that a postulated fault could cause the KH units to isolate from the overhead path and cause the loss of auxiliary power to the KH unit aligned to the underground path rendering both KH units inoperable. LER 269/92-16 determined that a potential existed for a single fault to cause a loss of both Oconee emergency power paths (overhead and

underground). LER 269/92-11 identified that a postulated failure of the KH underground feeder Air Circuit Breaker (ACB) could cause the KH overhead feeder ACB of the unit aligned to the underground to close tieing both KH units together. As with the potential event addressed in this report, many of these deficiencies were discovered as a result of an ongoing review of the KH electrical system by Oconee Engineering. Because this event is classified as a design deficiency associated with the failure to anticipate interaction of systems or components; it is considered recurring. Because the problem originated with the original design of the KH units, the corrective actions for subsequently identified problems could not be expected to have prevented this situation. Enhancements in the design process, since the original design of KH, should prevent this type of design oversight in the future.

This postulated event did not involve equipment failure and therefore was not NPRDS reportable.

CORRECTIVE ACTIONS

Immediate

1) The Keowee Hydro (KH) units were administratively prohibited from generating to the system grid.

Subsequent

1) A conditional operability evaluation was performed indicating that a KH unit could generate to the system grid at no more than 66 megawatts and no greater than a gross head of 146 feet.

2) On January 15, 1993, a restricted change to the Keowee Modes of Operation procedure (OP/O/A/2000/041) was issued and approved, limiting the KH output to the grid to 60 megawatts at a gross head of no more than 146 feet. It also prevented the dispatcher from using load control. After further evaluation, the Operation procedure was revised to allow a variable output of between 69 and 75 megawatts for a corresponding lake level.

3) The single failure analysis of KH units' power system was completed on January 21, 1993.

4) On March 20, 1995, a corrected calculation was approved using the appropriate statistical methodology and limiting the KH output to 68 megawatts.

Planned

1) Revise the Selected Licensee Commitments to include the Keowee Hydro operational restrictions.

2) Revise the Engineering Directives Manual to clarify the calculation and train applicable personnel on the appropriate use of the manual when performing engineering calculations.

SAFETY ANALYSIS

Keowee Hydro (KH) Station provides an emergency power source to Oconee Nuclear Station for scenarios which involve a Loss of Offsite Power (LOOP). In this event, the design deficiency introduced a failure mode that could have made a KH unit inoperable. If both KH units are inoperable an alternate power alignment for emergency offsite power is through the 100 KV transmission line from Lee Steam Station's gas turbines within 60 minutes. An alternate power alignment is from the Duke electrical grid system via the Central Switchyard.

Final Safety Analysis Report (FSAR) 15.8.3 addresses a simultaneous LOOP event on all three Oconee units. This analysis shows that natural circulation of the reactor coolant system (RCS) [EIIS:AB], turbine driven emergency feedwater system [EIIS:BA], condenser circulating water gravity induced flow, and gravity insertion of the control rods are among the design features provided to ensure the shutdown of the reactor and removal of decay heat for the RCS without offsite power being available. Additionally, FSAR Section 15.8.3 states that "Each reactor can sustain a complete electrical power loss without emergency cooling for about 23 minutes before the steam volume in the pressurizer is filled with reactor coolant" and that "beyond this time reactor coolant will boil off, and an additional 83 minutes will elapse before the boil off will start to uncover the core." Therefore, the 106 minutes given in the FSAR for core uncovering is well beyond the 60 minutes required for establishing emergency power from the Lee Steam Station gas turbines.

The Standby Shutdown Facility (SSF) is a separate seismically qualified building which houses the systems and components necessary to provide an alternate and independent means to achieve and maintain hot shutdown conditions for one or more of the three Oconee units. The SSF was designed to resolve the safe shutdown requirement for fire protection, turbine building flooding, and physical security. The SSF has the capability of maintaining hot shutdown conditions on all three units for approximately three days following a loss of normal AC power.

In the event that a Loss of Coolant Accident (LOCA) occurs simultaneously with a LOOP and power cannot be restored in a reasonable period of time, the emergency core coolant flow would have been delayed beyond what was assumed in the accident analysis. FSAR 15.14.3.3.6 assumes 48 seconds for the time required to begin delivering flow. If this happens, fuel damage could occur which will result in a radioactive release to the containment building. The FSAR states that without Reactor Building Spray [EIIS:BE] and Reactor Building Cooling Systems [EIIS:BK] the reactor building pressure would not exceed the design pressure for the containment following the LOCA. Given the 60 minute time frame to restore power, it is expected that the reactor building leak rate would not exceed the LOCA analysis rate, but dose rates may be higher due to a loss of filtered ventilation until power is restored. A design containment response evaluation has shown that equipment qualification conditions would not be exceeded in under two hours for the expected temperature and pressure resulting from this event. Therefore, reactor building equipment would be operable when unit power is restored.

The event described in this report did not lead to the release of radioactive material, exposure to radiation, or personnel injury. The health and safety of the public was not compromised.