9. **Keowee Hydroelectric Station**

Lake Keowee was the motive and cooling source for the two hydroelectric generators which functioned as Oconee's onsite emergency power. Water flowed from a common penstock, through the turbines and into the tailrace. Cooling flow came from a single pipe located in the penstock. Once the line entered the building housing the hydroelectric units it split into two lines, one for each unit. Cooling flow for the turbine bearing oil cooler, the stuffing box, eight thrust bearing heat exchangers and six generator air coolers came from the unit specific main line.

Inspections findings associated with Keowee were:

a. Corrective Actions

Previous NRC inspections identified that numerous aspects of the quality assurance program had been omitted from Keowee. In response to NRC observations the licensee established an integrated corrective action plan entitled the "Emergency Power Management Plan." Prior to the management plan, the licensee had initiated design study [illegible] to correct design document deficiencies at Keowee. [illegible] was not part of the committed Emergency Power Management Plan.

(1) Under the design study the licensee revised the Keowee Turbine Generator Cooling Water System drawings, KFD-100A-1.1 and KFD-100A-2.1. However, errors were still present on the drawings including an inconsistent piping class break in the supply line to the thrust bearing coolers, the connection of the supply line to the air compressor coolers on Unit 1 was indicated in the 12 inch portion of the main line instead of the 8" portion, a valve downstream of valve [illegible]-3 for Unit 2 was not indicated even though one was present, and the piping downstream of [illegible] to both units was indicated as carbon steel instead of copper. Subsequently, the licensee initiated a condition adverse to quality report to correct drawing errors. 10 CFR 50, Appendix B, Criterion V, "Procedures, Drawings, and Instructions," requires in part that drawings reflect the as-built condition of the facility. This is considered an example of Violation 50-269, 270, 287/93-[illegible]-13C, "[illegible] Procedure/Drawing Content or Procedure Implementation Inadequacies."

(2) Numerous errors existed in the I&C portion of drawings KFD-100A-1.1 and KFD-100A-2.1 and other related I&C drawings. The I&C drawing update portion of the design study was in progress and the licensee had already identified these same discrepancies for resolution. It was noted that the I&C drawing update portion of design study had not been met. As stated previously, the design study was not part of the committed Emergency Power Management Plan. Also, there was no definitive mechanism to assure the I&C drawings (part of the design study) were correct prior to

transferring instrument calibration responsibilities from the Keowee staff to the Oconee staff (part of the Emergency Power Management Plan). Prior to the end of the inspection period the two organizations involved discussed the situation and the licensee indicated that the appropriate integration would occur.

(3) Although the valve positions observed at Keowee were consistent with design requirements, no operating procedures existed for the mechanical systems reviewed. Therefore, no specific procedural controls existed for the throttled, manual valves in the generator air and thrust bearing discharge lines. The Keowee staff was aware of this deficiency and planned to generate procedures in the future. Also, the safety significance of this situation was reduced since these valves were locked throttled and rarely manipulated. However, the creation of these procedures was not identified as a corrective action under the management plan or the design study.

b. Turbine Bearing Oil Cooler Maintenance

During the inspection period, the licensee removed the Unit 2 safety related turbine bearing oil cooler from service to perform the triennial cleaning and inspection. While reinstalling the cooler, a coupling was broken and required replacement prior to completing the installation. Subsequently, a condition adverse to quality report was initiated.

(1) As part of the response to the adverse condition report, engineering personnel discussed unit operability without the turbine bearing oil cooler installed. Engineering personnel verbally determined that the cooler was only needed during extended high ambient temperature conditions (the summer) and unit operability was not affected. However, Nuclear Generation Department Directive 2.8.1, "Problem Investigation Process," step 3.4 directed that adverse conditions requiring engineering assistance be processed as an upper tier adverse quality report which receive a written operability evaluation. Subsequently, the cooler was reinstalled in the unit for emergency operation and PIP 93-0086 initiated for not performing the written operability evaluation. 10 CFR 50, Appendix B, Criterion V, "Drawings, Procedures and Instructions," requires in part that established procedures be followed. This is considered an example of Violation 50-269, 270, 287/93-25-13, "QA Procedure/ Drawing Content or Procedure Implementation Inadequacies."

(2) The work request for oil cooler maintenance specified housekeeping zone 4 for the cleanliness requirements. However, Oconee Nuclear Site Directive 1.4.1, "Cleanliness in Safety Related Areas," Section 3.1, stated the highest level zone designation allowed for safety related equipment was 3. The

difference between level 3 and 4 was zone 4 lacked personnel and tool accountability. A review of numerous completed safety related work requests on other equipment revealed that zone 4 was routinely designated. Contrary to the 10 CFR 50, Appendix B, Criterion V, "Instructions, Procedures and Drawings," requirements for procedure adherence, the licensee did not designate the correct housekeeping zones on safety related work requests. This is an example of Violation 50-269, 270, 287/90-25-10, "QSS Procedure/Drawing Content or Procedure Implementation Inadequacies."

c. Other Observations

(1) The scope of the calibration program was weak. Annunciator actuation was not verified in any of the calibration procedures reviewed and the licensee stated that this was generally the case with all calibration procedures at Keowee. Generator and thrust bearing cooling flow setpoints and the associated timers were not checked. The transmitter for the packing box's local pressure indicator was not being calibrated. The licensee indicated that these procedures would be reviewed for improvement. However, the description of the instruments being calibrated and how they affected system operation in individual calibration procedures was complete, accurate and well written.

(2) Historically, the mechanical systems at Keowee performed well. Little corrective maintenance was needed. Preventative maintenance was appropriate and consistent with operating experience and vendor manual recommendations where applicable. The hydroelectric station was operated almost daily. The daily operation functioned as a performance test in many respects and placed much of the mechanical systems under no worse conditions than would be experienced when operating as an emergency power source. However, no equipment performance trending, especially of the safety related heat exchangers, was being performed.

(3) One common mode failure vulnerability was identified. Within the common stretch of piping for cooling both units' mechanical support systems was a manual gate valve. Prior to the end of this inspection the licensee locked the valve open.

(4) Minimal housekeeping and material condition discrepancies were observed. Personnel were knowledgeable of their safety-related duties.

10. Miscellaneous Matters

Findings not tied to a particular system were:

a. The DBD concept and the associated testing acceptance criteria was a good initiative by the licensee. Generally, the DBDs provided the best description of the system, the system's function, the licensee's understanding of the licensing bases and the design requirements. There were, however, some implementation weaknesses resulting in errors and discrepancies in the DBDs. Also, the licensee partially attributed the lack of reconciliation and failure to update the SSF calculations to the lack of a completed DBD for the SSF.

b. There were FSAR omissions which could have clarified and more completely explained the actual design parameters for select components. An example was the flow to the RBCUs which the FSAR discussed as 1400 gpm whereas, certain testing configurations only exhibited 800 gpm flow and the system was considered as performing its design function.

c. Offsite review committee minutes contained the proper content, indicated that a proper quorum was present and met within the required frequency. Resumes indicated that personnel qualification requirements were met. Committee performance was consistent with regulatory requirements.

d. Design calculation OSC-3620, Establish an Administrative Minimum Lake Level for Keowee, contained unsubstantiated and nonconservative assumptions, and a variety of other calculational irregularities. The licensee indicated that the calculation was a theoretical "look see" calculation and the title was misleading. There were no other calculations associated with minimum Lake Keowee water volume. Further licensee initiatives to perform an actual analytical calculation to establish a minimum Lake Keowee level to assure adequate water volume is maintained is Inspector Follow-up Item 50-269, 270, 287/93-25-15, "Administrative Controls for Lake Keowee."

11. <u>Follow-up on Previously Identified Items</u>

(Open) Unresolved Item 50-269, 270, 287/93-13-03, "ECCS System Design and Testing": Sections 5.a.3, 5.a.7, 6.b.1, 6.a., and 6.b.2 discussed different aspects of this matter. However, further NRC review is necessary to ensure any regulatory action taken is consistent with the original licensing requirements.

12. <u>Exit Interview</u>

The team conducted an exit meeting on December 14, 1993, at the Oconee Nuclear Power Station to discuss the major areas reviewed during the inspection, the strengths and weaknesses observed, and the inspection results. Licensee representatives and NRC personnel attending this exit meeting are documented in Appendix A of this report. The team also discussed the likely informational content of the inspection report. The licensee did not identify any documents or processes as proprietary.

There were dissenting comments at the exit meeting associated with recommended regulatory action concerning the inadequate NPSH conditions in the LPSW pumps and the possible regulatory action involving the lack of dual turbine building isolation in the LPSW system. The licensee indicated a thorough review of the inspection findings would be necessary to ascertain the appropriate responses or corrective actions to the issues identified. Also, on February 3, 1994, NRC management discussed the unresolved LPSW turbine building isolation issue with the licensee via telephone.

ITEM NUMBER	STATUS	PARAGRAPH	DESCRIPTION
93-25-01	Open	3	DEV - Failure to Adequately Perform SWS GL Actions
93-25-02	Open	6.a.1	UNR - Turbine Building Isolation Single Failure Vulnerabilities
93-25-03	Open	6.b.1, 6.e, 5.a.4, 5.c.1, 5.c.2, 7.b.2	VIO - Failure to Perform Adequate Calculations and Evaluations to Support Facility Design
93-25-04	Open	4.c.3, 6.b.2	VIO - Inadequate Evaluation of Conditions Adverse to Quality by Engineering
93-25-05	Open	4.d	IFI - Additional Validation of RBCU Evaluation Inputs
93-25-06	Open	4.f.2, 5.c.3, 8.b.3	IFI - Actions to Improve Operator Responses to Abnormal Events
93-25-07	Closed	5.a.1	NCV - Inadequate Classification of Siphon Support Equipment for LPSW Supply
93-25-08	Closed	5.a.5, 7.c.1.c, 7.c.2.c	VIO - Inadequate SSF and ECCW Testing
93-25-09	Open	5.b.2	IFI - CCW Pump NPSH Information

93-25-10	Open	8.c.1	DEV - Inadequate HPSW SSD Test
93-25-11	Open	7.a.1, 7.a.2	IFI - Jocassee Dam Failure IPE Inaccuracies
93-25-12	Open	7.b.1, 8.a	VIO - SNS Procedure/Drawing Content or Procedure Implementation Inadequacies
93-25-13	Closed	8.c	DEV - Omissions of LPSW Check Valves from IST Program
93-25-14	Open	8.d.2	IFI - Review of Revised ASW Pump NPSH Calculation
93-25-15	Open	10.d	IFI - Administrative Controls for Lake Keowee
93-13-03	Open	11	UNR - ECCW System Design and Testing

APPENDIX A

Duke Nuclear Power Plant

Persons Contacted

* [illegible]. Azzarello, Mechanical/Nuclear Engineering
* S. Baldwin, Systems Engineer - Raw Water
* H. Barron, Station Manager - Oconee Nuclear Station
* R. Colaianni, Nuclear Licensing - General Office
* D. Coyle, Systems Engineering Manager
* J. Davis, Safety Assessment
* D. Dolan, Mechanical/Nuclear Engineering Manager
* P. Farish, Nuclear Engineer - PRA
* [illegible]. Grayson, Mechanical/Nuclear Engineering
* J. Hampton, Vice President - Oconee Nuclear Station
* [illegible]. Harling, Mechanical/Nuclear Engineering
* [illegible]. Harris, Senior Engineer - Systems Engineering
* J. Hemminger, Mechanical/Nuclear Engineering
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* [illegible]. Hubbard, Component Engineer
* [illegible]. Kelley, Civil Engineering
* [illegible]. Ledford, Instrumentation and Controls
* T. Ledford, Electrical Engineering
* [illegible]. LeDotte, Operations
* [illegible]. McAninch, Systems Engineer
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U.S. Nuclear Regulatory Commission

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* W. Rogers, Team Leader
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* A. Gibson, DRS Division Director
* M. Lesser, DRP Section Chief
* L. Wiens, NRR Licensing Project Manager
* P. Harmon, Senior Resident Inspector
* [illegible]. Partner, Resident Inspector
* L. Keller, Resident Inspector

* Indicates those present at the exit meeting on December 14, 1993

APPENDIX B

Generic Letter 89-13 Action Items

1. **Biofouling Control and Surveillance Techniques**

Action I of GL 89-13 requested licensees to implement and maintain an ongoing program of surveillance and control techniques to significantly reduce the incidence of flow blockage problems as a result of biofouling. The actions requested included intake structure inspections, periodic SWS flushing/flow testing and chemical treatment of the SWS.

SWS Intake Structure Biofouling Inspections - The licensee had developed a program to monitor, sample, and analyze the intake structure for Asiatic clams. This program was conducted once per refueling cycle or annually. The program had identified the presence of clams but at a low population density. There was no increasing trend in the number of clams. Also, some minor corrective maintenance in the LPSW, SSF and HPSW systems had been due to clam presence. The team considered the program adequate.

Periodic SWS Flushing/Flow Testing - The licensee had implemented a flow testing and piping inspection program to identify reduced and blocked flow to equipment. Hydraulic models had been developed for the ASW, SSF and LPSW systems. No periodic flushing program was established.

LPSW - The licensee's efforts had been very effective in identifying inadequate flow to numerous pieces of LPSW equipment through small bore piping. The hydraulic model had been fully benchmarked. However, instrument impulse lines had been excluded from the program. The corrective maintenance history indicated repeated instrument failures due to flow blockage. Subsequent actions under the SWS Steering Committee recognized the situation and prompted revision to the instrument calibration procedures to include flushing. Revision of the procedures was scheduled for completion in March, 1994. Also, without a flush program the LPSW crosstie line between Units 1/2 and 3 received no evaluation. As a result of other regulatory correspondence this section of stagnant piping was to be inspected and flushed at the next refueling outage.

Other Systems - The benchmarking of the SSF hydraulic model was incomplete with respect to the SSF diesel service water pump portion of the flow model and the SSF ASW pump discharge piping to the steam generators. The hydraulic model of the ASW system excluded the piping to the HPI pump motor coolers. Also, the flow downstream of the discharge valves to the steam generators had not been benchmarked. No program had been developed for the Keowee SWSs.

SWS Chemical Treatment - The licensee's biofouling monitoring program did not indicate a level of clam infestation that would warrant chemical treatment.

II. Monitoring Safety Related Heat Exchanger Performance

Action II of GL 89-13 requested licensees to implement a test program to periodically verify the heat transfer capability of all safety related heat exchangers cooled by the SWS. The test program was to consist of an initial test program and a periodic retest program.

In response to this item, the licensee established a performance monitoring program for LPSW heat exchangers. The program was a combination of inspections, performance tests and computer modeling. The program specifics and the team assessment were:

Low Pressure Injection Coolers - These coolers were tested during each refueling outage when the coolers were placed in service for decay heat removal. This test was conducted at a heat load less than would be experienced during accident conditions. A fouling factor was developed based on the test results and compared to historical data to identify any adverse trend that would indicate increasing fouling.

The team considered the LPI cooler performance monitoring as adequate.

Reactor Building Cooling Units - To determine operability of the RBCUs, the licensee used a computer code to predict the heat removal under accident conditions based on heat removal data taken during normal operations.

The team had two concerns with this process. The first concern was the ability of the computer code to predict RBCU heat removal under accident conditions. This computer code was divided into two separate calculations. First, a fouling factor was calculated based on data taken during normal operations. The fouling factor was then used to predict the heat removal during accident conditions. Because the airflow distribution was non-uniform, the licensee used another computer code that predicted the airflow distribution based on the data taken during normal operating conditions. This computer code was obtained from a vendor and the licensee relied on the vendor's benchmarking of the computer code. A non-regulatory required airflow test performed in 1987, indicated the airflow was substantially less than assumed in the computer code; however, the licensee stated this test was invalid due to significant air side fouling. The ability of this computer code to accurately predict the air flow distribution has a direct effect on RBCU operability.

The second concern was the accuracy of LPSW flow measurement. The determination of RBCU heat removal capability relied on the accuracy of the LPSW flow measuring device which was an installed orifice. The inspectors reviewed documentation and photographs that showed the LPSW

piping had fouled at various points. A reduction in the diameter of the piping in the area of the orifice would result in higher indicated LPSW flow. The licensee had performed a special test to determine the accuracy of the LPSW flow instrumentation by subtracting the indicated flows from other LPSW supplied components from the total LPSW flow; however, this resulted in unrealistically high LPSW flow to the RBCUs. The licensee also performed testing of the LPSW pumps using ultrasonic flow measurements which indicated substantially lower flows than the installed instrumentation. The licensee stated this was a special test for gathering data and did not constitute a valid performance test.

The team concluded that without field validation of the RBCU airflow distribution and stronger assurance of flow element accuracy, the RBCU computer results were questionable.

Small LPSW Heat Exchangers - Periodic flow verifications were performed. The team had no concerns.

The Main Condensers - The main condenser were cleaned and inspected each refueling outage. The team had no concerns.

SSF Diesel Engine Jacket Water Heat Exchangers - The ISI requirements for the SSF diesel lube oil and jacket water coolers was on a 10 year cycle verses the 5 year criteria in the GL. No other monitoring program was in place. The team considered the performance monitoring of these heat exchangers inadequate.

SSF HVAC Condensers - A semiannual preventive maintenance activity for the SSF air handling unit required cleaning of the condenser tubes if the head saturation temperature was more than 10°F higher than the outlet temperature. The licensee stated the condenser tubes had not been cleaned based upon the above conditions. The team had no concerns.

Keowee - No formal performance monitoring of the SWS heat exchangers had been established. In the licensee's informal SWS Program Manual the Keowee heat exchangers were discussed indicating that normal operation of Keowee by operators would identify any problems. The team considered the present monitoring methods as inadequate. First, the instrumentation that would be relied upon to inform the operators of a problem was not being fully maintained as discussed in Section 9.c.1. Second, there was no documented trending or operator rounds program in place for the SWS heat exchangers.

In summary the heat exchanger performance monitoring program had been inadequately implemented, mainly due to a lack of scope.

III. Routine Inspection and Maintenance

Action III of GL 89-13 requested that licensees implement a routine inspection and maintenance program for open-cycle SWS piping and components. This program was to ensure that corrosion, erosion, protective coating failure, silting, and biofouling would not degrade the performance of the safety related systems supplied by the SWS.

In response to this action item, the licensee had established periodic inspections, cleaning as needed, and piping replacements.

Piping - Design Study OSDS-252 evaluated SWS piping configurations for the sections with the highest potential for corrosion. The criteria for determining the most probable area of corrosion was piping material, piping diameter, duration of flow through the pipe and velocity of flow. Corrective action in the form of stainless steel piping replacements was accomplished in a number of the potential corrosion areas. Also, an aggressive program of pipe section inspections were in place. With the help of the SWS Steering Group a Service Water Piping Corrosion Management Program Manual dated October 29, 1993, had been developed to assure appropriate management control and attention were maintained for this effort. This piping inspection program did not include the Keowee SWSs. No other program encompassed Keowee.

The team considered the piping inspection and replacement program excellent except in terms of scope. This caused the licensee's actions to be inadequate due to the omission of the Keowee SWS piping from the program. For the systems where licensee actions were applied the maintenance program was adequate except in select equipment associated with the LPSW system and the CCW pumps. These pieces of equipment suffered from inadequate safety classification that reduced the rigor of assurance that the materials used in repair activities were proper and the work was performed properly. This also included the rigor used in post maintenance testing.

Pumps and Valves - Following the 1987 SITA a preventive maintenance schedule for the LPSW pumps was established. However, pump rebuild and refurbishment could not be accomplished within the TS LCO time allowed which caused maintenance constraints on the shared Unit 1/2 LPSW system. Pump performance deficiencies had centered around high temperatures in the stator of the motors. The CCW pumps were experiencing long term vibration/fatigue with adequate corrective actions being taken to address the issue. Valves were being adequately maintained.

Heat Exchangers - Periodic inspections and cleaning frequencies had been established for a number of heat exchangers.

IV. Design Function Verification and Single Failure Analysis

Action IV of GL 89-13 requested to licensees confirm that the SWS would perform its intended function in accordance with the licensing basis for the plant. This confirmation was to include a review ensuring requisite safety functions were accomplished even with the failure of a single active component.

In response to this action item, the licensee utilized the 1987 self-assessment of the LPSW system and the ECCW support (first siphon) to the LPSW system. Also, design calculations were performed to verify that safety functions were accomplished with a single failure occurring.

The team considered the LPSW design review of the 1987 self-assessment as thorough and comprehensive. However, some of the corrective actions did not adequately address the issues identified such as isolation of the LPSW turbine building header. Resolution to problems identified while implementing corrective actions to the self-assessment were occasionally inadequate as with the inadequate NPSH for the LPSW pumps and the postulated waterhammer in the RBCU discharge piping. Also, a number of corrective actions were untimely such as safety classification of the CCW pumps and, seismic suitability of the vacuum priming and NPSW systems which support ECCW (first siphon) operation. The self-assessment did not include the ASW, SSF SWS, Keowee, HPSW, and the other operating modes of the CCW system (second siphon and loss of Keowee Dam). In summary the licensee's corrective actions to this action item were inadequate.

V. Training

Action V of GL 89-13 requested licensees to confirm that maintenance practices, operating and emergency procedures, and training involving the SWS were adequate to ensure safety related equipment cooled by the SWS would function as intended.

In response to this action item the licensee evaluated LPSW maintenance practices, all LPSW operating (normal and abnormal) procedures, and LPSW training, as part of the 1987 self-assessment. Beyond this specific review, the licensee considered the established personnel qualification 2 year procedure review, 10 CFR 50.59 safety evaluation, qualified reviewer, operating experience and operator requalification programs as adequate to address this action item.

The team identified LPSW weaknesses which were within the scope of this aspect of the 1987 self-assessment. Examples of these weaknesses included the lack of an abnormal procedure addressing inadequate LPSW flow and, limited operator training on containment temperature concerns during an accident. Also, beyond the specific self-assessment, the established generic programs did not identify numerous weaknesses. Examples of these weaknesses included the lack of operating procedures

for Keowee SWSs, weak operator direction in response to the Keowee Dam failure, the inability to verify flow to the steam generators from the ASW system and incomplete verification that ASW actions could be accomplished within the 40 minute required timeframe. A review, similar to that performed on the LPSW system, of Keowee would almost certainly have identified the lack of key quality assurance elements in the operation, maintenance and training associated with the Keowee hydroelectric station years before operational events in 1992 brought them to light. In summary the licensee's corrective actions to this action item were inadequate.

APPENDIX C

Acronyms and Abbreviations

ANSI	American National Standards Institute
ASW	Auxiliary Service Water
BWST	Borated Water Storage Tank
CCW	Condenser Circulating Water
CC	Component Cooling Water
CGD	Commercial Grade Dedication
DBD	Design Basis Document
DEV	Deviation
DPC	Duke Power Company
ECCW	Emergency Circulating Cooling Water
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EP	Emergency Procedure
EPRI	Electric Power Research Institute
ESF	Engineered Safety Feature
EFW	Emergency Feedwater
EWST	Elevated Water Storage Tank
FSAR	Final Safety Analysis Report
GL	Generic Letter
GPM	Gallons per Minute
HPI	High Pressure Injection
HPSW	High Pressure Service Water
HVAC	Heating, Ventilation, and Air Conditioning
IFI	Inspector Follow-up Item
IPE	Individual Plant Examination
ISI	Inservice Inspection
IST	Inservice Test
LCO	Limiting Condition for Operation
LER	Licensee Event Report
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
LPI	Low Pressure Injection
LPSW	Low Pressure Service Water
MTOTC	Main Turbine Oil Temperature Control
NCV	Noncited Violation
NPSH	Net Positive Suction Head
PRA	Probabilistic Risk Assessment
PSIA	Pounds per Square Inch Absolute
PSIG	Pounds per Square Inch Gauge
RBCU	Reactor Building Cooling Unit
RCS	Reactor Coolant System
SBO	Station Blackout
SER	Safety Evaluation Report
SSF	Safe Shut Down Facility
SWS	Service Water System
SWSOPI	Service Water System Operational Performance Inspection
TDEFW	Turbine Driven Emergency Feedwater
TDH	Total Developed Head
TS	Technical Specification
URR	Unresolved
VIO	Violation