APPENDIX

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

NRC Inspection Report No.: 50-498/94-04
50-499/94-04

Licenses: NPF-76
NPF-80

Licensee: Houston Lighting & Power Company
P.O. Box 1700
Houston, Texas 77251

Facility Name: South Texas Project Electric Generating Station (STPEGS), Units 1 and 2

Inspection At: Matagorda County, Texas

Inspection Conducted: January 3-7, 1994

Inspectors: Mark A. Satorius, Project Engineer, Project Branch A, Division of Reactor Projects
D. M. Garcia, Resident Inspector, Project Branch A, Division of Reactor Projects
S. R. Jones, Reactor System Engineer, Plant Systems Branch, Division of Systems Safety and Analysis, Office of Nuclear Reactor Regulation

Approved: W D Johnson 2/9/94
W. D. Johnson, Chief, Project Branch A Date

Inspection Summary

Areas Inspected (Units 1 and 2): Routine, announced inspection to review the actions taken to improve the reliability of the essential chillers.

Results (Units 1 and 2):

- Restart Issue 12, as identified in NRC Inspection Report 50-498/93-31; 50-499/93-31 was considered resolved.
- The inspectors concluded that the cold weather enhancement modifications and the operating procedural changes that have been made to the essential chillers will provide additional assurance that these components will perform their as-designed safety-related functions (Sections 2.3 and 4.1).

- A noncited violation for failing to follow procedures was identified (Section 3.1).

- The inspectors concluded th [illegible] tenance backlog associated with the essential chillers con [illegible] safety significant outstanding service requests or modifi [illegible] that were not scheduled for completion during the current outage; [illegible] the inspectors determined that it would challenge the licensee [illegible] ete all of the outage scope prior to the end of the outage and that previously scoped outage work may need to be deferred (Section 4.2).

- The licensee has taken positive steps to improve the quality and quantity of maintenance training provided to workers (Section 4.3).

- The inspectors concluded that licensee management had been satisfactory in their identification and correction of problems associated with the essential chillers and the chill water system (Section 7).

Summary of Inspection Findings:

- Inspection Followup Item (IFI) 498;499/9404-01 was opened (Section 2.2.2.2).

- IFI 498;499/9404-02 was opened (Section 2.2.2.2).

- IFI 498;499/9331-07 was reviewed concerning the essential chiller issues and remained open (Section 5.1).

- IFI 498;499/9331-08 was reviewed and remained open (Section 5.2).

- IFI 498;499/9331-09 was reviewed and remained open (Section 5.3).

- Violation 498;499/9224-01 was closed (Section 6.1)

- IFI 498;499/9224-03 was closed (Section 6.2).

- Violation 499/9226-03 was closed (Section 6.3).

- Example 2 of Violation 498;499/9235-02 was closed (Section 6.4).

- Violation 498;499/9235-03 was closed (Section 6.5).

- IFI 498;499/9331-20 was closed (Section 6.6).

- IFI 498;499/9331-21 was closed (Section 6.7).

- IFI 498;499/9331-44 was closed (Section 6.8).

- IFI 498;499/9331-45 was closed (Section 6.9).

- IFI 498;499/9331-74 was closed (Section 6.10).

Attachment:

- Persons Contacted and Exit Meeting

DETAILS

1 BACKGROUND

Both units at STPEGS were shut down in early February 1993 and remain shutdown as a result of numerous broad scope problems identified by the NRC and the licensee.

NRC Inspection Report 50-498/93-31; 50-499/93-31, issued on October 15, 1993, identified 16 Restart Issues that required resolution prior to the restart of Unit 1. In addition to these Restart Issues, a number of items related to these Restart Issues were identified. The purpose of this inspection was to determine the licensee's effectiveness in resolving Restart Issue 12, "Essential Chiller Reliability." The specific concern of this Restart Issue was focused around the chillers being capable of functioning for extended periods during low heat load conditions and reduced ultimate heat sink temperatures.

2 ESSENTIAL CHILLER OPERATIONS (92720)

The inspectors conducted a review of the essential chillers, and their ability to operate at different loads and under various ambient conditions.

2.1 System Description

Each unit at STPEGS is equipped with three essential chilled water system trains, which provide cooling for the control room ventilation system, the electrical auxiliary building (EAB) ventilation system, and various individual air handling units providing room cooling. The system's safety function is to maintain the temperatures in these areas at acceptable levels to ensure the operability of safety-related systems. Each chilled water system train is cooled by a 150-ton essential chiller and a 300-ton essential chiller arranged in parallel. Based on vendor documents, the essential chillers are capable of operating at loads from 10 percent of rated capacity to loads in excess of 100 percent of rated capacity, depending on chiller condenser water supply temperature and other conditions. The essential chillers reject heat through the chiller condensers to the essential cooling water (ECW) system, which in turn transfers the heat to the essential cooling pond.

Under normal operating conditions, heat from the chilled water system vaporizes the refrigerant within the evaporator. The refrigerant vapor is drawn off the evaporator and compressed by a centrifugal compressor. The refrigerant, now at a higher pressure, is condensed by rejecting heat from the refrigerant vapor to the ECW system in the condenser. The condenser is physically located above the evaporator. The liquid refrigerant in the condenser is returned to the evaporator through a float valve. In order for the liquid refrigerant flow to exist, the condenser pressure must be maintained higher than the evaporator pressure.

The refrigerant side of the essential chiller condenser is a saturated system at a temperature slightly above the ECW essential chiller outlet temperature. Therefore, the pressure within the condenser is affected by the ECW supply temperature and the ECW differential temperature across the condenser. The ECW differential temperature is in turn affected by the ECW flow rate and the heat rejected to the ECW system in the condenser.

Similarly, the refrigerant side of the evaporator is a saturated system at a temperature slightly below the chilled water system outlet temperature. Therefore, evaporator pressure is primarily determined by the chilled water system outlet temperature.

The essential chiller condenser cooling water (in this application, ECW) supply temperature is typically higher than the chilled water system outlet temperature, ensuring that the condenser is at a higher pressure than the evaporator. However, the ECW supply temperature decreases during occasional periods of cold weather, causing the condenser refrigerant pressure to also decrease. The essential chiller attempts to control chilled water system outlet temperature and, therefore, evaporator pressure, at a nearly constant value for a given load by controlling the flow of refrigerant vapor from the evaporator to the compressor with prerotation vanes located at the inlet to the compressor. When chilled water system outlet temperature is below the setpoint, the prerotation vanes close to reduce the flow rate of refrigerant vapor from the evaporator. This action reduces the rate of heat removal from the chilled water system, and chilled water outlet temperature increases.

If condenser refrigerant pressure is not sufficiently high relative to evaporator pressure to maintain stable operation of the essential chiller, the essential chiller will be shut down on low evaporator temperature or pressure. Automatic shutdown of the essential chillers is more likely under low heat load conditions because refrigerant vapor is condensed at a lower rate in the condenser, which results in a reduced ECW differential temperature across the condenser and a reduced condenser pressure. When condenser pressure is lower than evaporator pressure, no liquid refrigerant is added to the evaporator. The continued withdrawal of refrigerant vapor by the compressor under that condition causes evaporator temperature to decrease.

The ECW piping from the essential chillers was originally provided with electrohydraulic controlled ECW essential chiller outlet valves. The electrohydraulic actuators were designed to throttle the flow of ECW as the supply temperature decreased to control condenser pressure and maintain stable operation of the essential chiller. However, due to excessive maintenance and control problems with the electrohydraulic actuators, the valve actuators were removed and replaced with manual operators under temporary modifications. The butterfly valves associated with the manual operators were large and do not provide acceptable control at low flow rates. The licensee has subsequently installed a bypass line, including flow instrumentation and a throttle valve, around each ECW essential chiller outlet valve under Modifications 93-049 and 93-050 for Units 1 and 2, respectively. The modification is intended to permit the precise control of ECW flow necessary for stable essential chiller operation when the essential cooling pond temperature is low.

The essential chiller operation at low heat loads is also limited by compressor surge. Compressor surge occurs when the compressor is operating at low volumetric flow capacity. When the volumetric flow through the compressor is low, the compressor may not be capable of continuously producing sufficient discharge head to overcome the pressure at the discharge of the compressor. Because the refrigerant vapor is compressible, the flow may reverse momentarily when the compressor discharge head is low. The resulting periodic flow reversal of the refrigerant, which is characteristic of compressor surge, causes vibration that may eventually damage the compressor. The essential chillers are equipped with prerotation vanes and a hot gas bypass valve to help maintain compressor operation in a stable state. Closure of the prerotation vanes is limited with the hot gas bypass valve closed in order to ensure sufficient compressor flow to prevent a surge is available. When the prerotation vanes reach this limit and a further reduction in refrigerant flow from the evaporator is necessary, the hot gas bypass valve opens to recirculate refrigerant from the compressor discharge back to the compressor suction. The hot gas bypass valve provides the capability to operate the essential chillers in a stable state at loads as low as 10 percent of rated capacity.

2.2 Licensee Evaluation of Essential Chiller Operation

The licensee computed the essential chiller load for each train of the chilled water system under various conditions, including the maximum and minimum expected chiller load with low ECW supply temperatures. A similar evaluation had been conducted prior to licensing during the process of chilled water system design. That evaluation had determined that the system was capable of remaining operable with various ECW supply temperatures; however, due to chiller reliability questions and the lack of a rigorous analysis of chiller performance under low ECW temperatures, this second analysis was performed. The licensee documented the results in Calculation MC-6412. In addition to analyzing chiller performance with low ECW supply temperatures, Calculation MC-6412 and other analyses performed by the licensee did not provide any basis that would conclude that the essential chillers were previously incapable of performing their safety-related function. The installation of Modifications 93-049 and 93-050 improved chiller performance and removed the previous burden on operators that had been required to repetitively adjust ECW flow in order to maintain chiller performance.

Calculation MC-6412 determined that the total calculated chiller load included steady-state, in addition to transient chiller loading resulting from transfer of the stored heat of the safety-related heat loads to the chilled water system following realignment of the system on a safety injection signal from the normal system configuration. For the maximum chiller heat load case, the licensee considered two separate accident scenarios: the first being a loss of coolant accident (LOCA) as the initiating event and the second a LOCA coincident with a loss of offsite power (LOOP). For this maximum chiller loading case, Calculation MC-6412 addressed the following limiting single failures: loss of one EAB supply fan; loss of one chilled water system train; and failure of a safety injection train. The licensee's calculation determined that a LOCA initiated with a failure of the safety injection Train A from steady-state operation of a single train of the chilled water system produced the maximum chiller loading under low ECW supply temperature operation. For the minimum chiller loading case, the licensee's calculation concluded that a LOOP without a single failure was more limiting than a LOOP with a single failure. These most limiting failures were utilized throughout the licensee's evaluation.

2.2.1 Chiller Operation at ECW Temperatures Greater than 60°F

In Calculation MC-6412, the licensee concluded that, with no changes from the current mode of operation and with ECW supply temperatures above 60°F, the installed chiller capacity of 450 tons per train (300-ton and 150-ton chillers operated in parallel) was adequate to maintain an acceptable chilled water outlet temperature for both maximum and minimum chiller loads. For the maximum chiller loading case, when transient loading was included, the total chiller loading at the design chilled water outlet temperature exceed 450 tons for a period of time. However, the licensee determined that safety-related heat loads were acceptably serviced at this short period of higher chilled water temperatures. The licensee based this conclusion on an analysis, which determined that actual heat removal capacity of the chillers exceeds the specified design value. Licensee communications with the chiller vendor confirmed this conclusion. The licensee concluded that the chiller will not shut down on high condenser pressure because peak chiller loading occurs on startup before accident heat loads raise the ECW supply temperature to higher levels and near the design value. Computed steady-state chiller loads were well below train capacity for the evaluated design basis events and, therefore, conservative.

2.2.2 Chiller Operation at ECW Temperature Between 60°F and 42°F

Calculation MC-6412 also evaluated chiller operation at ECW supply temperatures below 60°F, but above 42°F. This calculation determined that certain actions would enhance the chilled water system performance under these lower ECW supply temperature conditions. The changes for low ECW supply temperatures included: throttling ECW flow to the 300-ton chiller to 240 gallons per minute by positioning and locking in place the bypass valve around the ECW discharge valve installed by Modifications 93-049 and 93-050; limiting the ECW flow to the 150-ton chiller to prevent significant heat transfer between the ECW and chilled water systems by natural circulation of the refrigerant within the idle chiller and to reduce micro-biological induced corrosion; electrically locking out the 150-ton chiller to prevent an automatic start, thereby increasing the loading on the 300-ton chiller; and adjustment of the chilled water temperature control for the 300-ton chiller to control chilled water outlet temperature in a range from 40°F at 10 percent of rated load to 48°F at rated load in order to limit transient loading on the start of an idle chilled water system train. In addition, chilled water flow was maintained through the idle 150-ton chiller to further limit transient loading by mixing the chilled water flow from the operating 300-ton chiller and the idle 150-ton chiller to increase the temperature of the chilled water supplied to the cooling coils. The licensee's analysis concluded that, given these changes, increased chiller performance would be attained in this band of ECW temperatures. In addition, with these operational changes, the analysis determined that maximum chiller load conditions were also satisfied. The licensee documented these changes in Unreviewed Safety Question Evaluation Number 93-0036 for Modifications 93-049 and 93-050, which the inspectors reviewed.

The analysis also established that in the ECW supply temperature band of 60°F to 69°F the chiller would perform acceptably either configured in the manner described in Section 2.2.1 of this report or as just described in the previous paragraph. This would allow operators a band to facilitate shifting chiller operation from the normal line-up to a colder ECW supply temperature line-up.

2.2.2.1 Maximum Chiller Loading

While reviewing this portion of the licensee's analysis, the inspectors noted that, for the most limiting case of maximum chiller load, the computed transient chiller load was based on initial, preaccident control room temperature at the upper limit of Technical Specification allowed values, which was 78°F. This assumption was conservative and would place the maximum transient load on the chilled water system following the postulated accident. However, the inspectors also noted that temperatures of other rooms cooled by individual air handling units were assumed to be below the design maximum values. Consequently, transient heat removal from the EAB in this case was found to be slightly below the steady-state heat generation rate. However, the inspectors found this assumption to be realistic. Overall, the licensee's calculation indicates that the total steady-state chiller load for the same initiating event was approximately equal to the computed transient chiller load, and both the transient and steady-state maximum chiller loads were bounded by the rated capacity of the 300-ton chiller. The inspectors concluded that the licensee's approach was acceptable.

2.2.2.2 Minimum Chiller Loading

In Calculation MC-6412, the licensee calculated the minimum chiller loading from initial equilibrium conditions, with two chilled water system trains in service for a LOOP without a single failure. The heat removal rate from the EAB was based on the steady-state value, and the removal rate from the control room was based on an initial temperature of 72°F. Heat removal from the other air handling units was neglected to conservatively model the minimum chiller load. Based on the additional transient conduction available from the Train C structure, the licensee concluded that the Train B computed heat load of 108 tons would be the minimum chiller load during the first 30 minutes following the initiating event. The licensee determined that the minimum steady-state chiller load would be about 90 tons.

The inspectors noted that Calculation MC-6412 did not include conductive heat losses from the EAB, which the inspectors considered would occur during periods of cold weather. In order to resolve this concern, the licensee provided Calculation MC-5159, which computed heater capacity needed to compensate for conductive losses. Based on this calculation, the inspectors determined that the minimum chiller load for Train B should be reduced by approximately 8 tons in order to compensate for conductive heat losses at the assumed EAB and outdoor temperatures used in Calculation MC-6412. When applied to the original calculated transient chiller load of 108 tons and the minimum steady-state chiller load of 90 tons, this resulted in a conservative minimum transient load of 100 tons, 30 minutes following the initiation of the accident, and a steady-state load of 82 tons following the initiation of the accident.

In Calculation MC-6429, the licensee modeled chiller evaporator and condenser performance. The results of the model indicated that a chiller load of 100 tons could be accommodated at an ECW supply temperature of 42°F without an automatic chiller shutdown or unstable chiller operation. The inspectors questioned the licensee concerning the chiller's ability to operate in a stable manner without operator action greater than 30 minutes following the initiating event when the heat loads would be expected to stabilize at a steady-state load as low as 82 tons. The licensee stated that they considered there was sufficient margin in their calculations to support steady-state chiller operation at 82 tons; however, they would consider providing additional procedural guidance to operators. This issue will be tracked for future followup as an IFI (498/9404-01; 499/9404-01).

The inspectors noted that the transient minimum heat load was based on an initial control room temperature of 72°F; any initial temperature less than 72°F would be nonconservative. Review of the licensee's operating and administrative procedures addressing the control room envelope revealed that there was no specific guidance or requirement for maintaining minimum control room temperature other than for operator comfort. Although the licensee's analysis contained conservatisms that increased the margin of the calculation, the inspectors considered the use of 72°F in the analysis, without administrative controls in place to ensure the control room was bounded by a lower temperature limit, a weakness. This issue will be tracked for future followup as an IFI (498/9404-02; 499/9404-02).

2.2.3 Chiller Operation at ECW Temperatures Less Than 42°F

The licensee further evaluated chiller operations at ECW supply temperatures less than 42°F in order to provide the basis for continued chiller operation at those extreme supply temperatures. Historical information indicated that ECW temperatures in that low range were rare, with an occurrence approximately once each 15 to 20 years, and further less likely if one or both units were operating and adding heat to the essential cooling pond.

The licensee's evaluation concluded that chiller performance could be maintained by configuring and operating the chillers in the manner described in Section 2.2.2, with the exception that an operator would be required to be stationed to manually throttle the ECW supply flow, maintaining condenser pressure within prescribed limits. The analysis further concluded that at ECW supply temperature less than 37°F, chiller operation was not reliable and that the essential chillers would be required to be declared inoperable.

2.3 Conclusions

The inspectors concluded that the licensee's calculation had demonstrated that the chillers will perform acceptably under maximum and minimum loading conditions after implementation Modifications 93-49 and 93-50, as described in Unreviewed Safety Question Evaluation Number 93-0036. However, the inspectors noted that additional controls appeared necessary to justify assumptions in the calculations. These controls consisted of providing additional procedural guidance to operators to ensure acceptable chiller performance 30 minutes or greater following the initiating event at a minimum steady-state load and administratively maintaining control room temperature above 72°F when operating under low ECW supply temperatures in order to satisfy assumptions used in computing the minimum chiller loading.

3 MODIFICATION TESTING ON ESSENTIAL CHILLER 12B (62703)

On January 5, 1994, the inspectors observed portions of the postmodification testing on Essential Chiller 12B following the installation of Modification 93-049. The purpose of the test was to determine if the chilled water system would perform as required by Modification 93-049 during cold weather conditions and to field validate the analysis conducted in Calculation MC-6412.

3.1 Field Observation of Chiller Postmodification Testing

The test was performed in accordance with Procedure 1PEP07-CH-0002, Revision 0, "300-ton Essential Chiller Bypass Modification Verification Test." The procedure consisted of four separate test sequences which obtained various pressure, temperature, and amperage readings while operating the essential chillers. All tests were conducted with the chillers and chilled water configured in the manner described in Section 2.2.2 of this report.

The first test involved a single 300-ton idle chiller (12B) safety injection start during cold weather conditions. The second test simulated a single 300-ton chiller (12B), starting with a LOOP during cold weather conditions. The third test simulated two 300-ton chillers (12B and 12C) operating in steady-state cold weather conditions, which was the normal system lineup. In this test, the principle objective was to obtain data in order to calculate chiller load. The fourth test simulated a single 150-ton idle chiller (11B) safety injection start during cold weather conditions. The intent of this test was to ensure the chiller would successfully start and run while ECW was configured in the cold weather mode.

Acceptance criteria required the chiller to start and operate successfully for the duration of the test. Additionally, design engineers evaluated the results for peak condenser pressure and peak load on the condenser.

The inspectors observed the pretest briefing conducted by the test coordinator and given to all personnel involved in the testing. The briefing emphasized the STAR (Stop, Think, Act, and Review) program and the importance of self-verification.

At the start of the test, the required test equipment was being installed in Step 6.1.4 of the procedure. The technicians performed Substeps 6.1.4.3 and 6.1.4.4. prior to Substeps 6.1.4.1 and 6.1.4.2. The technicians were questioned by the inspectors on performing procedural steps out of sequence and work was stopped. Further review of the procedure revealed that a caution early in the procedure clearly stated that, "Substeps shall be performed in the order written." The test coordinator was notified and a station problem report was initiated to identify and follow up on the problem. The activities performed out of order were evaluated by the shift supervisor and the test coordinator and a decision was made to continue with the procedure in the order written without having to rework the steps previously performed.

The failure to follow procedures was a violation of the requirements of Technical Specification 6.8.1.a. This violation was not cited because the criteria in paragraph VII.B.1 of Appendix C to 10 CFR Part 2 of the NRC's "Rules of Practice," were satisfied. This violation was an isolated occurrence and the licensee staff took prompt and effective actions to correct the problem.

When performing Step 6.1.9.3 of the procedure for the first test, the chiller tripped on low oil pressure. The control room was contacted and the test was stopped. Electrical maintenance determined that a packing leak existed on the high pressure oil isolation valve to the purge unit. Electrical maintenance tightened the packing and purged remaining air in the oil lines. The oil pressure appeared satisfactory and the chiller was restarted. The chilled water discharge temperature stabilized at 48.5°F, as required.

The third test that was performed had to be repeated twice before the technicians were able to retrieve the data collected from the data logger. Apparently, when the test data were transferred to the laptop computer, it was lost. The third time the test was performed, a tape printout was used to collect the data for engineering evaluation purposes. Data were consistent for all three performances of the test.

The inspectors did not observe the second or fourth test; however, the test results were reviewed.

The performance of the tests was satisfactory and the essential chilled water system functioned as expected. The inspector verified that the test had the proper work start authorization. The instrumentation that was used had proper calibration. The technicians performing the test were knowledgeable of the system. Plant operations was informed of all conditions concerning the test, and the chronological test log was appropriately maintained.

3.2 Postmodification Test Results

The inspectors reviewed the data collected during the performance of the postmodification testing in order to determine if the test results validated the conclusions made by the licensee's analysis.

Based on the test results reviewed by the inspectors and a briefing provided by the licensee, the postmodification testing confirmed the engineering analysis conducted by the licensee and reviewed by the inspectors (refer to Section 2 of this report). For the plant conditions available at the time the tests were conducted, chiller capacities and heat loads calculated in the analysis matched acceptably with the actual recorded data.

3.3 Conclusions

The inspector noted that chiller postmodification testing was conducted appropriately. Initially there was a problem with procedure adherence; however, appropriate corrective actions were taken to ensure compliance with the remainder of the procedure. The postmodification testing validated the engineering analysis conducted by the licensee.

4 REVIEW OF IMPROVEMENTS TO CHILLER RELIABILITY (92720)

4.1 Operational Procedure Changes

The inspectors reviewed Procedure OPOP02-CH-0001, Revision 1, "Essential Chilled Water System." This latest revision of Procedure OPOP02-CH-0001 incorporated the necessary operational changes following implementation of Modification 93-049 on Train B of the chilled water system. The procedure directed plant personnel to operate the system in one of three configurations, depending on the ECW supply temperature. These temperature bands corresponded to the bands described in Section 2.2 of this report which were correlated to the licensee's analysis of the chilled water system.

For ECW temperatures greater than 69°F, system configuration and operation were unchanged from the manner that the chilled water system had been previously operated.

For ECW temperatures in the band 42-60°F, the following operational changes were required:

- The 150-ton chiller is made inoperable by placing its control switch on the main control board in the pull-to-lock position.

- The ECW supply flow to the 300-ton chiller is throttled using the ECW discharge bypass valve and a flow of 240 gallons per minute is established.

- The ECW discharge bypass valve on the 150-ton chiller is throttled open 3/4 turn in order to prevent microbiological induced corrosion.

- The temperature control valves for the EAB are closed, which places full chilled water flow through the EAB cooling coils and reduces the transient on the chilled water system following the initiation of the most limiting postulated accident.

For the temperature band 60-69°F, Procedure OPOP02-CH-0001 permits chiller operation in either the greater than 60°F mode of operation or the 42-60°F mode.

For ECW temperatures in the band 37-42°F, Procedure OPOP02-CH-0001 requires that an operator be stationed at each operable chiller train and further instructs that operator to throttle the ECW bypass valve in order to maintain chiller condenser pressure between 2 inches vacuum of mercury to 7 pounds per square inch gage.

For ECW temperatures less than 37°F, Procedure OPOP02-CH-0001 requires that the essential chiller be declared inoperable.

The inspectors concluded that these procedural changes were effective in implementing the chiller enhancements described in Modifications 93-049 and 93-050. The licensee plans to further revise Procedure OPOP02-CH-0001, as the modification was installed on the remaining trains of the essential chillers.

4.2 Essential Chiller Maintenance Backlog

The inspectors reviewed the maintenance outstanding on all Unit 1 essential chillers, with a particular focus on maintenance activities not scheduled to be completed during the current outage.

As of January 5, 1994, the list of outstanding maintenance not planned for work prior to the restart of the unit was relatively small with only 15 open service requests (SRs). Of these 15 SRs, 11 were modifications planned for enhancing chiller performance; 3 were SRs to improve compressor lube oil pressure switch calibration problems identified in Station Problem Report (SPR) 931842; and 1 generic SR was open, with no intention of closing, to provide support to collect oil samples, clean purge orifices as required, obtain refrigerant system levels, and provide general maintenance assistance to operations in starting and maintaining chilled water system availability.

Three of the modification SRs, although not scoped for work during the outage, would be worked and were associated with resetting the chilled water outlet temperature to 48°F in each of the chilled water trains, in support of the installation of Modification 93-049 (refer to Section 2.2.2 of this report). Two of the SRs were associated with Modification 89-063 and involved the installation of thrust covers and collars and vibration probes on two of the 300-ton chillers. This modification was under review by Design Engineering to determine if the hardware scoped for installation was actually beneficial.

The remaining six modification SRs involved the installation of refrigerant clean-up kits, an initiative recommended by the chiller vendor. A review of the chiller performance since 1989 indicated that the licensee had not been successful in maintaining the chillers' refrigerant and oil systems properly sealed; as a result, the intrusion of water and noncondensable gases had caused an unacceptable level of refrigerant and lubricating oil contamination. Although the system cleanliness had been improved by the licensee's heightened awareness to this past problem, the vendor had recommended that clean-up kits be installed. The inspectors were concerned that this modification, which would improve the chillers' reliability, was being deferred until the next outage in approximately 18 months. The licensee responded that there was not sufficient time for completion of the installation of the clean-up kits on Unit 1 chillers during the current outage, but that the modification would be completed on the Unit 2 chillers prior to the restart of that unit. As an interim measure, they had changed preventive maintenance Procedure EM-1-CH-93000272 for chiller lubricating oil and filter changes from the previous periodicity of 78 weeks to every 26 weeks. The inspectors considered this acceptable.

The inspectors reviewed the three open SRs not related to the installation of modifications that were not scheduled for work during the outage. All were associated with problems identified during the calibration of compressor lube oil pressure switches. During previous preventive maintenance activities conducted at refueling outages, the licensee identified a high occurrence of these pressure switches being out of tolerance. Although continuing to research the root cause of the problem, as an interim measure, the licensee revised preventive maintenance Procedure IC-1-CH-93000635 to change the periodicity of oil pressure switch calibration from each refueling outage (every 72 weeks) to every 52 weeks. The inspectors considered this acceptable.

Since the end of this inspection, the licensee has identified maintenance items previously scoped for completion during this outage that will not be worked and will have to be deferred. The adequacy of the licensee's deferral process and the thoroughness of their review of maintenance activities prior to deferring work was reviewed in NRC Inspection Report 50-498/94-08; 50-499/94-08.

4.3 Chiller Training Enhancements

The inspectors reviewed recent revisions to the licensee's chiller training program. The chiller training program consisted of three courses of instruction. All three courses had been revised in late 1993.

Course EMT901, "Air Conditioning and Refrigeration," was the first course taught to electrical maintenance personnel and was a prerequisite for all subsequent training on the chillers. This course was designed to require 80 hours of instruction and covered the refrigeration cycle, systems checks, and mechanical, and electrical troubleshooting. All training was conducted utilizing York chillers. Subsequent courses, EMT911, "York Chiller Maintenance," and EMT966, "Chiller Instrumentation," focused training on achieving higher levels of electrical maintenance personnel expertise. Both of these courses were of 40 hours duration and trained workers on accelerated skills associated with chiller maintenance and troubleshooting.

The inspectors determined that the training was based on a systems approach to training and represented improvements on the previous courses of instruction.

4.4 Conclusions

The inspectors concluded that the changes made to Procedure OPOP02-CH-0001 were effective in implementing the chiller enhancements described in Modifications 93-049 and 93-050. The chiller maintenance backlog was small. The licensee had taken appropriate steps following the deferral of the installation of two modifications to ensure reliable chiller operations. However, some maintenance items previously scoped for work during the current outage would have to be deferred. The deferral of these items were reviewed in another NRC inspection. The licensee had revised their chiller training and the resultant course of instruction was considered an improvement.

5 REVIEW OF ITEMS RELATED TO RESTART ISSUES (92701)

The following items related to Restart Issues were reviewed concerning the manner that the licensee had resolved the issue within the scope of Restart Issue 12, which addressed the licensee's efforts to improve the reliability of the essential chillers. They will remain open pending further NRC inspection effort to completely resolve the items during future Restart Issues and other inspections.

5.1 (Open) IFI 498;499/9331-07: The team found that maintenance and testing weaknesses reduced the reliability of safety-related and balance-of-plant equipment.

The inspectors determined that, based on the relatively small SR backlog, the improved material condition, and the extensive postmodification testing program, the portion of this IFI that refers to the reliability of the chillers was closed.

5.2 (Open) IFI 498;499/9331-08: Ineffective corrective and weak preventive maintenance significantly contributed to poor equipment performance.

Based on the improvements made to preventive maintenance conducted on the essential chillers and the SR backlog reduction (refer to Section 4.2), the portion of this IFI that refers to the chillers was closed.

5.3 (Open) IFI 498;499/9331-09: Ineffective corrective maintenance, caused by inadequate root cause analysis, poor prioritization of work, and poor craft performance, adversely affected safety-related equipment performance.

Based on the SR backlog reduction (refer to Section 4.2), the portion of this IFI that refers to the chillers was closed.

6 CLOSED ITEMS RELATED TO RESTART ISSUES (92701)

The inspectors determined that the licensee's actions to address the following issues was adequate. These items were considered closed.

6.1 (Closed) Violation 498;499/9224-01: Failure to take adequate corrective action to preclude essential chill water switch malfunctions during valving-in processes following maintenance.

The licensee's corrective action to this violation consisted of revising the preventive maintenance activities to include precautions concerning the acceptable manner of valving-in these particular differential pressure switches. Additional actions taken included the installation of equalization valves to facilitate test equipment installation by the implementation of Engineering Change Notice Packages 92-J-0012 and 92-J-0013. These engineering change notice packages were completed on both units' essential chillers during the current outages.

One of the root causes of this violation was the licensee's failure to implement a maintenance feedback request (MFR) that initially identified the problem associated with the differential pressure switches. This MFR had been rejected without receiving the concurrence of engineering, which was the department that originated to MFR. The licensee's corrective action to address this root cause consisted of revising Procedure OPGO03-ZM-00002, "Preventive Maintenance Program," to procedurally require that all rejected MFRs receive concurrence from the initiating department.

The final corrective action consisted of the licensee revising Procedure OPGP03-ZX-0002, "Corrective Action Program," to provide guidance on the expectations for correspondence involving SPRs. This procedure had been revised numerous times since the occurrence of this violation and currently provides specific guidance to station personnel regarding management's expectations concerning the corrective action program.

6.2 (Closed) IFI 498;499/9224-03: Essential chiller unavailability rates were excessive.

Based on the action taken by the licensee (refer to Section 4.2) this item was closed.

6.3 <u>(Closed) Violation 499/9226-03: Failure to perform a postmaintenance test of the Essential Chiller 21C supply breaker following maintenance, resulting in a failure of the chiller to start on demand</u>.

The licensee's corrective action to this violation consisted of revising the Maintenance Planners Guide to provide guidelines for the handling of multiple component work packages or work packages which were cross-referenced to ensure that the required postmaintenance testing was performed in individual components. In addition, operations department training was conducted in the licensed requalification training to reinforce the lessons learned from this inadequate postmaintenance testing activity. The operations manager issued a memorandum to all operations personnel emphasizing the requirements of Operations Policy 0-0054, "Electrical Breaker Continuity Checks."

6.4 <u>(Closed) Example Two of Violation 498;499/9235-02: Failure to take prompt corrective action to correct equipment deficiencies with Essential Chiller 21A by not installing Plant Equivalency Change (PCF) CH-178119</u>.

PCF CH-178119 was installed on all the essential chillers. In addition, the licensee has taken the initiative to install other equipment reliability enhancing modifications and PCFs, as well as evaluated the basis for deferring the installation of other modifications and PCFs (refer to Section 4.2).

6.5 <u>(Closed) Violation 498;499/9235-03: Failure to verify that the automatic load sequence timer was operable with the first sequenced load verified to be loaded within 1.0 second and 1.6 second and all other load blocks within ±10 percent of its design interval</u>.

This issue was first identified by the licensee in September 1991 and, at that time corrective action was taken to revise the load sequence timer Procedure 1/2PSP02-SF-0001A/1B/1C/2A/2B/2C, which was accomplished by procedural field changes. The issue consisted of the engineering safety features load sequence timer procedure failing to verify the essential chiller's internal timer for initiating the chiller starting sequence. After the field change to Procedure 1/2PSP02-SF-0001A/1B/1C/2A/2B/2C, this verification was performed.

6.6 <u>(Closed) IFI 498;499/9331-20: Functional and programmatic weaknesses were observed in the design, testing, modification, and maintenance of the essential chilled water system that, if uncorrected, could adversely affect the operability of the system</u>.

Based on the action taken by the licensee (refer to Sections 2, 3, and 4) this item was closed.

6.7 (Closed) IFI 498;499/9331-21: The ability of the essential chilled water system to function for extended periods, during a design basis accident under low heat load conditions, was never demonstrated, either by testing the system at various design basis accident heat loads or by engineering analysis.

Based on the action taken by the licensee (refer to Section 2) this item was closed.

6.8 (Closed) IFI 498;499/9331-44: Engineering will perform calculations, related to the essential chilled water system, which will provide the basis for evaluation and analysis of minimum and maximum chilled water loads under a range of weather-related conditions and postulated design basis accidents. Strategies will be developed to operate and test the system, and an evaluation of proposed chiller enhancements will be completed.

Based on the action taken by the licensee (refer to Sections 2) this item was closed.

6.9 (Closed) IFI 498;499/9331-45: Ensure that the essential chillers were capable of performing their design function.

Based on the action taken by the licensee (refer to Sections 2) this item was closed.

6.10 (Closed) IFI 498;499/9331-74: NRC assess the licensee's engineering analysis for essential chiller operation under low heat load accident conditions.

Based on the action taken by the licensee (refer to Sections 2) this item was closed.

7 ASSESSMENT OF MANAGEMENTS RECEPTIVENESS TO IDENTIFYING AND CORRECTING PLANT PROBLEMS (92720)

The inspectors determined that licensee management had responded adequately to the issue of improving the reliability of the essential chillers.

ATTACHMENT

1 PERSONS CONTACTED

1.1 Licensee Personnel

R. Caldwell, Assessor, Planning and Assessment
T. Cloninger, Vice President Nuclear Engineering
J. Conly, Licensing Engineer, Nuclear Licensing
E. Halpin, Manager, Fluid Systems Division
S. Head, Deputy General Manager, Nuclear Licensing
J. Johnson, Supervisor, Quality Assurance
T. Jordan, Manager, Systems Engineering
M. Kanavos, Manager, Mechanical-Civil Division
R. Kerr, Senior Engineer, Nuclear Safety Review Board
R. Pierce, Staff Engineer, Independent Safety Evaluation Group
J. Sheppard, General Manager, Nuclear Licensing
M. Smith, Senior Consultant, Planning and Assessment

The personnel listed above attended the exit meeting conducted on January 7, 1994. In addition to the personnel listed above, the inspectors contacted other personnel during this inspection period.

1.2 NRC Personnel

M. Satorius, Project Engineer, Project Branch A, Division of Reactor Projects
D. Garcia, Resident Inspector, Project Branch A, Division of Reactor Projects

2 EXIT MEETING

An exit meeting was conducted on January 7, 1994. During this meeting, the inspectors reviewed the scope and findings of this report. The licensee did not take exception with any of the inspection findings nor identify as proprietary any information provided to, or reviewed by, the inspectors.