UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report No.: 50-261/89-17

Licensee: Carolina Power and Light Company
P. O. Box 1551
Raleigh, NC 27602

Docket No.: 50-261 License No.: DPR-23

Facility Name: H. B. Robinson

Inspection Conducted: August 11 - September 10, 1989

Inspector: R. E. Carroll for 10/6/89
L. W. Garner, Senior Resident Inspector Date Signed

R. E. Carroll for 10/6/89
K. R. Jury, Resident Inspector Date Signed

Approved by: H C Dance 10/6/89
H. C. Dance, Section Chief Date Signed
Division of Reactor Projects

SUMMARY

Scope:

This routine, unannounced inspection was conducted in the area of operational safety verification, physical protection, surveillance observation, maintenance observation, and onsite followup of events at operating power reactors.

Results:

No violations or deviations were identified.

The motor driven auxiliary feedwater (AFW) pumps exhibited damage due to recirculation cavitation and the steam driven AFW pump exhibited cavitation damage due to both low recirculation flow and inadequate NPSH. The AFW system inspection/refurbishment and modifications are on-going, paragraphs 2 and 4.

The component cooling water system heat exchangers' performance appears to be adequate for plant cooldowns and design accidents, paragraph 5.

The Inservice Testing program may not be capable of detecting pump degradation. This issue is identified as an unresolved item, paragraph 3.

Communication and planning between the control room and testing personnel was effective during performance of operating procedure OP-402, Auxiliary Feedwater System, paragraph 2.

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REPORT DETAILS

1. Persons Contacted

R. Barnett, Maintenance Supervisor, Electrical
*D. Crook, Senior Specialist, Regulatory Compliance
*J. Curley, Director, Regulatory Compliance
*R. Dayton, Project Engineer, Technical Support
C. Dietz, Manager, Robinson Nuclear Project
R. Femal, Shift Foreman, Operations
W. Flanagan, Manager, Modification Projects (Outage Manager)
*S. Griggs, Technical Aide, Regulatory Compliance
E. Harris, Director, Onsite Nuclear Safety
D. Knight, Shift Foreman, Operations
D. McCaskill, Shift Foreman, Operations
*A. McCauley, Principal Engineer, Onsite Nuclear Safety
*J. Moon, System Engineer
R. Moore, Shift Foreman, Operations
*R. Morgan, Plant General Manager
*D. Nelson, Maintenance Supervisor, Mechanical
*M. Page, Manager, Technical Support
D. Quick, Manager, Maintenance
D. Seagle, Shift Foreman, Operations
*J. Sheppard, Manager, Operations
*R. Smith, Manager, Environmental and Radiation Control
*D. Stadler, Onsite Licensing Engineer
R. Steele, Operations Coordinator
*H. Young, Director, Quality Assurance/Quality Control

Other licensee employees contacted included technicians, operators, mechanics, security force members, and office personnel.

*Attended exit interview on September 15, 1989.

Acronyms and initialisms used throughout this report are listed in the last paragraph of the inspection report.

2. Operational Safety Verification (71707)

The inspectors evaluated licensee activities to confirm that the facility was being operated safely and in conformance with regulatory requirements. These activities were confirmed by direct observation, facility tours, interviews and discussions with licensee personnel and management, verification of safety system status, and review of facility records.

To verify equipment operability and compliance with TS, the inspectors reviewed shift logs, operations records, data sheets, instrument traces, and records of equipment malfunctions. Through work observations and discussions with Operations staff members, the inspectors verified the staff was knowledgeable of plant conditions, responded properly to alarms, adhered to procedures and applicable administrative controls, cognizant of in-process surveillance and maintenance activities, and aware of inoperable equipment status. The inspectors performed channel verifications and reviewed component status and safety-related parameters to verify conformance with TS. Shift changes were routinely observed, verifying that system status continuity was maintained and that proper control room staffing existed. Access to the control room was controlled and operations personnel carried out their assigned duties in an attentive and professional manner.

Plant tours and perimeter walkdowns were conducted to verify equipment operability, assess the general condition of plant equipment, and to verify that radiological controls, fire protection controls, physical protection controls, and equipment tagging procedures were properly implemented.

AFW System Testing/Modification

Subsequent to the AFW system's inoperability, delineated in Inspection Report 89-18, the inspectors witnessed various AFW component inspections, system testing and modification. The unit was placed in hot shutdown on August 22, 1989, at which time the testing/inspections commenced. All inspections witnessed and performed by the inspectors are detailed in paragraph 4. All testing witnessed and reviewed, as well as the system modifications, are discussed below.

On August 22, 1989, the AFW system was tested with various pump configurations, flow paths (i.e., recirculation flow only, feeding the S/Gs, and a combination of both), and flow rates. The testing was performed to verify actual pump/system performance with a CST level of approximately 88 percent full.

Each pump was tested individually and in combination with the other respective AFW pumps. The pumps were aligned in accordance with OP-402, revision 23, Auxiliary Feedwater System. During the test, communication between the control room and the system engineer coordinating the test was well controlled, with potential problems being addressed prior to test initiation. While testing the SDAFW pump at recirculation flow (approximately 160 gpm) and two MDAFW pumps at 650 gpm combined demanded flow (with an additional recirculation flow of approximately 100 gpm), reduced flow indications were observed; indicating insufficient NPSHa. This condition occurred prior to test completion, and the inspectors raised the concern of what effect continuing the testing with higher demanded system flow would have on the pumps. Additionally, the test was being performed without utilizing a special procedure, which could have addressed observed flow anomalies, effects of these anomalies on equipment, and any resultant required actions. After discussions with the Technical Support manager and other testing personnel, it was determined that further testing was not necessary, since the data taken provided sufficient information to demonstrate inadequate NPSHa. Subsequent to the testing, inspections, refurbishing, and repair commenced on the AFW piping, the MDAFW pumps, and the SDAFW pump, respectively (see paragraph 4).

Due to AFW system three-pump operation flow rates, it was determined that the existing AFW suction piping (6-inches) was inadequately sized and, with existing head losses due to the rusting/corrosion identified during the piping inspection, adequate NPSHa was not provided to the AFW pumps. Modification M-1018, was initiated as an "emergency" modification to provide larger diameter AFW suction piping, as well as changing the pipe material from carbon steel to stainless for corrosion protection. This modification is scheduled for completion in October 1989, and consists of the following piping changes:

- Outlet piping from the CST is being increased from 6-inch inner diameter piping to 12-inch up to, and approximately 6-feet past the tee to the MDAFW pumps. The outlet piping will tap off the CST with two 6-inch nozzles feeding the 12-inch line.
- The MDAFW pump piping will remain the same diameter; piping material (as discussed above) was changed.
- The 12-inch piping is to be reduced to 8-inch for approximately 15-feet, then reduced to 6-inch up to the SDAFW pump suction.

Additionally, due to the MDAFW pumps' damage incurred from recirculation cavitation, pump testing methodology and flows are being evaluated to minimize future recirculation cavitation. The above modifications and the effects of this cavitation on the pumps, should adequately address AFW NPSHa deficiencies. Resolution of the recirculation flow analysis should prevent future recirculation cavitation concerns. This is tracked as an IFI: Review AFW System Hardware Modifications and Testing, 89-17-01.

No violations or deviations were identified.

3. Monthly Surveillance Observation (61726)

The inspectors observed certain safety-related surveillance activities on systems and components to ascertain that these activities were conducted in accordance with license requirements. For the surveillance test procedure listed below, the inspectors determined that precautions and LCOs were adhered to, the required administrative approvals and tagouts were obtained prior to test initiation, testing was accomplished by qualified personnel in accordance with an approved test procedure, test instrumentation was properly calibrated, the test was completed at the required frequency, and that the test conformed to TS requirements. Upon test completion, the inspectors verified the recorded test data was complete, accurate, and met TS requirements; test discrepancies were properly documented and rectified; and that the systems were properly returned to service. Specifically, the inspectors witnessed/reviewed portions of the following test activities:

- OST-253 (revision 10) RHR Pump Flow Test

  On August 27, 1989, during performance of OST-253, the B RHR pump flow rate was measured at 2,592 gpm with a fixed differential pressure of 110 psi. This flow rate was determined to be in the IST required action range (i.e., flow less than 2,700 gpm) and the pump was declared inoperable. Calibration of the process instrumentation utilized for the test revealed that all the instrumentation was within their respective calibration tolerances; however, the B pump discharge gauge was found to be reading approximately 5 psi lower than the nominal calibration value. Due to instrument accuracy, indication can vary by plus or minus 12 psi and still be within allowable calibration tolerances. After the instrument was adjusted, the applicable portion of OST-253 was re-performed on August 31, 1989. The subsequent indicated pump flow rate of 2,994 gpm fell within the acceptance criteria range of 2,820 to 3,060 gpm and the pump was then declared operable. Apparently, due to the operating characteristics of the RHR pumps, a small change in differential pressure can result in large changes in flow rates. Thus, the installed process instrumentation, as currently utilized, may not be capable of detecting pump degradation. This situation may also exist for other safety-related pumps. This item is considered an *URI: IST Program May Not be Capable of Detecting Pump Degradation, 89-17-02.

  During this surveillance test, the flow value is calculated from an average of twelve flow transmitter voltage readings. The inspectors observed that this data is routinely recorded on notebook paper and attached to the completed procedure. The shift foreman had independently observed the lack of an information data sheet, and had identified the need to generate a procedure change request.

No violations or deviations were identified.

4. Monthly Maintenance Observation (62703)

The inspectors observed safety-related maintenance activities on systems and components to ascertain that these activities were conducted in accordance with TS, approved procedures, and appropriate industry codes and standards. The inspectors determined that these activities did not violate LCOs and that required redundant components were operable. The inspectors verified that required administrative, material, testing,

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*An Unresolved Item is a matter about which more information is required to determine whether it is acceptable or may involve a violation or deviation.

radiological, and fire prevention controls were adhered to. In particular, the inspectors observed/reviewed the following maintenance activities:

- WR/JO 89-AHLX1 Disassembly/Inspection and Repair of A AFW Pump
- WR/JO 89-AHLX2 Disassembly/Inspection and Repair of B AFW Pump
- WR/JO 89-AFGM1 Disassembly/Inspection and Repair of the SDAFW Pump

AFW System Inspection

Subsequent to August 22, 1989, disassembly and inspection commenced on the AFW system piping, pumps, motors, and valves. These inspections were conducted in order to assess the AFW systems components' condition and to implement any necessary corrective actions (refurbishment/replacement).

The AFW system suction piping inspection consisted of the following activities: (1) a boroscope was utilized to inspect approximately 60 feet of suction piping (20-feet toward the SDAFW pump from the CST, 20-feet toward the CST from the SDAFW pump, and 20-feet from the MDAFW pumps toward the CST); (2) boroscope inspection of suction piping from the SW header; and (3) inspection of three removed sections of piping (SDAFWP suction line, MDAFWP suction line, and SW supply piping), with the SDAFWP suction line section being sent to the Harris E&E Center for analysis. The inspectors witnessed the majority of these evolutions and based on observations and discussions with the responsible engineer, the common piping from the CST to the SDAFW and the MDAFW pumps is in the worst condition (i.e., pitting and corrosion). The SW header piping was found to be in relatively good condition. The Harris E & E Center's analysis confirmed the boroscope observations.

The MDAFW pump motors were removed and sent to Westinghouse in Spartanburg, S. C., for inspection and any necessary repairs. The B pump motor had exhibited arcing and sparking. The results of the inspection revealed minor wear in the B pump motor and vibration induced internal cracking on the pump motor rotor bars. The rotor bars are currently being replaced and were the apparent cause of the observed arcing/sparking. Westinghouse has recommended that the motors be completely overhauled during the 1991 refueling outage.

The MDAFW pumps were disassembled per WR 89-AHLX1 and AHLX2, respectively, in accordance with procedure CM-007, revision 2, Electric Driven Auxiliary Feedwater Pump Overhaul. The SDAFW pump was disassembled per WR 89-AFGM1 in accordance with procedure CM-008, revision 2, Turbine Driven Auxiliary Feedwater Pump Overhaul. The pumps' disassembly and inspection activities were overseen by technical representatives from the respective pump vendors (MDAFW pumps - Dresser, SDAFW pump - Pacific); the inspector observed these activities on a routine basis.

Results of the MDAFW pumps inspection revealed that there was damage to the pumps which was apparently caused by recirculation cavitation. Recirculation cavitation is caused by inadequate recirculation flow, which could be the result of various factors (i.e., undersized recirculation lines, high DP in recirculation piping, running the pumps with low recirculation flow for an extended period, etc.). No damage was apparent on the MDAFW pumps from inadequate NPSHa (i.e., suction starvation). The A pump's cavitation damage was evident on the first three stages of the impeller (high pressure end) and the first five stages of the intermediate cover (diffuser). Additionally, there was a crack in the leading edge of the ninth stage impeller's inlet vane and the eighth stage intermediate cover's diffusing vane's tips were chipped. The motor's casings also showed cavitation damage in the first stage diffuser seating face, as well as product wash in a small area leading from the pressurized area of the casing to a stud. Other observed damage/discrepancies observed include, but are not limited to, the following:

- Service water cooling lines were clogged
- Stuffing box cooling jackets were clogged
- Thrust bearing shoes showed excessive wear
- Lube oil was contaminated with sludge and sediment
- Drive end and thrust end radial bearings showed excessive wear
- Impeller locking nuts were loose
- Heat cracks were visible on the inboard and outboard packing sleeves

Additionally, all stages of the impeller are being replaced as the bores were slightly undersized. The pump shaft is also being replaced. The pump casings are currently being machined/repaired by the Pacific Pump Division of Dresser Industries, and are scheduled back on site by October 4, 1989.

The B MDAFWP showed damage and wear very similar to the A pump. Three impeller stages and seven intermediate cover stages were damaged by recirculation cavitation. The B pump's internal element (impeller diffuser and shaft) is being replaced. The pump casing is also being repaired and machined.

Commencing the week of September 4, 1989, the SDAFW pump (single stage, centrifugal) and its turbine were disassembled, inspected, and refurbished per WR 89-AFGM1. This disassembly, inspection, and refurbishment were also conducted under the auspices of the vendor's technical representative. This inspection paralleled that of the MDAFW pumps, in that, worn parts were to be either refurbished or replaced. However, the SDAFW pump's impeller was damaged from cavitation, apparently due to insufficient NPSHa. The pump's diffuser also exhibited recirculation cavitation damage. The turbine appeared to be in relatively good condition with no major repair, nor component replacement necessary. This inspection/refurbishment was still on-going as of September 21, 1989, and is being monitored on a routine basis by the inspectors.

The AFW suction piping valves were removed and inspected. Most of these valves only exhibited normal wear and will be utilized in the replacement piping where possible.

No violations or deviations were identified.

5. Onsite Followup of Events at Operating Power Reactors (93702)

CCW HX Performance

Inspection Report 89-11 issued a NOV for failure to perform an adequate 10 CFR 50.59 review associated with the number of plugged tubes in the CCW HX. The report documented that 190 and 36 tubes had been plugged in the A and B HXs, respectively. The licensee has inferred from calculations that under design operating conditions, HX performance has not been degraded (i.e., actual individual HX heat removal capability is greater than the 29.4 million BTU/Hr value specified in the purchase order specification). During cooldown for the current forced outage, the temperatures of the SW and CCW water entering and exiting the HXs were recorded. Based on the measured CCW flow rate, the heat rejected from the CCW via both the A and B HXs was calculated to be 80.2 million BTU/Hr. Using a methodology from ASME paper 84-JPGC-NE-14, the expected heat transfer was calculated for the operating conditions existing during the cooldown. In addition, 200 tubes and 58 tubes were assumed to be plugged in A and B HXs respectively. This calculation yielded an expected heat transfer value of 73.5 million BTU/Hr; thus, the actual HX performance is apparently 9.1 percent better than that predicted by the model. Using the same number of plugged tubes, but assuming design worst case conditions, the model yielded a value of 55.0 million BTU/Hr or 6.5 percent less than the combined specification value for the HX (58.8 million BTU/Hr). Since the actual system performance is 9.1 percent better than the model predicts under normal operating conditions, it can be expected that the system can also perform approximately 9.1 percent better under worst case design conditions. Hence, a projected 6.4 percent reduction in performance (under worst case conditions) due to tube plugging is offset by the model under-estimating the actual performance by 9.1 percent. Apparently, the better than expected performance is due to less fouling than assumed in the design analysis.

Subsequent to the report period, three additional tubes were plugged in the A CCW HX. However, the above conclusion remains valid since A CCW HX has a total of 193 tubes plugged, whereas the above analysis assumed 200 tubes plugged.

No violations or deviations were identified.

6. Licensee Quality Assurance Program Implementation (35502)

An internal office evaluation was conducted on July 13, 1989, of the licensee's quality assurance program implementation by reviewing recent inspection reports, SALP reports, open items, licensee corrective actions for NRC inspection findings, and licensee event reports. Particular emphasis was placed on all new items or findings since the last SALP report period (October 31, 1988). It was recognized that an operational safety team inspection was scheduled during this SALP period. Recommendations were made to perform additional inspection modules in the Engineering and Technical Support area.

7. Exit Interview (30703)

The inspection scope and findings were summarized on September 15, 1989, with those persons indicated in paragraph 1. The inspectors described the areas inspected and discussed in detail the inspection findings listed below and in the summary. Dissenting comments were not received from the licensee. Proprietary information is not contained in this report.

Item Number	Description/Reference Paragraph
89-17-01	IFI - Review AFW System Hardware Modifications and Testing (paragraph 2)
89-17-02	URI - IST Program May Not Be Capable of Detecting Pump Degradation (paragraph 3)

8. List of Acronyms and Initialisms

AFW	Auxiliary Feedwater
ASME	American Society of Mechanical Engineers
BTU/Hr	British Thermal Units Per Hour
CCW	Component Cooling Water
CFR	Code of Federal Regulation
CM	Corrective Maintenance
CST	Condense Storage Tank
ESF	Engineered Safety Feature
gpm	Gallons Per Minute
HX	Heat Exchanger
IFI	Inspector Followup Item
IR	Inspection Report
IST	Inservice Testing
LCO	Limiting Condition for Operation
MDAFW	Motor Driven Auxiliary Feedwater
NOV	Notice of Violation
NPSH	Net Positive Suction Head
NPSHa	Net Positive Suction Head available
NRC	Nuclear Regulatory Commission
OP	Operating Procedure
OST	Operations Surveillance Test
PSI	Pounds Per Square Inch
RHR	Residual Heat Removal
SDAFW	System Driven Auxiliary Feedwater
S/G	Steam Generator
SW	Service Water
TS	Technical Specification
URI	Unresolved Item
WR/JO	Work Request/Job Order