ENCLOSURE 2

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Inspection Report: 50-298/95-11

License: DPR-46

Licensee: Nebraska Public Power District
1414 15th Street
Columbus, Nebraska

Facility Name: Cooper Nuclear Station

Inspection At: Brownville, Nebraska

Inspection Conducted: August 14-17 and September 12-13, 1995

Inspectors: T. Reis, Senior Project Engineer

Approved: P. H. Harrell, Chief, Project Branch C — Date 9/26/95

Inspection Summary

Areas Inspected: Special inspection of an adverse condition that involved significant water accumulation in the high pressure coolant injection (HPCI) turbine exhaust line and subsequent licensee corrective actions.

Results:

Operations

- Operations failed to recognize either the accumulation of water in the HPCI turbine exhaust piping or the consequences of the accumulation for many years. Only when a modification was implemented that required manual action to drain the line was the adverse condition recognized. Even after the manual action was instituted, at least one opportunity to identify the problem was missed (Section 1.5).

Engineering

- The corrective actions taken and analyses performed by the licensee supported interim operation of the HPCI system until the root cause of the water accumulation can be corrected during the upcoming outage (Section 1.7).

- The licensee utilized an acceptance criteria for the stresses imposed on the affected piping which was inconsistent and less conservative than

the guidance provided in Generic Letter 91-18. The Office of Nuclear Reactor Regulation indicated that the criteria used, however, was justifiable on an interim basis (Section 1.7).

- The degraded condition of the HPCI system and the potential impact on containment integrity, were principally the result of an inadequate design and past identification and corrective action failures on the part of the licensee. There were, however, some current performance issues. The inadequacy of corrective actions is a violation of NRC requirements (Sections 1.4 and 1.5).

- Engineering was heavily dependent on contractors to perform the required analyses and engineering had difficulty understanding and explaining the actions taken by its contractors (Sections 1.6 and 1.7).

- The licensee's operability determination and evaluation processes were consistent with Generic Letter 91-18 guidance (Section 1.6).

Summary of Inspection Findings:

- Violation 50-298/9511-01 was opened.

Attachments:

Attachment 1 - Persons Contacted and Exit Meeting

DETAILS

1 ONSITE RESPONSE TO AN EVENT (93702, 92903)

1.1 Event Description

On July 5 and 6, 1995, the licensee drained approximately 120 gallons of water from a low point in the HPCI turbine exhaust line. Licensee contractors performed analyses of the dynamic effects of the presence of water in the line on the HPCI turbine and exhaust line, which is an integral part of the primary containment boundary. The analysis determined that a turbine start with accumulated water in the exhaust line could result in a waterhammer that imposed stresses on the exhaust piping and supports that would exceed the design criteria by a substantial margin.

1.2 System Description

The HPCI turbine exhaust line is routed to discharge to the suppression pool. Downstream of the turbine in the 20-inch discharge line are a check valve and a stop check valve in series, which form an integral part of the containment boundary. These valves are located in a horizontal run of piping that constitutes a low point in the exhaust piping. Downstream, and forming a T off the exhaust line, are control room operated drain valves designed to remove small amounts of condensate from the exhaust line. The check, stop check, and drain valves are located outside of the suppression pool (containment boundary). Inside the suppression pool, the turbine exhaust piping discharges below the water line. Above the water line, the piping is equipped with four 2-inch lift check valves that function as vacuum breakers. These vacuum breakers preclude the drawing of suppression pool water up the vertical discharge line and initiating a siphoning of suppression pool water to the low point in the discharge line when a vacuum is created by condensation in the turbine exhaust line.

The licensee concluded that the most probable source of the 120 gallons of water that accumulated in the exhaust line low point was a siphoning of water from the suppression pool. The inspector determined that the licensee's conclusion was appropriate.

1.3 History and Synopsis of Licensee Actions

The inspector found that the vacuum breakers in the turbine exhaust line were installed during original plant construction. In May 1977, the first documented nonconformance report was initiated that documented that the vacuum and siphoning problem was to such an extent that compressed air was required to be applied to the system to clear the vacuum condition in the piping. The operations department reported that the condition had existed since original testing of the system.

In response to the nonconforming condition, Minor Design Change 77-35 was developed but never implemented. The design change would have replaced the 2-inch lift check valves with swing check valves. During the 1979 outage, the existing valves were inspected and repaired. It appeared that the decision was made that the preventive maintenance performed on the valves was sufficient to return the valves to a reliable operability status. In 1980, the licensee was advised by an engineering consultant that the 2-inch vacuum breakers installed in the system were not sufficient to prevent reflooding of the exhaust line and that the installation of additional vacuum breakers outside the torus, as recommended by the plant vendor, would also not be an acceptable solution. No action was taken on the observations that the existing installation would not prevent water from accumulating in the turbine exhaust line.

During this timeframe, the operations department was provided with "work around" instructions (Procedure 2.3.2.22) in the form of an annunciator response procedure that stated the operators should break the HPCI exhaust line vacuum as necessary by applying compressed air to the system. This annunciator response procedure was valid as late as 1993.

In 1983, Minor Design Change 83-023 was performed to install a 10-inch vacuum breaker in parallel with the existing 2-inch breakers. This modification was short lived in that, during a September 1983 surveillance test, the 10-inch breaker hung open, resulting in pressurization of the suppression chamber air space. Subsequently, the 10-inch breaker was removed and a licensee event report was submitted to the NRC, which committed to install a suitable breaker during the next outage.

From 1983 to June 1989, there was no modification performed per the commitment and there existed no engineering documentation supporting the operability of the exhaust line in the as-left condition. In 1989, the plant engineering supervisor documented that the existing configuration was adequate, provided preventive maintenance was performed on the existing vacuum breakers. In performing reviews of commitments during the 1994 outage, the licensee self-identified commitment to the NRC to install appropriately sized vacuum breakers was missed. Again, an engineering judgement document was generated declaring that the existing vacuum breakers were operable provided preventive maintenance continued.

1.4 Analysis of Past Licensee Actions Taken

As recently as late 1994, the licensee justified that the existing 2-inch vacuum breakers were operable provided the PM was performed each refueling outage. However, from a review of plant computer records from 1990 to July 1995, the inspector determined that, of 11 HPCI turbine runs sampled, in 7 of the 11 cases reviewed, it took from 50 to 75 minutes to drain the line, which was an indication of the presence of substantial volumes of water. Although a direct correlation between drain times and volume of water was not possible due to the cycling of the gland seal condenser, it took approximately 60 minutes to drain the 120 gallons of accumulated water found on July 6,

1995. This indicated that the design of turbine exhaust line was inadequate to preclude the siphoning of water from the suppression pool.

The accumulation of water in the turbine exhaust line was a condition adverse to quality in that the system was vulnerable to a severe water hammer that would challenge both primary containment integrity and operability of the HPCI system. The corrective actions taken between 1978 and 1995 were inadequate to preclude repetition of the water accumulation as evidenced by the significant quantities of water drained from the exhaust at various times between 1990 and 1995. The inadequacy of corrective actions taken by the licensee to correct a known deficiency in a safety system is a violation of NRC requirements (298/9511-01).

1.5 Identification of Issue

Prior to resuming operation of the plant in February 1995, following an extended unplanned outage, the draining of the HPCI turbine exhaust line condensate pot via Valves AOV-70 and AOV-71, installed in the turbine exhaust line, had been an automatic function. A level switch would provide a signal for the valves to open at a preset level. During a 1994 review of containment penetration functions, the licensee properly identified this undesirable design function, which was improper because the valves could receive an open command in the presence of a primary containment isolation signal, providing for a release path of radioactivity from inside the containment structure. The licensee performed a modification during the 1994 outage to require that the draining function be performed manually.

Therefore, this condition was self-disclosing in that, on July 6, 1995, it took approximately 1 hour to drain the water accumulated in the turbine exhaust line, Valves AOV-70 and AOV-71, sufficiently to clear the alarm on Level Switch LS-679. On July 7, 1995, the operations department initiated Condition Report 95-0621 to document that a vacuum problem was resulting in water accumulation in that after 1 hour of draining, the alarm associated with Level Switch LS-679 remained valid.

It was evident from the computer records, discussed in Section 1.4, that the water accumulation problem had been an ongoing problem. However, the operations department only became sensitized to the degree of the problem when they were required to take manual actions for prolonged periods to clear the alarm. For an extended period, it appeared the operations department did not consider the repeated receipt of the alarm associated with Limit Switch LS-679 to be an adverse condition and did not initiate corrective actions prior to June 7, 1995. However, on April 11 an opportunity to identify the same condition was missed. On that date, computer records indicated drain time was in excess of 48 minutes.

It was documented in Section 6.2 of NRC Inspection Report 50-298/95-09 that, on July 5, 1995, the engineering supervisor cognizant of the system was unaware of operations department belief that an exhaust line vacuum was the cause of the water accumulation and that this belief was based on the

assumption that the water originated from leakage past the HPCI turbine inlet valve. The engineering supervisor was unaware of the content of Condition Report 95-0621, which indicated that water was being drawn up from the suppression pool. The inspector made the engineering supervisor aware of the operations department concern. The inspector considers that the engineering supervisor would have shortly learned of the operations department concerns without the conversation, but the supervisor's unawareness was indicative of the lack of aggressiveness in pursuing a safety issue documented a month earlier.

1.6 Analysis of Current Licensee Actions Taken

Upon recognition of the magnitude of the problem on July 6, 1995, the actions taken by the engineering department improved. It was engineering personnel who identified that the reason no water seemed to accumulate during the July 5, 1995, test was because the level switch which actuated the annunciator alarm had failed. Upon this discovery, 120 gallons of water were drained from the exhaust line.

At this time, engineering recognized that both the HPCI system and primary containment integrity were vulnerable to a potential waterhammer. It was further recognized that the HPCI turbine was vulnerable to tripping because of the backpressure that would be developed in the exhaust line.

The licensee entered its Procedure 0.27, "Operability of Systems, Structures, and Components." Operability Determination, OD 95-031 was initiated on July 6, 1995, and the results indicated that both the HPCI system and primary containment remained operable. This was formally documented approximately 53 hours later. The licensee procedure required that Plant Manager approval be obtained for any determination in excess of 24 hours. The inspector concluded that senior management was integrally involved in the decision making process and that the 53 hours was not unreasonable given that it was evident that the licensee was aggressively pursuing the issue and had a reasonable expectation that the systems would remain operable. This expectation was supported by documented engineering judgement provided by the design engineering department, turbine vendor, and engineering consultant.

The inspector concluded that Operability Determination 95-031 was consistent with the guidance provided in Generic Letter 91-18. As acknowledged in the generic letter, determining operability was a continuous decision making process. The licensee's initial operability determination was valid given the information available at the time.

Following the initial determination, the licensee embarked on a more thorough operability evaluation to support the initial determination. Per Generic Letter 91-18, operation of the plant may continue provided there is reasonable expectation that the system is operable and that the evaluation process will support that determination. The inspector concluded that, between July 8 and August 2, 1995, the licensee had sufficient technical justification to support its operability determination in that all indications from design engineering,

the turbine vendor, and the licensee's engineering consultant for stress analysis were that the final analysis would demonstrate that the added stresses imposed by the postulated waterhammer would be within code allowable values.

On August 2, 1995, a licensee employee reviewing the contractor calculations noted that the analysis supporting operability incorrectly assumed that a vendor modification had been installed on the HPCI turbine to substantially reduce the effects of a startup transient. For units without the modification, the turbine control valves are fully open when steam is first admitted to the turbine. The modification had never been installed on the licensee's HPCI turbine. Accordingly, the energy transferred to the turbine exhaust piping was significantly greater than had been assumed in the calculation generated to verify operability. Reanalysis with this information demonstrated that the turbine was still not susceptible to a trip from high backpressure, but the analysis of the loading on piping and supports was suspect.

On August 3, 1995, the HPCI system was declared inoperable. Again, the inspector found no fault wit the licensee's operability determinations given the Generic Letter 91-18 guidance. However, the fact that the incorrect assumption in the modeling of the pipe stress analysis was not recognized until August 2 is yet another indication of a weakness in the engineering department. It appeared that prior to this date engineering did not have a clear understanding of, nor was it involved with, the calculations being performed by its contractors.

1.7 Corrective Actions

1.7.1 Interim Corrective Actions

The licensee and its contractors were reasonably confident that a more detailed modeling and analysis could be performed that would support operability of the system in the degraded state. However, such modeling could not be performed within the constraints of the 7-day Technical Specification action statement that was entered on August 3, 1995.

The licensee installed modifications in the HPCI system to alleviate the identified operability concerns. The first modification involved the reconfiguration of the HPCI turbine governor valve to reduce the effects of the starting of the turbine on exhaust piping pressure. The two remaining modifications involved the installation of a larger snubber on the support immediately downstream of the exhaust line check valves and modification of a stationary support further downstream. With the installation of these modifications, licensee contractors demonstrated by analysis that the addition of the waterhammer loads to those loads assumed for the faulted condition was less than two times the yield stress ($2S_y$), which for the material in question, was approximately 59,00 psi.

The inspector reviewed the licensee's methodology and found it consistent with regulatory guidance in this area. However, it was not clear how the licensee determined that the acceptance criteria was $2S_y$. The guidance provided in Generic Letter 91-18 states that, upon discovery of a nonconformance with piping and pipe supports, licensees may use the criteria in Appendix F of Section III of the ASME Code for operability determinations. These criteria and use of Appendix F are valid until the next refueling outage when the supports are to be restored to the Final Safety Analysis Report criteria. The inspector found the acceptance criteria referenced in the generic letter was a much more conservative value of $2.4S_h$ (design stress for hot service applications), or approximately 38,000 psi for this application. The inspector noted, during review of the calculation, that the combined stresses after the modifications were in excess of $2.4S_h$.

Licensee engineering personnel were not able to readily explain the apparent discrepancy identified by the inspector. This discrepancy was identified on August 16, 1995, nearly 1 week after the system had been returned to service, based on the less conservative acceptance criteria. On August 17, the licensee responded to the inspector's concern. The licensee acknowledged that it did not have a docketed acceptance criteria for degraded conditions associated with torus attached piping, but noted that the less conservative value of $2.0S_y$ had become a generally accepted industry acceptance criteria and had been accepted by the NRC staff numerous times for other licensees. The inspector informed the licensee that NRC Information Notice 95-09, "Use of Inappropriate Guidelines and Criteria for Nuclear Piping and Pipe Support Evaluation and Design," reiterated the NRC position that it continued to endorse Generic Letter 91-18 and Appendix F of Section III of the ASME Code as the accepted criteria for operability determinations.

The concern with the application of the undocketed acceptance criteria was minimal in that a more refined analyses was completed and demonstrated that operability would have been maintained under either acceptance criteria prior to any modifications being performed. The inspector discussed the application of the undocketed acceptance criteria with the Office of Nuclear Reactor Regulation, which indicated that the alternate acceptance criteria was technically justifiable for interim operation.

Other than the discrepancy with respect to the appropriate acceptance criteria, the operability evaluation produced by the licensee was acceptable and supported interim operability of the HPCI system in such a manner that primary containment would not be adversely affected.

1.7.2 Evaluation of the Final Analyses

On September 8, 1995, the licensee provided the inspector with the final analyses that demonstrated that the potential waterhammer condition would not impose stresses on the HPCI turbine exhaust piping or its supports that would exceed code allowable values. Accordingly, the inspector determined that a past inoperable condition did not exist.

The inspector reviewed the revised calculation methodology and found it consistent with regulatory and ASME Code guidance. The technical input regarding the modeling of the waterhammer and the resultant stresses were developed by licensee approved vendors. The final elastic and dynamic structural analysis of the piping components and supports was performed with a computer analysis consistent with the requirements of ANSI B31.1, "Power Piping Code," and ASME Section III. The inspector confirmed that these were the appropriate design codes for the affected piping.

The difference in the outcome of the final analysis and that used to support interim operability, as discussed in Section 1.7.1, stems from differences in the calculation of the forces imposed by waterhammer on the piping segments in the exhaust line, which was referred to as the forcing function. The initial, manual calculation yielded more conservative results because of simplistic assumptions. For example, the manual method assumed the movement of a solid slug of water down the exhaust line in lieu of a two-phase mixture of steam and water. Also, the manual calculations assumed a constant pressure in the line during the transient, whereas the final analysis was able to model the decreasing pressure that would be seen as the fluid was displaced, and the initial analysis did not model the sparger, which would act to suppress the discharge velocity yielding a reduced forcing function.

The final analysis utilized the Reactor Excursion and Leak Analysis Program (RELAP5) to compute the forcing functions. This code was developed by the Idaho National Engineering Laboratory under NRC support and can be used for the simulation of a wide variety of hydraulic and thermal transients involving steam-water noncondensible fluid mixtures. The inspector found the application of the code and the modeling assumed appropriate to the circumstances.

ATTACHMENT

1 PERSONS CONTACTED

1.1 Licensee Personnel

M. Boyce, Engineering Support Manager
J. Gausman, Plant Engineering Manager
R. Godley, Nuclear Licensing and Safety Manager
P. Graham, Senior Engineering Manager
J. Herron, Plant Manager
J. Mueller, Site Manager
M. Peckham, Senior Manager Site Support
R. Sessoms, Quality Assurance Division Manager
N. Thomas, Public Relations Coordinator
D. VanDerKamp, Operations Supervisor

1.2 NRC Personnel

W. Beckner, Director, Project Directorate IV-1, Office of Nuclear Reactor Regulation (NRR)
L. Callan, Regional Administrator
E. Fuentes, Intern, NRR
J. Hall, Project Manager, NRR
M. Hammond, Public Affairs Officer
P. Harrell, Chief, Project Branch C

1.3 Other

R. Stoddard, Lincoln Electric System Representative

The personnel listed above attended the exit meeting. In addition to these personnel, the inspector contacted other licensee personnel during this inspection period.

2 EXIT MEETING

At the exit meeting on August 17, 1995, the licensee acknowledged that, although the outcome of the final analyses would most probably support the position that Code allowable stresses would not be exceeded, the accumulation of water in the HPCI turbine exhaust line is a condition adverse to quality. At the exit meeting, the Site Manager committed to take action to reduce or eliminate the accumulation of water in the exhaust line and that this action will be completed during the fall 1995 refueling outage. It was further stated that, upon return to power from the outage, the water accumulation would be monitored to determine if any additional actions are required above those taken during the outage.

During this meeting, the inspector reviewed the scope and findings documented in this report. The licensee acknowledged the findings and requested that the violation be considered for discretion under the enforcement policy. The licensee did not identify as proprietary any information provided to, or reviewed by, the inspector.

On September 15, 1995, the inspector held a followup conversation with Mr. Robert Godley, Manager of Nuclear Licensing, to indicate that the final analyses had been reviewed and found satisfactory. It was indicated that the past operability of the HPCI system, which had been left unresolved at the exit meeting, was now closed and that other findings remained as discussed at the exit meeting.