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August 23, 1994

Docket No. 50-336
B14942

Re: 10CFR50 App. R

U. S. Nuclear Regulatory commission
Attention: Document Control Desk
Washington, DC 20555

Millstone Nuclear Power Station, Unit No. 2
10CFR50, Appendix R Compliance Information Letter

Purpose

The purpose of this letter is to inform the NRC Staff that Northeast Nuclear Energy Company (NNECO) is in the final phase of completing modifications to the reactor coolant pump (RCP) motor lube oil collection system. The system, as modified, is consistent with the requirements of 10CFR50, Appendix R. Upon completion and testing of these modifications, Millstone Unit No. 2 is scheduled to return to service by August 28, 1994.

Summary

On July 27, 1994, NNECO removed Millstone Unit No. 2 from service due to 'A' RCP motor lube oil system leakage not collected by the RCP lube oil collection system. During the outage, all RCP motors were inspected, cleaned, repaired, and retested, as necessary. The 'A' and 'D' motors were found to be leaking lube oil. The RCP motor lube oil collection systems were inspected, substantially enhanced, and determined now to be in compliance with the requirements of 10CFR50, Appendix R, Section III, Paragraph O, except for the exemption previously granted by the NRC Staff for the seismic design criteria.[1]

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(1) H. R. Denton to W. G. Counsil, "Fire Protection Exemption — Haddam Neck Plant and Millstone Station, Unit 2," dated November 11, 1981.

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Background

RCP Motors:

The four RCP motors that were originally installed at Millstone Unit No. 2 are General Electric, model 295X290, type K, vertical squirrel cage induction motors rated at 6500 hp. Each motor is equipped with upper and lower guide bearings, an upper double-acting thrust bearing, an anti-reverse device (ARD), and a flywheel. The bearings reside in oil reservoirs with the upper bearing having an external oil cooler and the lower reservoir having an internal oil cooler. The motor also has an externally mounted supplemental lubrication bearing lift pump package, which provides low pressure oil to the ARD and high pressure oil to the thrust bearing, when the RCP motor is started or upon coastdown. The motor contains approximately 137 gallons of lube oil with 90 gallons in the upper reservoir, 12 gallons in the lower reservoir and 35 gallons in the upper bearing reservoir cooler and piping. The lubrication system performance is monitored by instrumentation and alarms that include reservoir level, oil flow, oil temperature, and bearing temperature. Each motor also includes an external oil collection system, previously considered to be compliant with Appendix R requirements, which consists of a series of trays, collection devices, and a collection tank.

The history of the 'A' RCP motor was reviewed in an effort to understand the nature of the oil system events, to provide insights into what actions could be taken in the future to improve the reliability, and to prevent recurrence. The 'A' motor is part of the original complement of motors that went into operation in 1975 and has been associated with the 'A' RCP during most of its life. Relevant chronology for the motor is:

- 1975 - Placed in service on the 'A' RCP
- 1985 - High Pressure hoses replaced on all inservice motors
- 1989 - Taken out of service; spare motor installed on 'A' RCP
- 1991 - Overhauled by vendor
- 1992 - Returned to service on the 'A' RCP; lift pump package modified for quick disconnect fittings

During the current operating cycle, the 'A' motor lube oil temperatures were within the acceptable range, but were approximately 20 degrees higher than expected. In October 1993, alarms were received that indicated low oil flow to the ARD, which is located on the top of the motor. The alarm was cleared by operation of the bearing lift pump, which is an accepted practice. Evaluations conducted by plant personnel, with vendor assistance, attributed the higher temperatures to an oil flow deficiency.

Oil had been added to this motor in August 1993 and again in April 1994. Each time, the excess oil around the torque drum was cleaned and the motor was inspected for leaks. In April 1994, a fire hazard review was conducted, the judgment was made that the oil collection system was adequate for the conditions being experienced, and that no fire hazard existed. The system engineer and maintenance personnel monitored the performance of the motor and were developing an action plan to further investigate the leakage during the September 1994 refueling outage.

Motor Lube Oil Collection System:

The RCP motor lube oil collection system was designed, installed, and accepted as meeting the requirements of 10CFR50, Appendix R, with the exception of the exemption for seismic design criteria, granted by the NRC Staff in a letter dated November 11, 1981.

The RCP lube oil collection system was designed and installed during the 1980 refueling outage to meet the initial requirements of 10CFR50, Appendix R, as the rule was understood at that time. The system as initially installed, consisted of stainless steel collection pans, drain piping, and two collection tanks. The pans were located below the high pressure lift pump package, the lube oil cooler, the lube oil cooler discharge line, and circumferentially around the motor support stand, for each RCP motor. These pans drained to one of the two collection tanks which have flame arresters in their vent lines. The intent of the oil collection system was to prevent leaking lube oil from causing a fire which would render safe shutdown equipment inoperable. Design changes were implemented in 1990, to enhance the lube oil collection system capability.

Recent Events:

On July 11, 1994, the Haddam Neck Plant experienced an RCP motor lube oil leak leading to a unit shutdown for repair and modification to the RCP lube oil collection system. Millstone Unit No. 2 technical support staff followed the Haddam Neck Plant event and reviewed the Millstone Unit No. 2 system design to verify that a similar event was not likely to occur. A specific review of the Millstone Unit No. 2 vulnerabilities was conducted on July 15, 1994. This review concluded that although some unprotected, but seismically qualified lube oil piping did exist, Millstone Unit No. 2 was not vulnerable to a fire which would prevent safe shutdown and that the applicable requirements of 10CFR50, Appendix R were met. Significant factors in the review were the presence of mirror (metal) insulation around the RCPs, the limited amount of unprotected lube oil piping that previously had been determined acceptable by fire protection engineering personnel, and the fact that in May 1994, the conditions on all four motors had

been visually inspected and judged to be adequate by both unit maintenance personnel and the unit fire protection engineer. The result of this review was discussed with operations department personnel, plant management, and engineering management.

On the evening of July 26, 1994, at approximately 1725 hours, Millstone Unit No. 2 operations personnel received an RCP motor low oil flow to the ARD alarm on the 'A' motor and responded by operating the bearing lift pumps which cleared the alarm. This was followed by a series of intermittent low upper bearing oil level reservoir alarms during the night.

At 0600 hours on July 27, 1994, a power reduction was started in response to an RCP motor oil system low flow alarm. Initial containment entries for visual inspections of the 'A' RCP motor were made by engineering and maintenance personnel at approximately 1000 hours. While neither smoke nor fire were observed, some accumulated oil was noted on and in the immediate vicinity of the 'A' motor. Upon completion of the inspections, the decision was made to remove the unit from service. Detailed inspections were conducted by unit engineering personnel and representatives of unit and corporate fire protection engineering during the evening of July 27, 1994. The following observations were made:

'A' RCP motor - Oil had accumulated on the upper flange of the motor and was dripping down the motor housing. It was observed that approximately one-half to one gallon of oil was not collected by the oil collection system. A small amount of oil was noted on nearby blanket type insulation.

'B' RCP motor - No accumulated oil was noted in the immediate vicinity.

'C' RCP motor - No accumulated oil was noted in the immediate vicinity.

'D' RCP motor - Minor accumulations were noted. It was observed that approximately one-half to one pint of oil was not collected by the oil collection system.

In response to the oil collection system issues and the necessary repairs, a multiple team approach was adopted. One engineering team was assigned to review the present oil collection system capability, assess 10CFR50, Appendix R, Section III.O, compliance, identify all potential leak paths, and develop concepts for additional collection devices to enhance Appendix R, Section III.O compliance. Another engineering team was assigned to design and install the additional oil collection devices. The unit maintenance department was tasked with investigating and repairing

the lube oil systems on all four RCP motors. In addition to this work, maintenance personnel performed routine preventive maintenance on all except the 'B' motor, since it will be removed during the upcoming refueling outage.

The assessment of the first engineering team, which included fire protection engineering personnel, concluded that the system was not in compliance with 10CFR50, Appendix R. The oil collection system did not collect lube oil from all potential pressurized leakage sites. This assessment was based on observations made at Millstone Unit No. 2, and considered lessons learned from the recent Haddam Neck Plant experience. A prompt report was initiated to the NRC pursuant to the requirements of 10CFR50.72.

Discussion

RCP Motors:

NNECO's inspection of the RCP motors has identified several causal factors which could explain the oil leakage from the 'A' motor. Motor and bearing vendor personnel were contacted to assist in the investigations. The disassembly and maintenance performed on the 'A' motor torque drum and oil system resulted in a number of findings.

Contributors to the oil on the external surfaces of the motor were degraded internal hoses, loose internal fittings, and the absence of a torque drum cover seal. The apparent source of the additional oil leakage on the external structure of the 'A' RCP motor was a loose threaded pipe fitting on a lube oil supply line from the bearing lift pump package to the torque drum. The fitting was outboard of the torque drum and apparently did not leak during normal operations. It only posed a direct leak path to the containment environment when the lift pump was operating during startup, shutdown, or when operated to clear a lube oil low flow condition to the ARD, as was the case on July 26, 1994. These are also the probable cause of the low-reservoir level alarms and the lube oil system low flow alarms. Similar conditions, to the extent discussed above, were not identified on the 'B,' 'C,' or 'D' motors.

The elevated temperatures and the damaged thrust bearing on the motor are believed to have been caused by internal leakage of fittings, degraded internal hoses, and the bypassing of the oil from the bearing cooler suction header to the oil reservoir.

Six of the eighteen high pressure hoses, internal to the upper oil reservoir area, were found to be degraded and leaking on the 'A'

motor. This prevented the upper thrust bearing from building up sufficient oil film and caused the associated thrust bearing shoes to be damaged. This may explain the previous oil loss which could not be identified during earlier inspections. These hoses were visually inspected and considered acceptable by the vendor during the motor overhaul. These high pressure leaks were internal to the reservoir, thus could not leak directly to the containment environment, but could have caused more of the oil to be vaporized, thus making it easier to transport throughout the torque drum area.

The low pressure header ring, which is a fabricated rectangular box attached to the reservoir wall, was found to have clearances at various locations on its perimeter. This would allow oil from the bearings to bypass the oil cooler and to recirculate directly into the reservoir. This is the most probable cause of the elevated bearing oil cooler inlet temperatures, which had been attributed to restricted or deficient flow to the cooler.

Various threaded fittings, internal to the torque drum and oil reservoir, were also found not to be tight, which could exacerbate the conditions where oil could be vaporized internally and transported to the containment atmosphere. Both the suction header and the fittings were assembled by the vendor during the motor overhaul.

The torque drum cover was found to have no gasket or sealant. The vendor drawing, vendor manual, and maintenance procedure do not specify that a gasket is required for this cover, but gaskets were found on the other RCP motors. This presented a less restrictive transport path for the oil vapor and droplets present inside the torque drum area, due to the leaking hoses, to get to the containment environment.

These causal factors for elevated lube oil temperatures and the oil leakage will be validated via visual inspection and data trending after the motor is returned to service.

As previously stated, the inspections, repairs, and preventive maintenance tasks performed on the 'A' motor were also performed on the 'C' and 'D' motors. The 'B' motor, which showed no indication of leakage, was only inspected since it is scheduled to be removed from service during the upcoming refuel outage. The tasks performed on the 'A,' 'C,' and 'D' motor included the replacement of all high pressure hoses, visual inspections, tightening of internal and external fittings where necessary, repair of the low pressure header on the 'A' RCP motor, routine preventive maintenance, and installation of the torque drum cover sealant.

The high pressure hoses, which had been in service for approximately seven years will be examined to determine the cause

of the degradation. Radiation exposure, which is the only defined life limiting mechanism in the vendor manual, is not believed to have been a contributor to these failures. These hoses have seen only a small fraction (<10%) of their service life for radiation exposure.

Other maintenance performed included a general cleanup of oil and the replacement of a small amount of blanket type insulation, located in the immediate vicinity of the 'A' motor.

Motor Lube Oil Collection System:

Investigation into the RCP motor lube oil collection system identified two causal factors to explain the reasons for the lube oil found outside of the collection system.

The Millstone Unit No. 2 RCP motor lube oil collection system was installed in 1980 to satisfy the requirements of 10CFR, Appendix R, Section III.O. The original design was intended to meet the requirements of Appendix R, as they were understood at the time. The system, as originally designed and modified, was believed to have met that intent. It is also surmised that the design assumed that threaded or bolted joints that might leak would drip rather than spray. Hence, a collection system which relied on drip pans was implemented. This design approach was consistent with industry practice at the time.

Following the recent experience at the Haddam Neck Plant, the Millstone Unit No. 2 collection system design was re-evaluated. The lessons learned at Haddam Neck revealed two additional leak phenomena which degrade the effectiveness of a drip pan based collection system. The first was the interaction of leaking oil with air flow from the containment air recirculation fans. Although the Millstone Unit No. 2 RCP motors are not subjected to CAR fan airflow, the cooling air stream generated by the motor itself may have the capability to cause oil leakage, in some circumstances, to be transported away from the collection pans. The second phenomena is oil leakage which adheres, by surface tension, to instrumentation conduit, tubing, or structural members and travels away from the motor, before collecting on a surface which leads to the collection pans.

The lack of knowledge of these leak path phenomena is considered to be the primary causal factor for not fully collecting oil from potential leakage sites.

The identification of oil from the 'A' RCP leaks, which had not been captured by the collection system combined with the knowledge gained from the recent Haddam Neck events caused NNECO to reassess our compliance with Appendix R. Appendix R is quite specific in

requiring that "collection systems shall be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the reactor coolant p' ı lube oil systems." NNECO's interpretation of that requirement, in light of our recent experience, caused us to declare that the Millstone Unit No. 2 RCP motor lube oil collection system did not fully comply with Appendix R, Section III, Paragraph O.

In parallel with the motor inspection and repair, the oil collection system design was significantly enhanced.

Present Oil Collection System Design Philosophy:

As a result of the Haddam Neck Plant experience, the design philosophy utilized there was revised for use at Millstone Unit No. 2. The following is an excerpt from the General Requirements:

> The purpose of the collection system is to divert and collect oil which leaks from the lubrication oil system prior to coming in contact with an ignition source (e.g., hot pipe or electrical source).
>
> The primary design goal of the system is to collect oil from all pressurized and unpressurized potential leakage points. As such, the system is not designed to survive the effects of a fire. However, the design will utilize noncombustible materials (with the exception of gasket, sealant materials, and drain hose lining and jacket material). Therefore, the system will have an inherent ability to perform if, in the worst case, a minor fire were to occur.
>
> The specific design guidelines [in the actual design philosophy] are specified based on the fact that the oil lubrication system for the RCP is seismically qualified.
>
> The oil collection system shall be designed, engineered, and installed such that its failure, in and of itself, will not lead to a fire or affect safe shutdown of the plant.
>
> Generic Letter 86-10 Response 6.1 identified credible leaks as those from joints that could occur during the lifetime of the plant.

Improved Oil Collection System Design:

The RCP lube oil collection system for all four (4) installed RCPs is being enhanced by installing stainless steel sheet metal splash shields, collection pans, and encapsulation shields to improve the ability to collect and divert oil which has the potential to leak from the RCP motors. The collection system was redesigned to

provide increased assurance that lube oil from all credible pressurized and unpressurized leakage sites will be collected and contained. The shields and pans are attached to the motor housing and sealed to divert potential leakage into existing RCP oil collection tanks. The collection equipment was fitted with drain lines to allow the leak sites to be drained to the existing RCP oil collection tanks.

We believe that these modifications enhance the existing RCP lube oil collection systems and are designed, engineered, and installed such that leakage of RCP lube oil will not lead to a fire or affect safe shutdown of the reactor plant, pursuant to the requirements of 10CFR50, Appendix R, Section III, Paragraph O, Oil Collection System for Reactor Coolant Pumps (in non-inerted reactor containment buildings).

Appendix R Compliance:

NNECO concludes that the RCP lube oil collection system, as modified and configured, is in full compliance with 10CFR50, Appendix R, Section III, Paragraph O, with the exemption for the seismic design criteria previously referenced, based on the discussion below.

The original drip collection system was field fabricated and installed during the 1980 refueling outage. In 1990, a modification upgraded the lower collection pans. In conjunction with the current modifications, NNECO reassessed potential pressurized and unpressurized leakage sites in the reactor coolant pump lube oil system. This modification has upgraded the drip collection system to a system which collects potential pressurized and unpressurized leak sources through spray deflectors and encapsulation.

Based upon the material used (i.e., stainless steel drip pans, etc.) and the seismic 2 over 1 design installed, we believe that oil collection system components will not fail in a manner that will lead to a fire. Per the existing NRC Appendix R exemption granted in a letter dated November 11, 1981, the oil collection system is exempt from the requirement to withstand the Safe Shutdown Earthquake on the basis that the RCP lube oil system itself can withstand the Safe Shutdown Earthquake.

Millstone Unit No. 2's oil collection system design does take into account spray possibilities, as well as internal and external air flow effects. It specifically addresses lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the reactor coolant pumps, and ensures that all potential leak sites are protected.

Each of the two installed oil tanks has a capacity of 275 gallons, per original specifications. One RCP lube oil system capacity is approximately 137 gallons. The drain lines are sized large enough to accommodate the largest potential oil leak.

Conclusion

NNECO is confident that the source of the 'A' RCP motor oil leakage has been determined and corrected. Additionally, we have reasonable assurance that similar leakage will not occur on the other motors. Based on the discussion in the previous section, we are confident that the enhanced lube oil collection system will function consistent with the requirements of 10CFR50, Appendix R, Section III, Paragraph O, with the previously-granted exemption. We will provide the results of our material evaluations and future corrective actions, as appropriate, in a supplemental Licensee Event Report.

If you have any questions regarding these issues, please contact Mr. R. H. Young, Jr. at (203) 440-2073.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

J. F. Opeka

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