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Subject: McGuire Nuclear Station - Units 1 & 2
Docket Nos. 50-369, 50-370
Inservice Testing Program
Relief Request MC-SRP-NS-01
Supplement

Reference: (1) Letter from Mr. G.R. Peterson of Duke Power to NRC, dated August 12, 2004, (2) Letter from Mr. G.R. Peterson of Duke Power to NRC, dated November 18, 2004, (3) Letter from Mr. Jim Shea of the NRC to Mr. G.R. Peterson of Duke Power (TAC NOS. MC4507 and MC4508), dated February 24, 2005, and (4) Letter from Mr. G.R. Peterson of Duke Power, dated February 24, 2005

Attached is additional material to supplement the information discussed with the NRC staff during the telephone conference call conducted on March 8, 2005. Questions with respect to this matter should be directed to Norman T. Simms of Regulatory Compliance at 704-875-4685.

Sincerely,

G.R. Peterson

Attachment

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xc:

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ATTACHMENT

Relief Request MC-SRP-NS-01
Supplement

Additional Information
Relief Request MC-SRP-NS-01
Alternative to ASME OM Code
Duke Power Company
McGuire Nuclear Station, Units 1 and 2

I. Background

On March 8, 2005, Duke and NRC staff discussed via telephone conference call additional information that was provided in Duke's letter dated February 24, 2005 related to Relief Request MC-SRP-NS-01. This relief request proposes alternative testing requirements to that of ISTB-3300 (e)(1) of the 1998 Edition of the American Society of Mechanical Engineers Operating and Maintenance (ASME OM) Code regarding testing of the Containment Spray (CS) System pumps. This Code requirement to test at a minimum of 80% of design flow poses a hardship in that the CS System and supporting Refueling Water System will require modifications to provide such capability.

During the March 8th telephone call, the NRC staff indicated concerns regarding (1) the effectiveness of Duke's vibration monitoring program to detect degradation at the proposed alternative test flow rate vs. the design flow rate, (2) the effects of modifications to the CS pump structural supports, and (3) the effects of the CS pump motor replacement/refurbishments. This attachment provides supplemental information regarding these concerns.

II. Vibration Monitoring Program Effectiveness at the Alternative Test Flow Rate

MNS's Vibration Monitoring Program provides trending and analysis of vibration data, including data collected during each IST Program pump performance test. This program monitors overall vibration levels, operating speed (1X) vibration level, and excitation of resonance frequencies. Monitoring of this vibration data for the CS pumps provides early detection of any degradation in balance of rotating components, bearing health, and motor health. Note that alignment is not an issue with the CS pumps since the motor and pump impeller share a common shaft.

The following is an examination of the effectiveness of MNS's Vibration Monitoring Program at the proposed alternative test flow rate vs. the design flow rate of the CS pumps. This examination considers the differences and effects of variation in (1) operating speed, (2) axial thrust, and (3) turbulent flow.

Effects of Operating Speed

Significant variations in operating speed (1X) could shift the operating speed such that it could overlap with a resonance frequency and produce significant vibrations. The following will evaluate this concern by comparing the effects of testing the CS pumps at an alternative flow rate of 1200 gpm vs. the full design flow of 3400 gpm.

The CS pump motors are 4000 volt AC induction motors, which provide very low motor slip with a rated speed of 1791 rpm. This represents a motor slip of 9 rpm between the unloaded synchronous speed of 1800 rpm and the rated full load speed of 1791 rpm. Table 1 provides actual CS pump operating speeds as recorded during recent quarterly pump test.

Table 1 – Containment Spray Pump Test Data

Pump	Operating Speed (RPM)	Flow Rate (GPM)	Vibration Radial (in / sec)	Vibration Radial +90 (in / sec)	Vibration Axial (in / sec)	Test Date
1A	1795	985	0.087	0.084	0.085	3/10/2005
1B	1793	1000	0.122	0.148	0.099	1/27/2005
2A	1793	990	0.085	0.111	0.074	1/19/2005
2B	1795	1000	0.078	0.275	0.062	4/3/2005

Table 1 verifies the CS pumps are operating within the expected 9 rpm band of motor slip, with some deviation influenced by voltage and frequency variations. The operating speed at the proposed alternative test flow rate of 1200 gpm would be equal to or slightly less than these values. This is based on the pump performance curve indicating a motor load of 300 brake horsepower (bhp) at 1200 gpm vs. 290 bhp at 1000 gpm (reference: Figures 1 through 4 in the attachment to Duke's letter dated February 24, 2005). The operating speed at the design flow rate of 3400 gpm would be expected to be 1791 rpm, based on a load of 410 bhp vs. the full rated load of 400 bhp. Therefore, the variation in operating speed between the proposed alternative test flow rate and the design flow rate of 3400 gpm is expected to be 2 to 4 rpm, which is well within the 9 rpm rated motor slip.

This variation in operating speed is confirmed by comparison to actual test results from a Residual Heat Removal (RHR) pump. The RHR pumps are similar to the CS pumps in that they are the identical model, Ingersoll-Rand 8x20WD, and the motors are equivalent 400 HP motors with the exception of the thrust bearings for the RHR pump being at the upper bearing location, where the thrust bearings for the CS pumps are at the lower bearing location. Table 2 provides actual test data demonstrating that the operating speed on the RHR pump is within the 9 rpm rated motor slip. The variation in operating speed of this RHR pump is only 3 rpm between a flow rate of 897 to 3375 gpm. This data supports that a CS pump operating between the alternative test flow rate of 1200 gpm and the design flow rate of 3400 gpm would have an expected variation in operating speed in the range of 2 to 4 rpm.

Table 2 – Residual Heat Removal Pump Test Data						
Pump	Operating Speed (RPM)	Flow Rate (GPM)	Vibration Radial (in / sec)	Vibration Radial +90 (in / sec)	Vibration Axial (in / sec)	Test Date
2A	1794	897	0.139	0.117	0.119	3/28/2005
2A	1792	1958	0.120	0.109	0.087	3/28/2005
2A	1792	2827	0.040	0.055	0.056	3/28/2005
2A	1791	3375	0.034	0.057	0.050	3/28/2005

Analysis of vibration data for CS pumps at MNS indicate that a typical band width of resonance for this pump structure is 2 Hz, which equates to 120 rpm. When considering a potential 4 rpm variation in operating speed, it is concluded that this small variation in speed is not significant for shifting the operating speed of the pump relative to a resonance frequency. Therefore, the effectiveness of the vibration monitoring program is not significantly affected when considering operating speed variations experienced between a 1200 gpm and a 3400 gpm flow rate.

Effects of Axial Thrust

Axial thrust loading is a hydraulic performance difference to be considered in comparison of testing the CS pumps at the alternative test flow rate of 1200 gpm vs. the design flow rate of 3400 gpm. Axial thrust load is affected by variations in suction and discharge pressure over the flow range of the pump. These loads are transferred through the impeller and shaft to the thrust bearing. At higher thrust loads, critical clearances tend to be reduced. The monitoring of vibrations at a well developed thrust load provides adequate indication of any developing degradation resulting in clearance or load issues with the rotating components (e.g., bearing defects, motor defects).

The characteristics of axial thrust load to vary with flow for the Ingersol-Rand Model 8X20WD are graphically depicted in Figure 1 of NRC Information Notice 93-08. This figure shows that the characteristic for the CS pump is to have a higher thrust loading at a flow rate of 1200 gpm than at a flow rate of 3400 gpm. This figure demonstrates that axial thrust is fully developed with little variation between 1000 gpm to 2600 gpm. Axial thrust at flow rates greater than 2600 gpm is significantly reduced as flow is increased. Therefore, testing at a reduced flow rate of 1200 gpm provides an adequate ability to identify degradation. Testing at the design flow rate of 3400 gpm does not provide any increase in this ability, and is slightly less capable in detecting degradation in comparison to tests performed at lower flow rates.

Effects of Turbulent Flow

Turbulent flow is a hydraulic effect that needs consideration when considering the differences between a test flow rate of 1200 gpm and 3400 gpm. The CS pumps and RHR pumps are identical pumps and as such the RHR pumps can be used as a comparison to confirm the hydraulic characteristics of the CS pumps. A review of vibration data from the RHR pumps confirms that this pump characteristically has higher vibration levels at 1200 gpm than at the design flow rate of 3400 gpm. Table 2 provides overall vibration levels recorded during recent testing of a RHR pump and demonstrates this typical characteristic. The basis for this characteristic is that at a flow rate of 1200 gpm, this pump design has internal recirculation within the pump casing that produces excitation of structural resonance frequencies. This excitation enables trending of these resonance frequencies, which provides early indication of any shifts in resonance, which can be indication of degradation such as loose components or developing bearing defects. Therefore, vibration testing at a reduced flow rate of 1200 gpm provides adequate excitation to trend vibration levels and resonance frequencies for early detection of degradation. Testing at the CS pumps' design flow rate of 3400 gpm does not enhance this ability to detect degradation due to lower energy levels available to produce vibration and excite resonance frequencies.

Conclusion

The vibration monitoring program has been shown to be more effective when testing at the proposed alternative flow rate of 1200 gpm, than at the design flow rate of 3400 gpm. This is supported by the CS Pump characteristics of very small variation in operating speed over its load range, fully developed thrust loads at low flow rates, and a higher level of excitation of resonance frequencies at the proposed alternative test flow rate of 1200 gpm vs. the design flow rate of 3400 gpm. Therefore, the effect on the vibration monitoring program of testing at 1200 gpm vs. 3400 gpm is that the 1200 gpm provides better conditions for vibration monitoring with no significant benefits for testing at higher design flow conditions.

III. Structural Support System Modifications

Modifications MGMM-8752 and MGMM-8771, modified the structural support system for the 1A and 2A CS pumps, respectively. Similar modifications were not needed and not performed for the 1B and 2B CS pumps.

These modifications were implemented to reduce vibration levels below the alert range. Vibration in the alert range constitutes a threshold where additional monitoring is required to enable increased trending focus for potential further degradation. This increased monitoring is accomplished through an increase in the frequency of testing. The 1A and 2A CS pumps were experiencing vibration in the alert range, and as such the testing frequency had been increased from quarterly to monthly. The cause of these vibration levels was that the inherent natural resonance frequencies of the pump structure were overlapping with the pump operating speed. These modifications were successful in reducing these vibration levels below the alert range and therefore, returning the testing frequency to a quarterly frequency. This previous alert level of vibration is not indicative of any damage to the CS pumps.

The scope of these modifications included providing tight fitting lateral supports. This lateral support is located at the pump casing flange, approximately 6" above the attachment point of each pump's main support. This lateral support provides additional stiffness in both lateral directions to that of the main pump support. Additional lateral stiffing at the pump casing reduces pump casing motion and reduces the sensitivity of the assembly to flow forces originating in the impeller/diffuser, which reduces vibration amplitudes.

These modifications were successful in shifting the natural resonance frequencies away from the operating speed of the pumps. The reduction in vibration levels experienced following these modifications demonstrates this success. These physical changes provide no other limitations or adverse effects that influence the performance of the CS pumps.

IV. Motor Replacement/ Refurbishment

The motors for the CS pumps have a planned replacement every 20 years. This replacement program is not the result of observed degradation or a service life concern, but rather provides a method to perform periodic internal inspections of these enclosed housing motors.

Table 2 of the attachment to Duke's letter dated February 24, 2005 describes the motor replacement activities to date. These motor replacements restore each motor to the original equipment specifications and do not result in any significant changes.

As part of the motor replacements, the 1A CS pump motor was replaced with the "spare motor." This spare motor is identical to the replaced original 1A CS pump motor. Also, this spare motor successfully satisfied both electrical and pump performance testing prior to being placed in service.

The CS motor replacement includes refurbishment of the removed CS Pump motors by the OEM per Duke Specification DPS 1318.00-00-0001. The removed motors from the 1A, 1B, and 2A CS pumps have been rotated to the next subsequent replacement, with the exception of the motor removed from the 1B CS pump that has been refurbished and is currently waiting to be substituted as the motor for last of the four replacements, which is the 2B CS pump in October of 2006. As part of these refurbishments, the OEM was required to document an as-found inspection of each motor. These inspection reports confirm that there were no significant degradation issues, including that the bearings were found to have no unusual wear. The refurbishment of each motor includes electrical testing, dynamic balancing, and replacement of the upper guide bearing and lower thrust bearings with equivalent bearings. These equivalent bearings are the same size, materials, and load rating, but may have minor differences due to manufacturer's improvements in its design.

The motor challenges are subject to the previously discussed effects of operating speed variation, axial thrust, and electrical challenges. As discussed earlier, the operating speed variation between 1200 gpm and a design flow of 3400 gpm is insignificant. Axial thrust is actually more severe at the 1200 gpm flow rate than at 3400 gpm. However, the primary challenge for the motor in completing its pump performance test is the electrical challenge of the starting current that is drawn to accelerate the shaft to operating speed. During this starting transient, the motor pulls locked rotor current until the shaft approaches its operating speed for that load. This higher current challenges the motors ground-wall insulation. This electrical challenge occurs each time the pump motor is started. Considering this electrical challenge, there are no significant benefits of a CS pump test at the design flow rate of 3400 gpm vs. the proposed alternative flow rate of 1200 gpm.

V. Conclusions

In summary, there have been no significant modifications or corrective maintenance performed on the four CS pumps since preoperational testing. The CS pump hydraulic characteristics of (1) the slope of the head curve, (2) insignificant variations in shaft speed over the range of flow, and (3) higher axial thrust loadings at lower flow rates disposition these pumps such that the alternative test requirements proposed by the relief request are adequate to assure the ability of the NS pumps to perform their intended functions.

Therefore, there is not a compensating increase in the level of quality and safety in comparison to the hardship of completing plant modifications that would be necessary to enable testing of CS pumps at design flow rates.