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18 May 2005

Mr. William Levis
Chief Nuclear Officer and President
PSEG LLC - N09
P. O. Box 236
Hancocks Bridge, NJ 08038

Dear Mr. Levis,

Re: Hope Creek B Reactor Recirculation Pump

I have recently become aware of reports of high vibration on the Hope Creek B Reactor Recirculation Pump. We have extensive historical knowledge and experience with these Byron Jackson pumps; from 1989 through 1992 we were involved with the detection of shaft cracks in seven Byron Jackson rotors in BWR applications like yours.

We have learned that your pump has shown high vibration for some time. We are very concerned that the Hope Creek B Reactor Recirculation Pump has a developing shaft crack. Please allow me to explain our reasoning.

A rotor with shaft asymmetry (for example, a transverse or circumferential crack) will experience a reduction in stiffness in the plane of the crack. When the rotor is subjected to a radial force, a shaft with a crack will bow more than a similar shaft without a crack. **The bowed rotor condition is indicated by a change in the 1X phase, the 1X amplitude, or both. The resulting asymmetric rotor stiffness can also produce changes in 2X response.** In addition, the a shaft with a crack will exhibit a changing and evolving dynamic response during startup or shutdown operating conditions, i.e. higher resonance amplitudes, lower resonance frequencies, different low-speed vectors, etc.

In main coolant pumps, radial side loads at the impeller, as well as unidirectional forces resulting from misalignment of the motor and pump shafts, provide the necessary radial forces to drive both the 1X and 2X responses.

It is important to recognize that as a transverse crack propagates, the rotor will eventually bow, resulting in a change in the 1X response. However, 2X activity is dependent on the combination of shaft asymmetry and the radial forces acting on the shaft. Because of this, the presence of a significant 2X component may be indicative of shaft asymmetry, but the converse is not true. Significant 2X activity will not be observed until the asymmetric rotor bending stiffness and the radial forces acting on the shaft are sufficient to generate a 2X response. **In approximately 60% of the rotor crack incidents, the 1X response is the first indicator of the problem.**

It is quite possible for 1X vibration amplitude to decrease at some point during crack development. This decrease occurs when the crack-induced bow in the rotor acts in a direction that partially or completely cancels out the normal residual unbalance in the rotor. When this happens, 1X phase will often continue to evolve over time. Eventually, as the crack grows towards catastrophic failure of the rotor, both 1X and direct vibration amplitude will increase again, and the rate of change will increase quite rapidly near the end.

It is very important to adequately monitor the evolution of the vibration on these pumps. X and Y shaft-relative, eddy-current probes are preferred over casing-mounted seismic transducers. Also, to obtain 1X- or 2X-filtered amplitude and phase information, a Keyphasor® probe, which provides a once-per-turn timing reference, is necessary. 1X and 2X amplitude and phase should be monitored during steady-state operation. In addition, 1X and 2X startup and shutdown data should be carefully reviewed for changes in the locations of resonances or their amplitudes. 1X low-speed vectors can be sensitive to changes in rotor bow; they should be examined during every startup and after every shutdown and compared to archived data. Changes in low-speed vectors are another indicator of an evolving crack.

In the past, rotor cracks developed just above the impeller in the hydrostatic bearing area. The vibration measurement location is usually located far away from where the cracking is actually happening, so vibration measurements, especially casing measurements, may have poor sensitivity to the vibration that will actually be occurring near the impeller. For this reason, any unusual vibration should be taken very seriously.

In Byron Jackson pumps, a resonance exists near running speed that involves relatively large motion of the pump impeller. These pumps have five impeller vanes. When the rotor operates at 1/5 of running speed (around 360 rpm), the vane pass frequency can strongly excite this vibration mode during startup or shutdown. The frequency of this resonance is very sensitive to rotor stiffness and, hence, to the presence of a crack. It is also helpful to have a good rotordynamic model that can be compared to vibration data.

Hopefully, this letter will help to provide you with additional insight into this pump's behavior. If I or my team can be of further assistance, please feel free to contact me at 775-783-4610, or e-mail me at don@bpb-co.com .

In reading the report it was noted that the vibration was very large, but suddenly decreased for no apparent reason. In the case of a shaft radial cracking, this can be a very bad sign. Possibly meaning that the rotor is already broken or severely cracked. I, therefore, agree with the opinion of GE that the machine should be stopped and checked for shaft crack or other major malfunction. This is not a certain thing because the recurring motor system has a very poor vibration information observation system on it. However, it is certain that the machine should be stopped as it may have some major malfunction.

Sincerely Yours,

BENTLY PRESSURIZED BEARING COMPANY

Donald E. Bently

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CC: Eugene W. Cobey, Chief, Projects Branch 3, Division of Reactor Projects, United States Nuclear Regulatory Commission

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