AREVA Field Balancing and Vibration Diagnostics Services

Condition-Based Monitoring of Reactor Coolant Pumps (RCPs)

Thorough condition monitoring on RCPs can provide insights to the integrity of the equipment. However, several practical limitations on the extent of those insights exist.

Performance indicators on the mechanical condition of RCP internals that can be monitored continually typically include flow rates, bearing temperatures, and vibration levels. In all cases, these variables are best evaluated together. However, historical precedent has shown that the vibration signature typically provides the greatest detail as to potential faults the machine may undergo.

The most effective condition monitoring includes (1) frequent or continuous monitoring while at power, and (2) the capture of routine transient conditions such as system pressurization/de-pressurization and pump startup/coast-down. Equally critical to the monitoring technique is having knowledgeable individuals evaluate the acquired data with sufficient frequency to identify issues in a timely manner.

Field Vibration and Balancing Services Include:

- Routine (scheduled) vibration monitoring and trend evaluation
- Post-maintenance trim balancing and condition assessment
- Technical support to apparent cause and root cause evaluations
- Expert oversight for vibration-critical maintenance evolutions (e.g. alignment)

Features & Benefits

- Highly experienced personnel
  - Specific expertise in mechanical design as well as vibration theory and practice
  - Accustomed to nuclear plant work environment and operating considerations
- Monitoring and equipment compatible with most commonly-used rotating machinery diagnostics applications

AREVA
forward-looking energy

Detectable Conditions

Reactor recirculation pump motor bearing damaged from oil whirl. Detectable before the failure and after, and preventable if identified promptly.

Routine Faults

Pump condition monitoring can provide timely insights to routine issues such as misalignment, unbalance, runout, and (motor) bearing condition. These faults can typically be assessed and corrections implemented with sufficient lead time to protect equipment from more severe problems.

Unusual Conditions:
Shaft Cracking

More severe issues such as shaft cracking can be identified with sufficient margin to provide a safe shutdown and planning for a repair — weeks or months in advance of failure. However, history has shown that shaft cracks typically do not present distinct dynamic characteristics more than a fuel cycle in advance of failure. Therefore, with regard to shaft cracking, any projections made as to the integrity of a pump for a fuel cycle or longer are based only on the ***absence of indications*** to the contrary. Ultrasonic testing of pump shaft base material is sometimes used as a confirmatory technique in conjunction with monitoring. Similarly, this technique can confirm the detection of a crack, but will not typically detect crack initiation more than a fuel cycle in advance of failure.

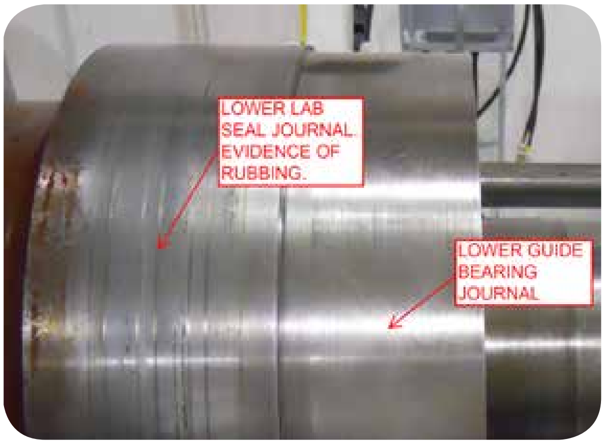
Unusual Conditions:
Turning Vane Bolting Failure

The failure mechanism — identified by Westinghouse as a nuclear safety concern — which has led W-93A owners to assess pump integrity is the failure of turning vane bolting. There are only a few known cases where all the turning vane bolts failed and the turning vane dropped from its installed position. Therefore little published information exists detailing the effects of vibration that resulted from these conditions. However, analysis of other related conditions such as internal rubs in these pumps suggests strongly that this condition is detectable if monitored carefully, though it does not suggest that there is any early warning for this failure mechanism. The turning vane bolted joint remains an ordinary bolted joint up to the point of failure. Prior to failure, the bolted components remain (1) in position, and (2) in compression, so there is no loss of stiffness. No changes to vibration signature would be expected prior to the “dropping” of at least some portion of the turning vane joint.

Unusual Conditions:
Age-Related and 'As-Built' Issues

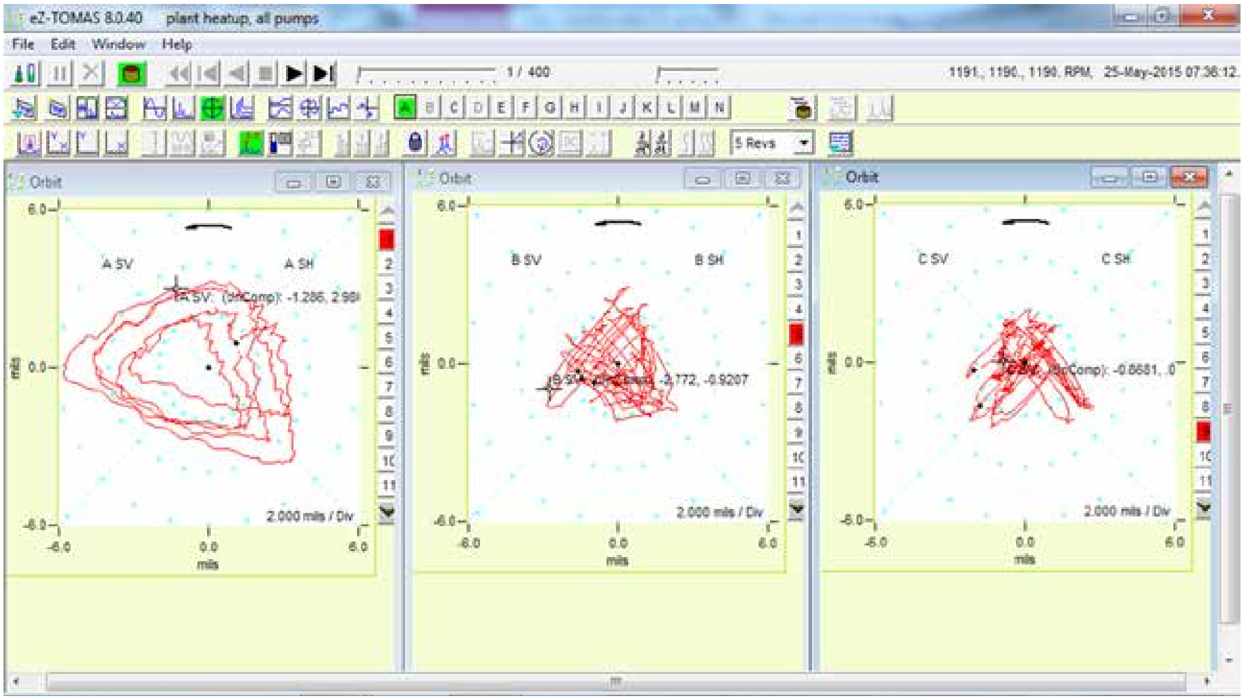
Many W-93A and other RCPs were built with substantial hydraulic unbalance. This feature is very detectable, and is often offset (but not corrected) by mechanical balancing. History has shown that RCPs can function with hydraulic unbalance. However, its dynamic characteristics are similar enough to mechanical unbalance and runout that it is critical to identify the condition via startup monitoring, so it can be distinguished from other 'abnormal' behaviors.

Similarly, some conditions have developed after many years of service which generally have little or no effect on the operability of a pump. Impeller looseness is one such condition. A thorough monitoring program can identify it in an existing pump, so that it can be distinguished from other issues that may threaten the integrity of the pump. Extra mechanical balancing may be required to mitigate the effects of impeller shifting. New or refurbished pumps have a design upgrade to preclude this mechanism.



Both the bearing journal and the labyrinth seal fit show evidence of mechanical contact. Rubbing can usually be identified by vibration analysis and often corrected.

Flywheel fit area of motor shaft showing wear. This condition may be detected during operation with vibration monitoring.



Shaft orbits shown here for three reactor coolant pumps (shown together for comparison). The orbit is the trajectory of the shaft centerline as it rotates. Evaluation of the shaft orbit is one of the fundamental tools used regularly by AREVA to evaluate the health of rotating equipment.

AREVA Inc.
For more information, contact:

Gerry Ottman
Sr. Manager of Innovation and Technology
Gerald.Ottman@areva.com
(434) 832-4097 - Office
(434) 841-1912 - Cell

us.areva.com