Dynegy – Wireless MCT Implementation

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Background

Dynegy provides electricity, natural gas and natural gas liquids to customers throughout the United States, and owns power plants that cumulatively provide of up to 12 000 MW. The Baldwin Energy Complex, discussed in this document, is a coal-fired plant that generates about 1 761 MW.

In April 2003, EPRI (Electric Power Research Institute) partnered with Dynegy on a joint venture pilot project to demonstrate a wireless vibration monitoring solution for a coal pulverizer. The coal pulverizer was one of six pulverizers located on the basement floor of Unit 3. The reason for selecting a versatile wireless solution was primarily of economic nature. The costs associated with installing conventional LAN cable or fiber optics were higher.

Figure 2. The SKF Velocity and Enveloped Acceleration Machine Condition Transmitters (MCTs).

Figure 1. Dynegy's Baldwin Energy Complex.

The objective was to identify a reliable wireless system able to provide overall vibration magnitudes to Dynegy's OSI PI Historian at one-minute intervals. Eventually, this data would be routed to the control room operator to display the values and provide alarming for the operator.

Dynegy took a proactive approach to monitoring vibration levels on mission critical assets, focusing on early detection and notification of abnormal machine conditions, with the ultimate goal of enhancing equipment reliability and personnel safety.

The original wireless pilot system, provided by a competing vendor, failed to deliver reliable data and was taken out of service after six months.

Dynegy still considered a working solution for a wireless vibration monitoring system as the way to go and selected two new vendors to evaluate, one of them being SKF Reliability Systems. Both vendor solutions were employed side by side, each system monitoring different parts of the pulverizer.

After eight weeks SKF Reliability Systems was chosen to provide the wireless vibration monitoring solution, when the other vendor's solution failed to provide reliable and continuous service.

The application

A single CE-Raymond Model 923 RP pulverizer equipped with eight Wilcoxon 786A accelerometers was chosen for monitoring. Accelerometers were positioned on two motor sleeve bearings, two worm screw rolling element bearings, one bearing at the bottom of the bull gear vertical shaft and at each grinding roll. The accelerometers were mounted on each of the three grinding roll journal assemblies, as shown in **fig. 4**.

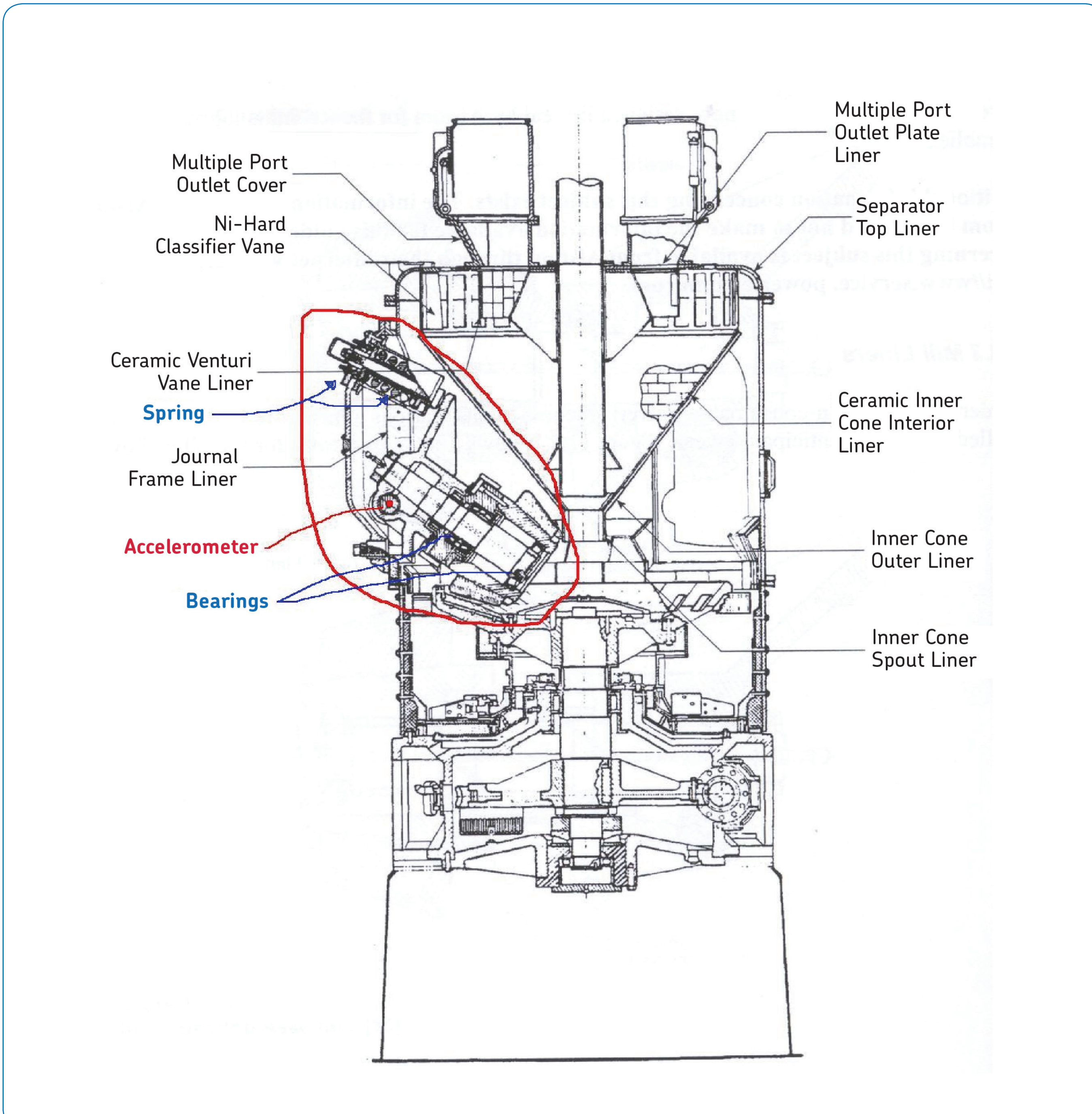

Figure 3. Sensor configuration on pulverizer.

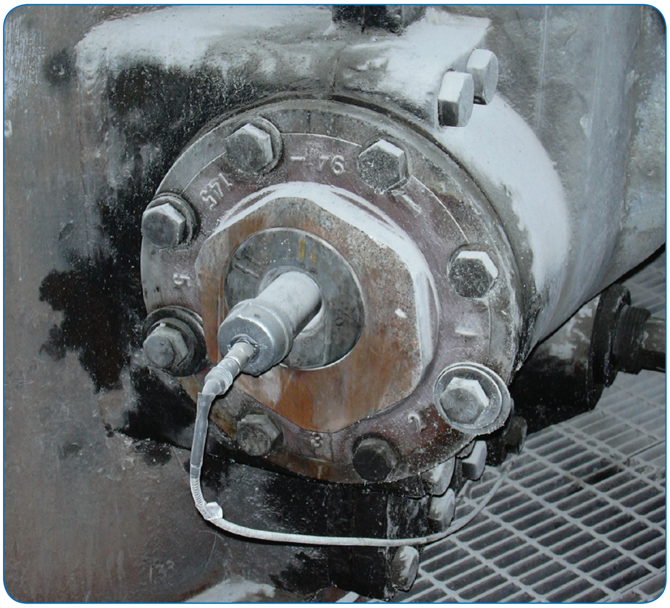

Figure 4. Accelerometer mount.

Figure 5. Industrial environment with obstacles; initial measurements with the SKF Microlog.

In order to challenge the wireless solution, the pulverizer located the furthest away, approximately 60 m *(200 ft.)*, from a wireless access point was selected. Although this distance is fine for office environments, it can be difficult in an industrial environment that has walls, I-beams, pipes and other metal structures that serve as attenuating obstacles for wireless signals. In this case, the wireless system needed to be able to transmit through a path that included 5 × 5 ft. metal air ducts connected to each of the pulverizers. The typical indoor range of the wireless radios used is 150 to 450 m *(500 to 1 500 ft.)* and up to 26 km *(16 mi.)* outside with line-of-sight (and high-gain antennas).

In addition to the wireless obstacles, the environment itself was subject to harsh conditions, including wide seasonal temperatures ranging from 4 to 38 °C *(40 to 100 °F)*, fly ash and water wash-downs. Besides the environment, some monitoring points were looking at equipment running speeds of 45 to 600 r/min. A reliable solution able to withstand these conditions and meet application requirements was required.

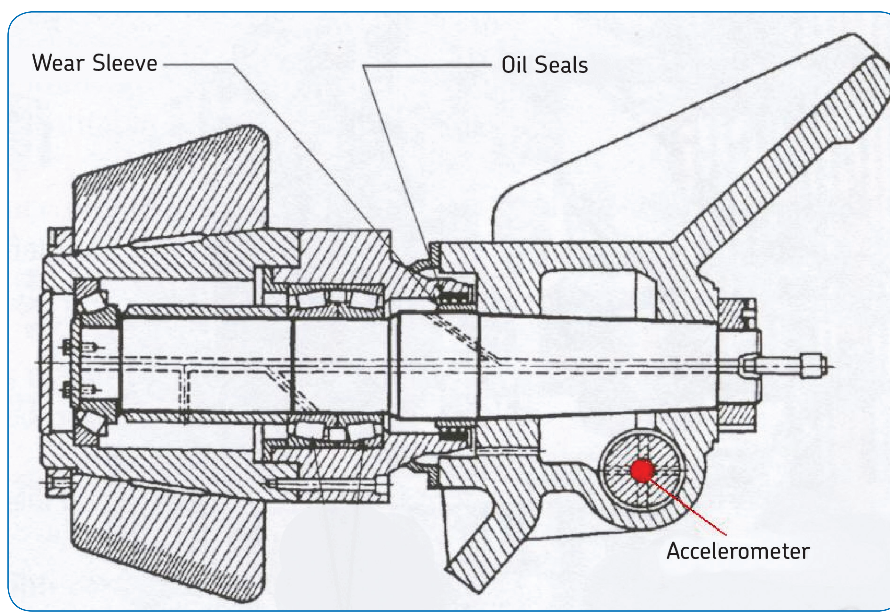

Figure 6. Side view of the grinding roll showing the sensor location.

Table 1. MCT configuration.

MCT channel	MCT type	Part number	Application tag	RPM
1*	Velocity	CMSS 530-100A-ER-ISO LF	Drive Motor Number 1 – Horizontal	600
2	Velocity	CMSS 530-100A-ER-ISO LF	Drive Motor Number 2 – Horizontal	600
3*	Enveloping, Band 3	CMSS 590-100A	Worm Screw Number 1 – Axial	600
4*	Velocity	CMSS 530-100A-ER-ISO LF	Worm Screw Number 2 Velocity – Axial	600
5*	Enveloping, Band 3	CMSS 590-100A	Worm Screw Number 2 Enveloping – Axial	600
6	Enveloping, Band 3	CMSS 590-100A	Grinding Roll Number 1 – Axial	90
7*	Enveloping, Band 3	CMSS 590-100A	Grinding Roll Number 2 – Axial	90
8	Enveloping, Band 3	CMSS 590-100A	Grinding Roll Number 3 – Axial	90
9	Enveloping, Band 3	CMSS 590-100A	Bull Gear Vertical Shaft F3 – Axial	45
10	Enveloping, Band 2	CMSS 590-100A	Bull Gear Vertical Shaft F2 – Axial	45

* These channels were not connected to the SKF system; however, the system was installed complete and ready to go for all channels after the evaluation period was complete.

Solution

During the pilot period, half of the accelerometers were connected to the SKF system, and the other half were connected to the other vendor's system.

Working from the sensors up, we first started with Velocity and Enveloped Acceleration Machine Condition Transmitters (MCT). In general, the Velocity Transmitter provides an indication of the machine health, like imbalance or misalignment; and the Enveloped Acceleration Transmitter provides an indication of the bearing degradation. The MCT's were configured as shown in **table 1**.

Although only eight accelerometers were employed, ten MCT's were used. The system was delivered with the buffered output from Channel 4 (the raw acceleration signal) serving as the input to Channel 5. Similarly, the buffered output from Channel 9 fed into Channel 10. This daisy chaining of MCT's allows additional multi-parameter measurements to be made without having to install more sensors.

All of the Velocity MCT's were configured for a 1 IPS full scale range, while all of the Enveloping MCT's were configured for a 10 gE full scale range. All MCT's provide a 4 to 20 mA processed output that is representative of the overall channel value. By using a CMCP RM-16A1 16-channel A/D converter, the 4 to 20 mA signals could be converted to Modbus Ethernet (RS-485) and sent wirelessly to the access point.

The wireless transceiver selected for this project was the Locus OS2400-485 Industrial Ethernet Radio. All of the devices were DIN-rail mounted and fit nicely in a small, easy-to-mount enclosure.

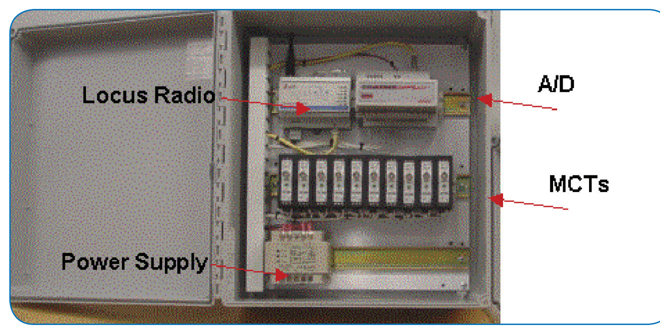

Figure 7. MCT front end.

Impact

The system was installed and fully operational in one day, and the actual installation took place on March 9, 2004. On March 15, only five days after installing the SKF solution, the pulverizer experienced a bearing failure on the Number 2 grinding roll. As Dynegy put it, "The [SKF] system was instrumental in notifying plant personnel of a change in operating characteristics of the pulverizer. A review of the PI Historian showed the correlation between changes in pulverizer motor current and the vibration trends on the inboard motor bearing, outboard worm shaft bearing and the Number 1 and Number 3 rolls, prompting the PdM Engineer to take more in depth vibration data with a portable analyzer". What the plant personnel saw is shown in **fig. 8**.

Motor current was also plotted along with the Number 1 and Number 3 grinding roll vibration data. The data from these rolls came from the SKF system. Even though the failure did not occur within these rolls, the vibration from the failed roll Number 2 was strong enough that the MCT's were able to detect it. Again, the plot **(→fig. 9)** shows a distinct correlation between the motor current and the vibration data from the rolls.

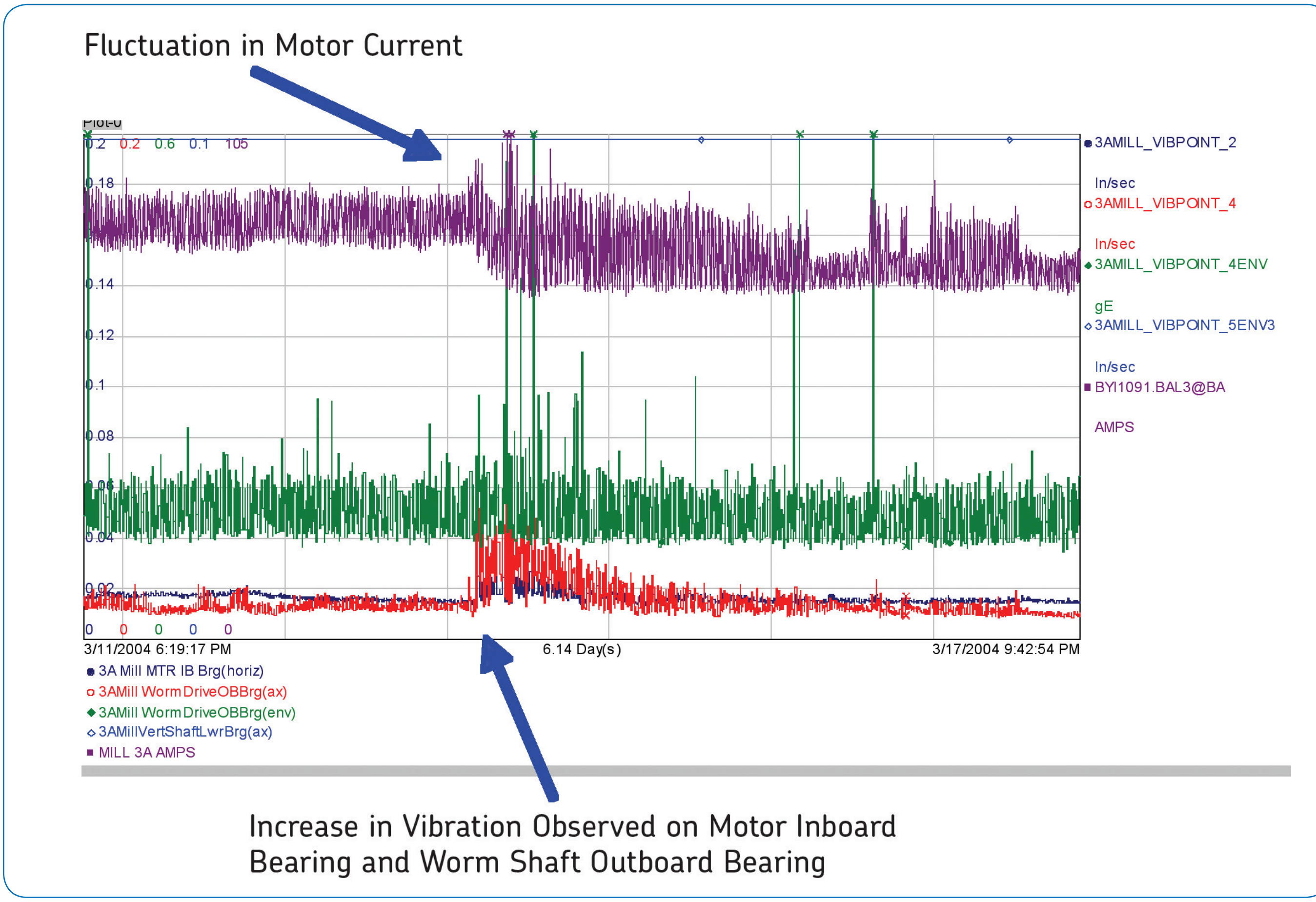

Figure 8. Plot showing the correlation between motor current and bearing related vibration data.

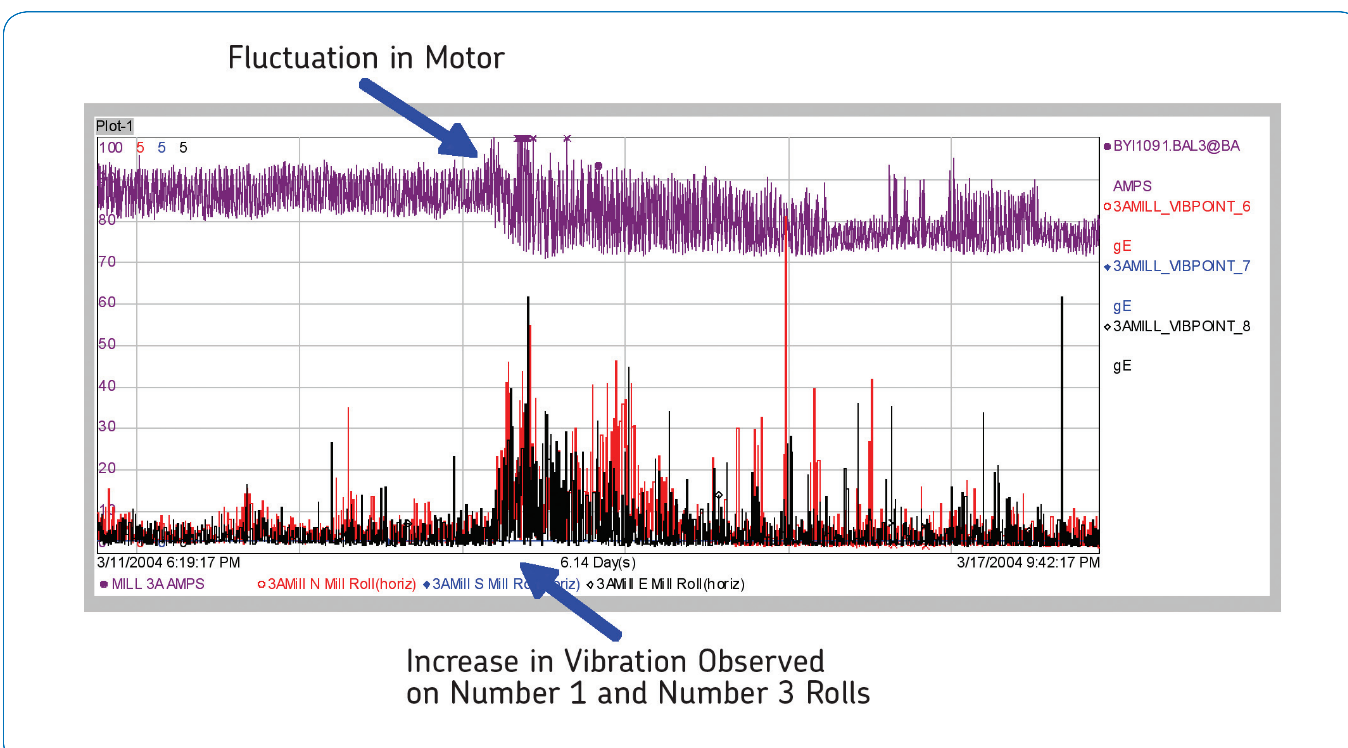

Figure 9. Plot showing the correlation between motor current and the grinding roll vibration data.

The vibration data collected by the PdM Engineer, coupled with an unsuccessful attempt to adjust the grinding roll, forced a visual inspection. This inspection revealed the Number 2 grinding roll bearing had failed, and the roll had dropped into the bowl and come in contact with the cone assembly **(→fig. 10)**.

Both bearings in the roll had failed and had actually disintegrated. The root cause is suspected to be a lack of oil in the journal, which would contribute to the relatively rapid failure. The journal shaft was also distorted from the heat, and the inner races of the bearing were stuck to the shaft. Furthermore, the bolts holding the upper journal housing to the grinding roll were sheared off, causing the grinding roll to slide and hit the center feed pipe, and even breaking a piece out of it, as shown in **fig. 11**.

Unfortunately, the measurements from grinding roll Number 2 were being fed into the other vendor's system, but even then, the MCT system detected a higher vibration level. We suspect that if the SKF system had been monitoring this particular channel, the enveloped readings would have detected this earlier. This would have clearly shown that a drastic change had occurred and, more than likely, it would have been soon enough to prevent a catastrophic failure.

As a result, the SKF system (Wireless MCT System) was chosen as the wireless vibration monitoring solution for this coal pulverizer and recommended for many more applications.

Figure 10. The failed bearings.

Figure 11. The damaged center feed pipe.

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