



EMERSON[™]
Process Management

Vibration Monitoring of Electric Rope Shovels



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Vibration Monitoring of Shovels

- MINExpo 2012: Caterpillar announced the largest Electric Rope Shovel, capable of 120 short tons
- The next day, JoyGlobal (P&H Mining) CAT, introduced a shovel capable of 135 short tons
- **Large Concern:** breakdown (unplanned outages) of one machine will be more disruptive to production

Machinery Health Overview

Diagnosing machines is similar to diagnosing people



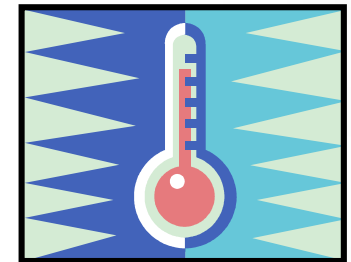
Vibration:

The 'pulse' of the machine



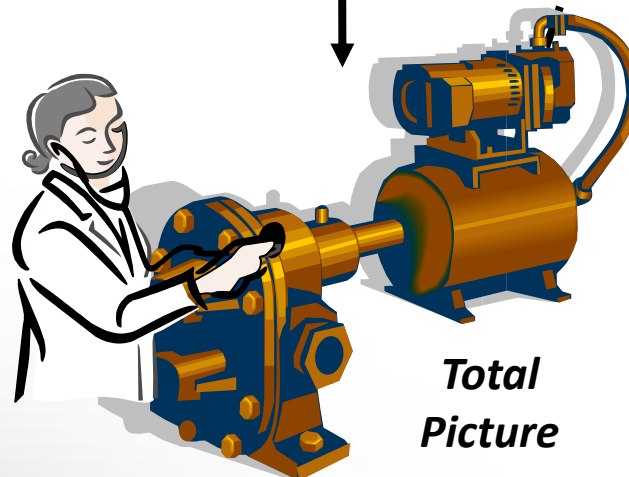
Oil:

The 'life blood' of the machine



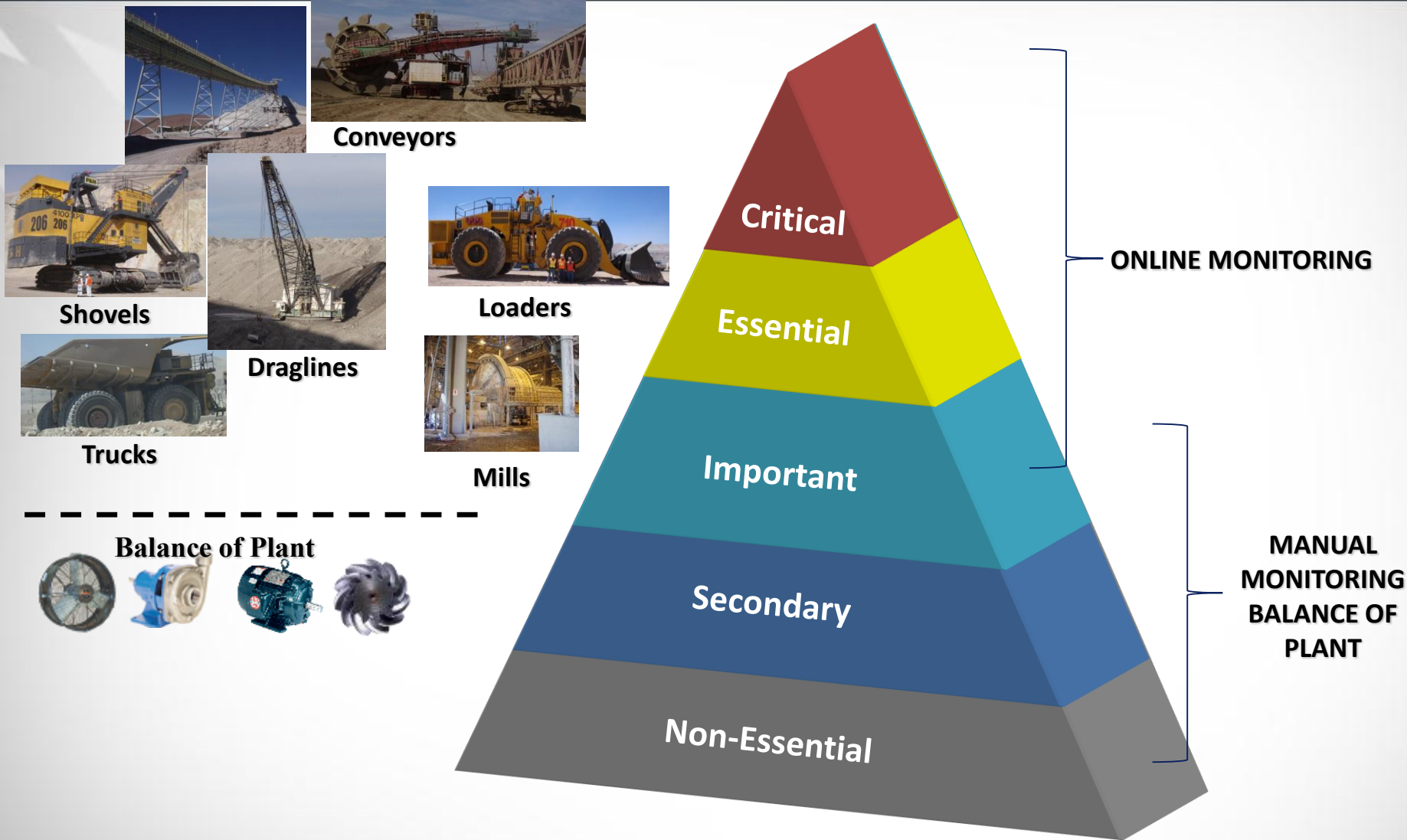
Thermography:

'Taking its temperature'



**Total
Picture**

MHM Throughout the Mine



The Mining Pinch

- Because of global demands, Mine operations cannot afford any of their critical assets to shut down unexpectedly
- Electric Rope Shovels are one of the most critical assets in Open Pit Mining
- Shovels are very large, complex machines with large rolling element bearings and gearboxes
- This machine complexity combined with the tough 24/7 service duty results in too much unplanned shovel downtime
- This unplanned downtime can affect the entire downstream process



Shovel's Part in the Mining Pinch

- Due to the machine complexity, Vibration Analysis and PeakVue[®] tends to be the best technologies to determine the Machine's Health
- Arguably, shovels are the most difficult to monitor because of their inconsistent, short cycles and variable load operation [\(video\)](#)
- The Machine Health of most shovels is not monitored in any way
- Progressive mines remove shovels from operation monthly to determine machine health, but there are issues with production and safety





Manual Monitoring of Shovels

- Portable (Manual) Route is ideally scheduled every month
- Requires a 3-6 hour planned outage that is difficult to coordinate
- No other maintenance activity can be performed
- Frequently the task is rescheduled
- Safety issues during manual data collection
- Requires specialized pit technicians



Automate Shovel Monitoring

- The solution is to automate the shovel monitoring
- Utilizing the adaptive monitoring of Emerson's online monitoring system has proven to capture consistent, repeatable data to accurately determine shovel health
- Emerson's online monitoring system can continuously monitor the health of the following Shovel Systems
 - Swing
 - Hoist
 - Crowd
 - Propel



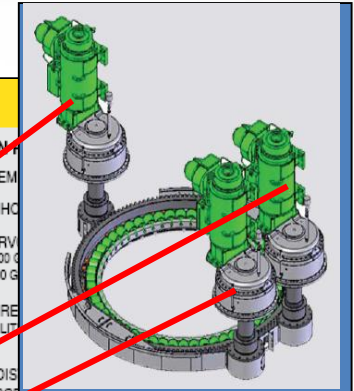
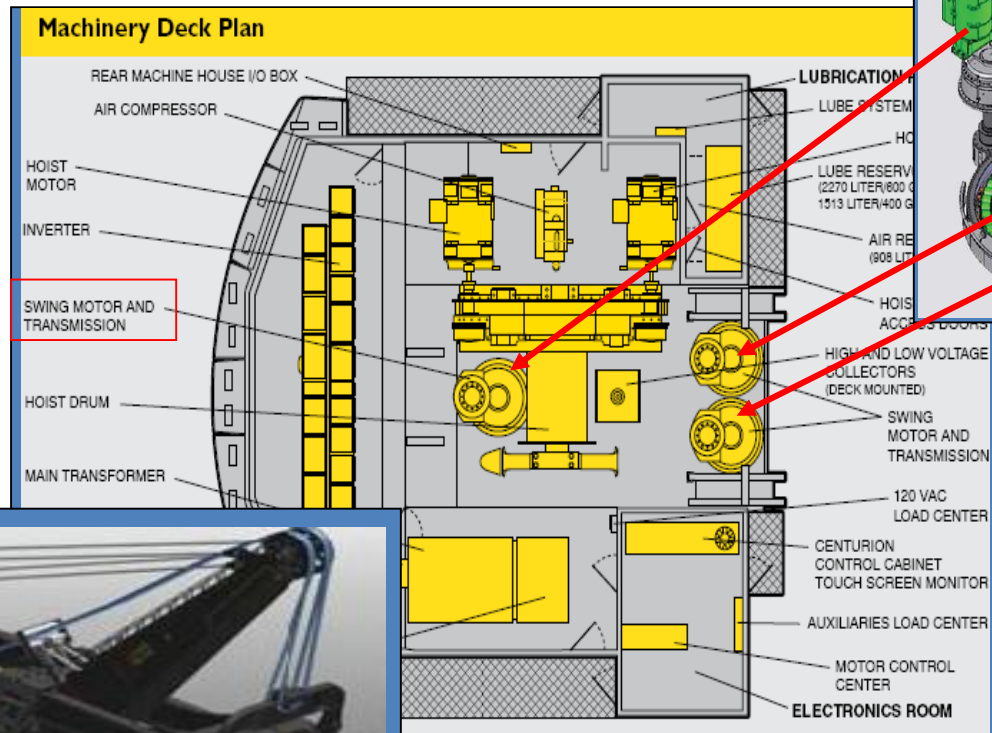
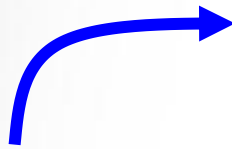
Shovel Primary Systems



Shovel Primary Drive Systems

SHOVEL PLAN VIEW

Shovel



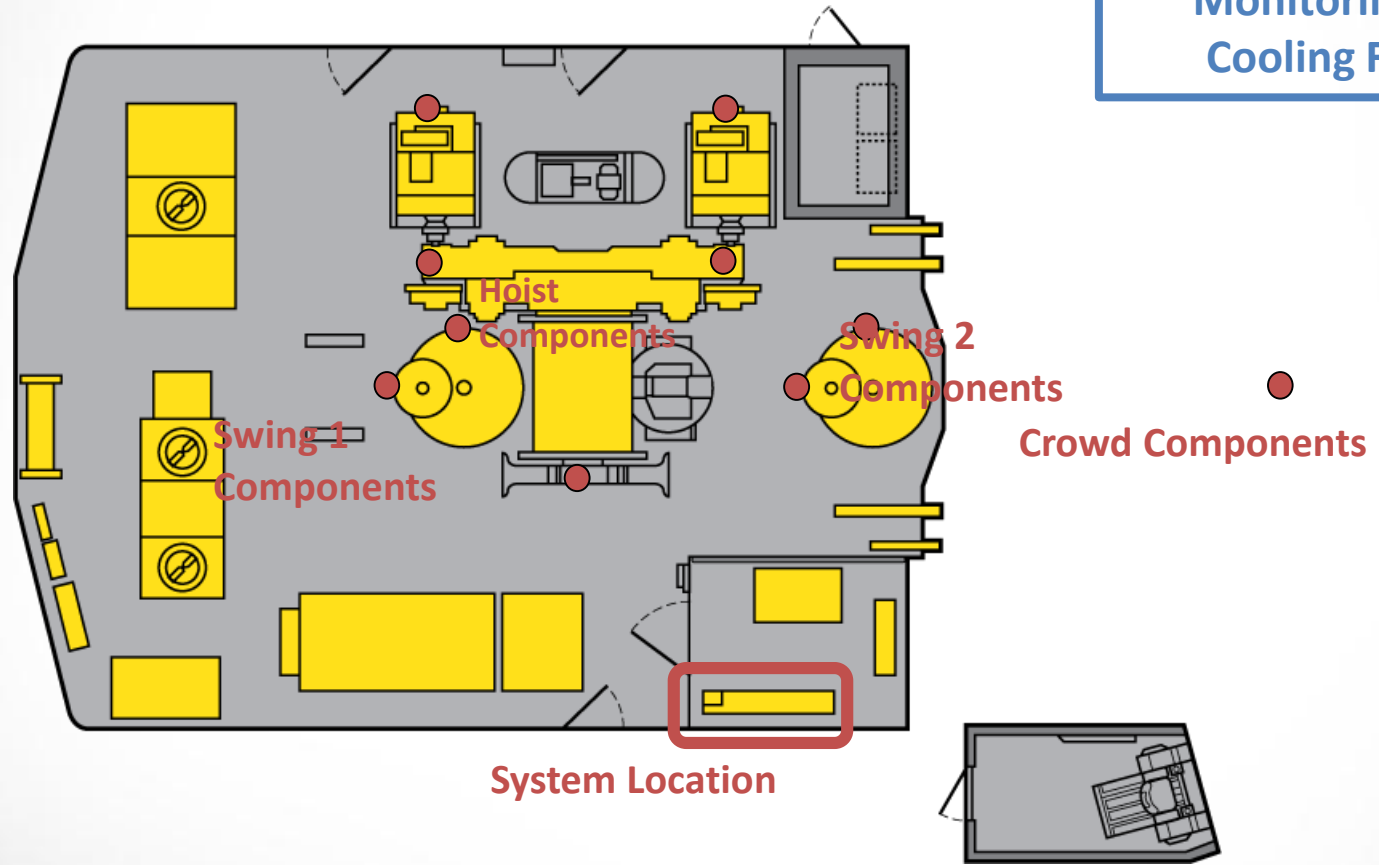
System Implementation Challenges

- System Design: Where to install the Sensors
- Installation Time
 - System Cabinet
 - Sensors, Junction Boxes and Cabling
 - Cabinet Acquisition Screen
- Data Collection
- Getting Data out of the Pit

System Design

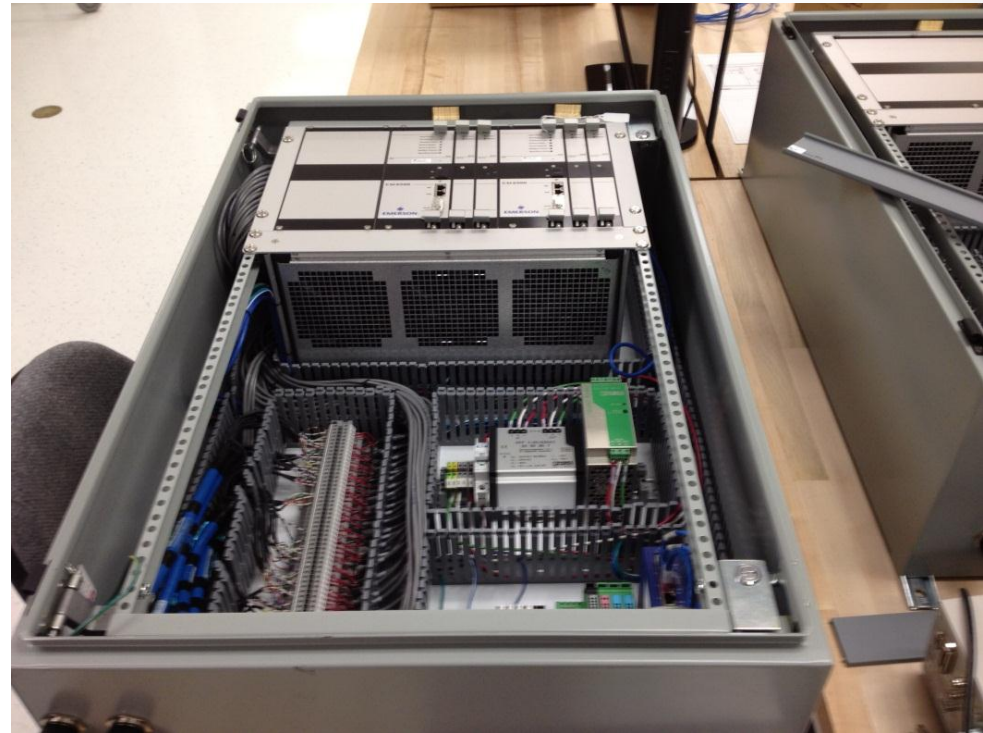
Typical Shovel – one cabinet
Largest Shovels – two cabinets

New addition
Wireless Vibration
Monitoring of
Cooling Fans



Plan View: Shovel Machinery Deck

Installation Time: Vibration Monitoring Cabinet



CSI 6500 Cabinet

Installation Time: Wiring Harnesses



Cable Assemblies

Installation Time: Plug & Play



Cable Connectors on Cabinet

Data Acquisition: Typical Operation & Staged Testing

Test controlled by
operator
or remote personnel

Start Hoist Test

- Ⓜ Begin Test - Crowd out almost to limits and quickly move the hoist up and down
- Ⓜ Testing underweigh - Continue hoisting up and down
- Ⓜ Test Completed - Stop Hoisting

Start Crowd Test

- Ⓜ Begin Test - Raise dipper until the dipper handles are at perpendicular to the boom and at the inner limits. Set the hoist brake. Move the crowd in and out at maximum speed.
- Ⓜ Testing underweigh - Continue crowding in and out
- Ⓜ Test Completed - Stop crowding

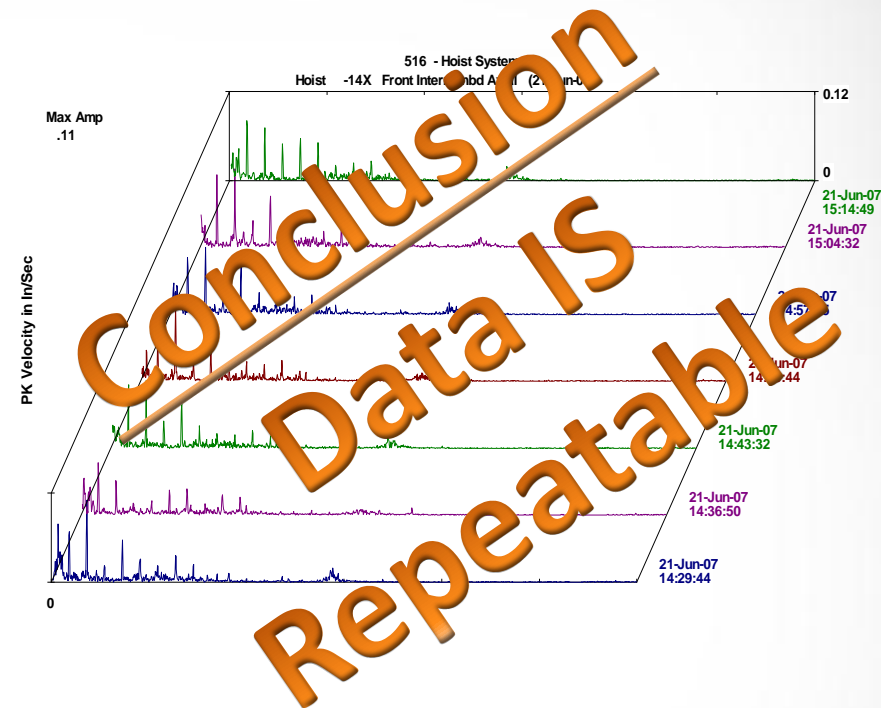
Start Swing Test

- Ⓜ Begin Test - Raise the bucket to be under the boom end - set the hoist and crowd brakes. Begin swinging to the right at maximum speed.
- Ⓜ Testing underweigh - Continue Swinging to the right
- Ⓜ Reverse direction - Swing to the Left
- Ⓜ Testing underweigh - Continue Swinging to the right
- Ⓜ Testing Completed - Stop swinging

Data Acquisition:

Primary Test Criteria: Repeatability

- The system was able to trigger and collect data both during staged test and during digging operations:
 - High Resolution data was collected each cycle during dipper latching



Data Acquisition:

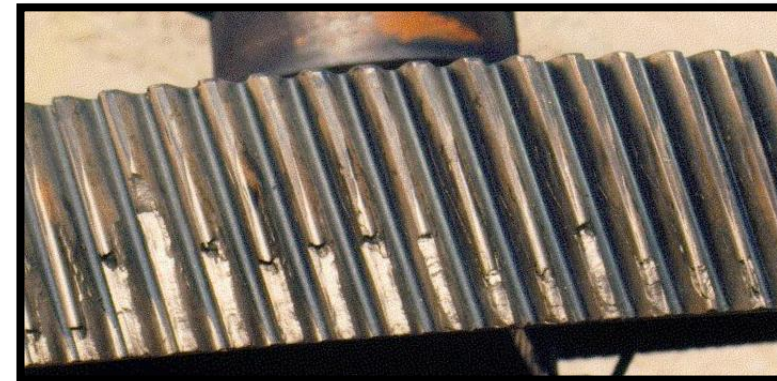
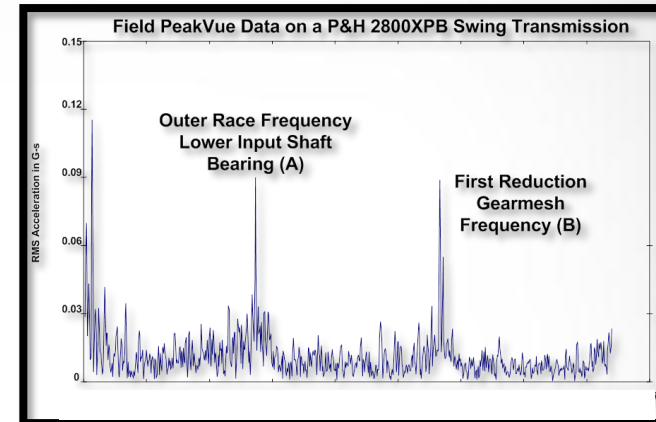
What faults can be found?

CHALLENGE

- It is difficult to monitor complex gearboxes and non-traditional motors
- Complexity comes from variable speed + variable load + short duration operations which makes data gathering difficult

SOLUTION

- Online continuous vibration monitoring with PeakVue provides earliest possible detection of swing, hoist, and crowd issues ranging from bearing anomalies to gear mesh and impacting
- Example: Identified a problem in the crowd transmission → planned shutdown
- Example: Identified a problem with shovel hoist gear wear → planned shutdown



Failed Shovel Hoist Gear

How is the data uploaded?



Customer's Choice

How is the data uploaded?

- Manual Wireless Backhaul
 - Local Analysis
- Automatic Wireless Backhaul
 - Local Analysis
 - Remote Analysis
- Satellite Upload
 - Remote Analysis

Major OEM Recognizes MHM Value

JOYGLOBAL
P&H

Site: Global



Work Scope per Shovel

- Continuous Monitor:
 - CSI 6500 Prediction units
- AMS Machinery Manager installed onboard shovel
- Sensors with Plug & Play cables

- JoyGlobal is the largest manufacturer of mobile mining equipment in the world
- Covers Online Vibration Monitoring on P&H's Centurion[®] Controlled Shovels
- Hoist, Crowd and Swing systems are monitored with standard system vibration monitoring system
- Integrated to the JoyGlobal PreVail[®] Remote Monitoring System to send vibration information to the JoyGlobal HQ

Enjoy Responsibly



Electric Rope Shovel Monitoring

For more Details:

- Emerson Process Experts Blog
<http://www.emersonprocessxperts.com/2011/10/if-it-moves-monitor-it/>
- Maintenance World Magazine
http://palvelut.promaint.net/lehti/maintworld_2_2013.html
- Contact Information
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QUESTIONS?