Improving Reliability with Caterpillar Condition Monitoring Services

Presented by

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Topics

• About Caterpillar Global Petroleum
• Background – Why Condition Monitoring
• Overview of the Caterpillar Solution
• How the PI System Fits into the Solution
Products – Global Petroleum

- Natural Gas Engines
  95 to 8180 bhp
- Diesel Engines
  40 to 21,760 bhp
- Generator Packages
- Well Service Packages
Global Petroleum Applications Served

- Gas Compression
- Drilling
- Well Servicing
- Production
Condition Monitoring Service Opportunity

• Pressure to increase productivity
• Equipment is more complex
• More data available
• Limited Information for Decision Making
• Changing workforce

• Assets are
  – Dispersed
  – Low Population Density
  – Autonomous

• Experts are
  – Valuable
  – Not next to equipment
Bathtub Curve

- Quality
- Infant Mortality
- Wear out
- Useful Life
- Reliability
- Operating Hours
- Durability
Reliability & Condition Monitoring

• General Sense (Military) - "The probability that an item will perform a required function without failure under stated conditions for a stated period of time."

• Business Sense (Barringer) – Includes long term costs
  – Procurement
  – Installation
  – Operations
  – Maintenance

• Caterpillar - “A proactive analysis process using equipment & application data from multiple sources to make informed application, maintenance, repair, or component replacement decisions.”

Elements
  – Electronic Data
  – Fluid Analysis
  – Inspections
  – Component Life Cycle Position
  – Site Conditions
Solution Requirements

- Aggregate from Cat & non-Cat equipment
- Transport data offsite
- Analyze data automatically 24/7 to find exceptions for early warning
- High fidelity data to capture fast acting & intermittent events
- Distribute exceptions to experts
- Provide drill down
- Distribute recommendations and asset performance to stakeholders
- Maintain Knowledge Base
Service Solution Using the PI System

Customer Process Network -> Data Aggregation -> Cat Interface

Parameters Events Diagnostics -> Data Archiving & Visualization

Parameters -> 24/7 Data Analysis

Dashboard Health

Recommendations

Management -> Maintenance Customer -> Operations

Caterpillar Dealer
Exception Interpretation

Caterpillar

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Solution Using the PI System

- PI Modbus Interface
- PI OPC Interface
Solution Using the PI System

- Cell to Caterpillar PI Server
- DSL to Caterpillar PI Server
- PI to PI Interface
- Other Historian to PI Server
Solution Using the PI System

- PI SDK – PI Server to SmartSignal
- EPI Center
- Identify exceptions to obtain early warning of pending failures
Solution Using the PI System

- PI AF
- PI ProcessBook
- PI DataLink
- PI WebParts
- PI SMT
- PI ACE
- PI Notifications
Solution Using the PI System

- PI AF
- PI WebParts
- PI ACE
- PI Notifications
Solution – Early Warning of Developing Failures

Filtered Combustion Time – Cylinder #1

6 months

- Recommended Action – Visually inspect cylinder head at next out of service PM.
- Found eroded pre-chamber
- Avoided Potential Piston/Liner and Turbocharger Failure
Solution – Drill Down – PI WebParts

- Used to assess incidents reported by EPI Center
- Where is engine relative to expected performance?
### Solution – ECM Event & Diagnostics – PI WebParts

#### Engine Speed

#### Turbine Inlet Temp

- **Turbine Inlet Temp**
- **Turbine Outlet Temp**
- **Diagnostic Active**

#### Start Duration (Minutes) Description

<table>
<thead>
<tr>
<th>Start</th>
<th>Duration (Minutes)</th>
<th>Description</th>
</tr>
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<td>08-Apr-10 02:17:24</td>
<td>3.3</td>
<td>Right Turbo Turbine Inlet Temperature Sensor : Voltage Above Normal</td>
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<td>08-Apr-10 02:46:34</td>
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<td>0.3</td>
<td>Right Turbo Turbine Inlet Temperature Sensor : Voltage Above Normal</td>
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</tbody>
</table>

- **Used to detect short duration, intermittent events prior to failure**
- **Link diagnostics to observed behaviors to identify mode.**
Solution – High Fidelity Capability

- High fidelity data for most of operation.
- But low fidelity could miss important events.
Solution – High Fidelity Capability

- UCP automatically loads compressor up to next load step
- Engine speed droops.
- Indicated load increases.
- UCP unloads compressor after 5 seconds.
- Engine is stopped after 7 seconds.
Solution – High Fidelity Capability

- Governor racks fuel
- Wastegate closes to maintain air/fuel ratio.
- Turbo lag causes mixture to go rich.
- Multiple cylinders detonate
Solution – High Fidelity Capability – Tracking Misfire

• Increasing Misfire Possible Causes
  • Excessive Spark Plug Gap
  • Fouled Spark Plug
  • Fouled Needle Valve
  • Fouled PC Check Valve
• Detect before cylinder goes cold

Exhaust Port Temperatures

% Misfire
Solution – Tag Tuning – Before & After

- Unfiltered Combustion Time
- Interested only in misfires
- 1 second updates = 1 million data points per day for 12 cylinder engine.
- Tag tuning reduces to 10 to 20k per day.
Condition Monitoring Benefit

Revenue Impact

• G3616 Gathering Compressor
  – 32 MMSCFD @ $4.00/MSCFD
  – Increase Utilization by 0.1 point = $47,000 / yr
  – 8.75 Hours

Cost Impact

• Failed pre-chamber
  – Replace piston & liner $25 to $35K
  – Replace turbocharger $50 to $75K
Questions

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