



Improving Reliability with Caterpillar Condition Monitoring Services

Presented by

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Caterpillar, Inc. - Global Petroleum

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





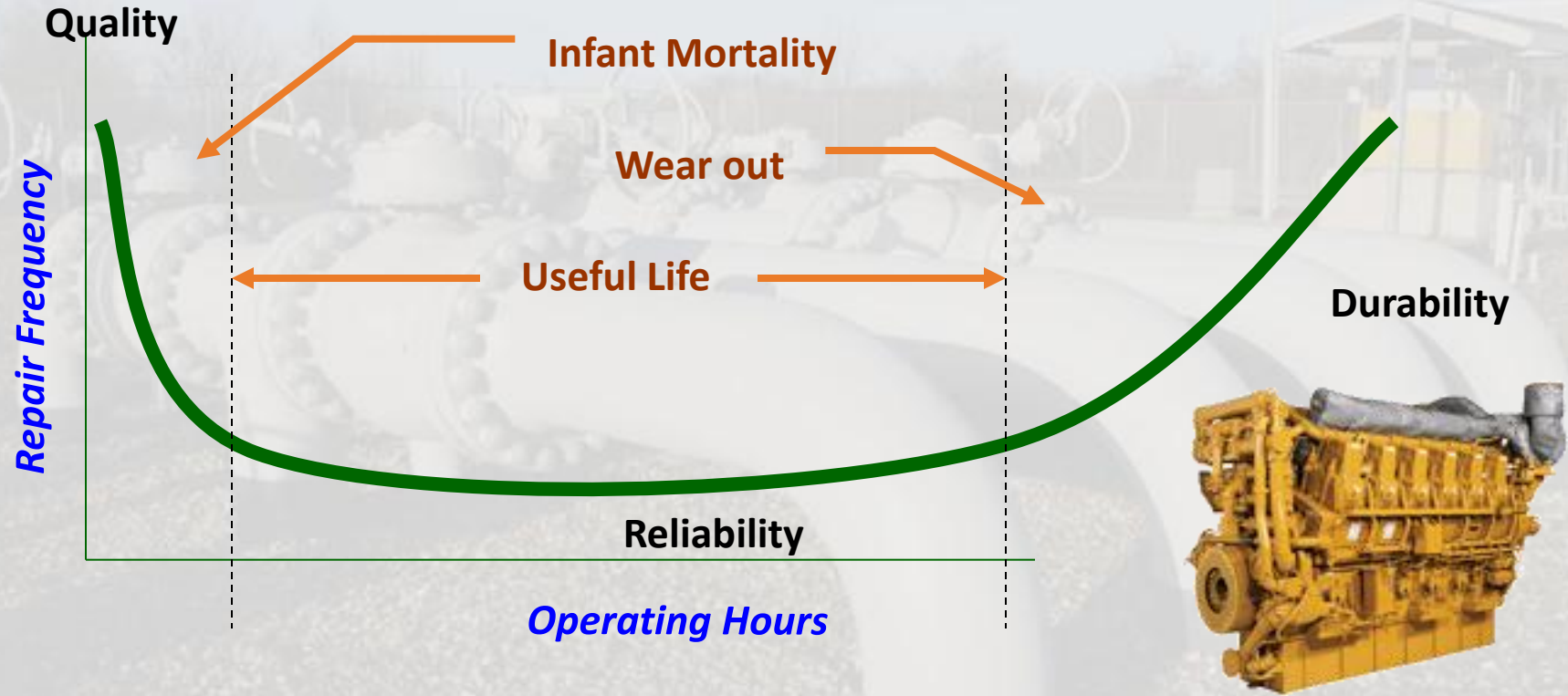
Global Petroleum Applications Served

- 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



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

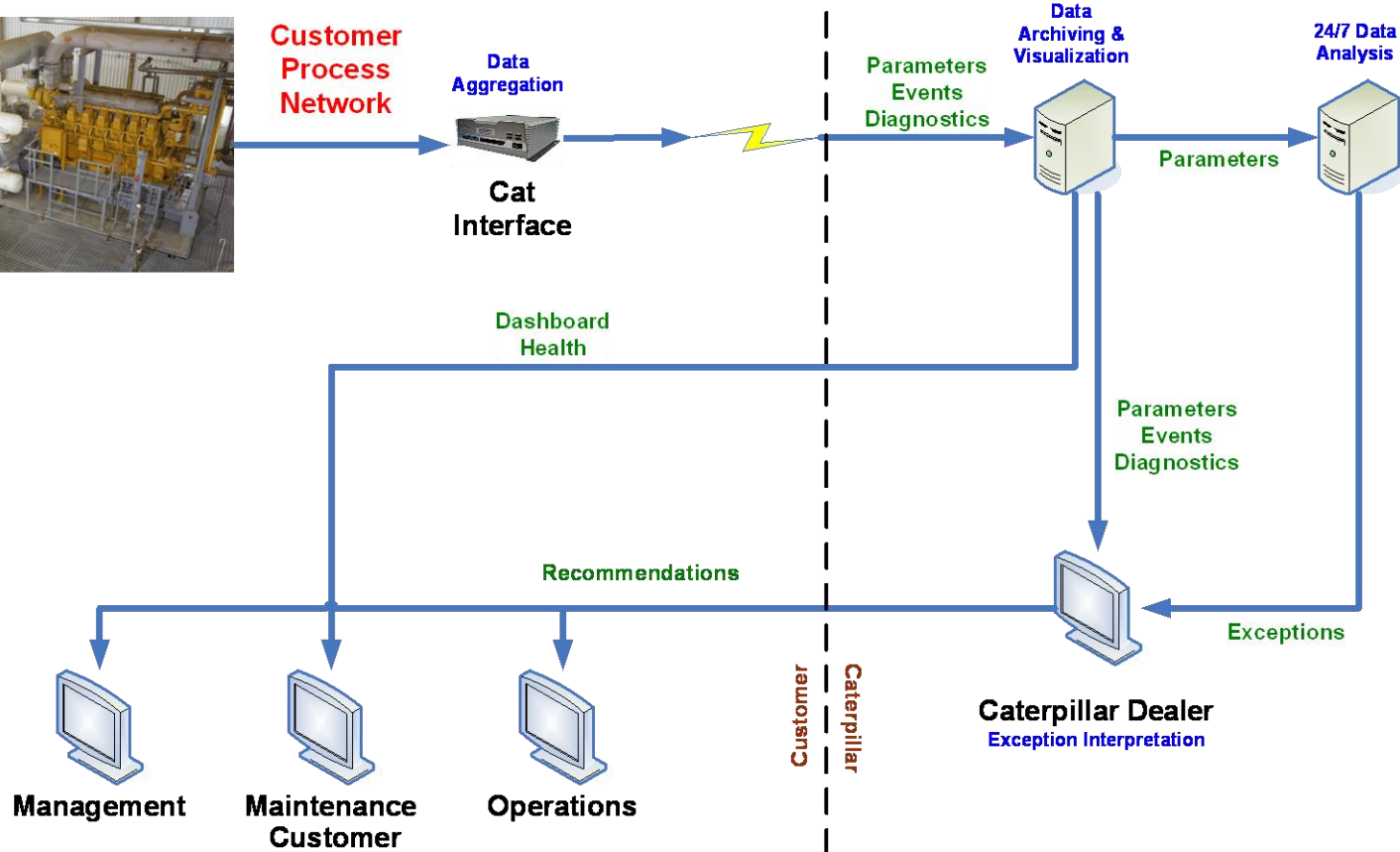


Solution Requirements

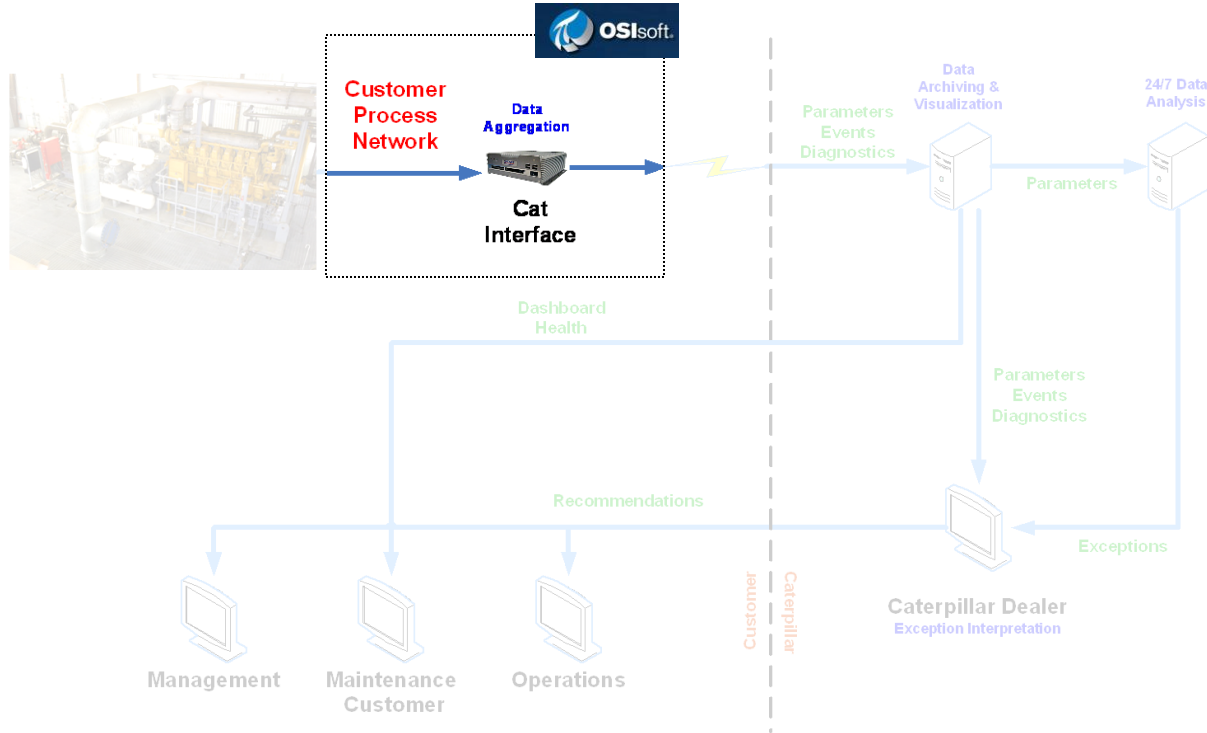
- Aggregate from Cat & non-Cat equipment
- Transport data offsite
- Analyze data automatically 24/7 to find exceptions for early warning
- High fidelity data to capture fast acting & intermittent events
- Distribute exceptions to experts
- Provide drill down
- Distribute recommendations and asset performance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



Service Solution Using the PI System

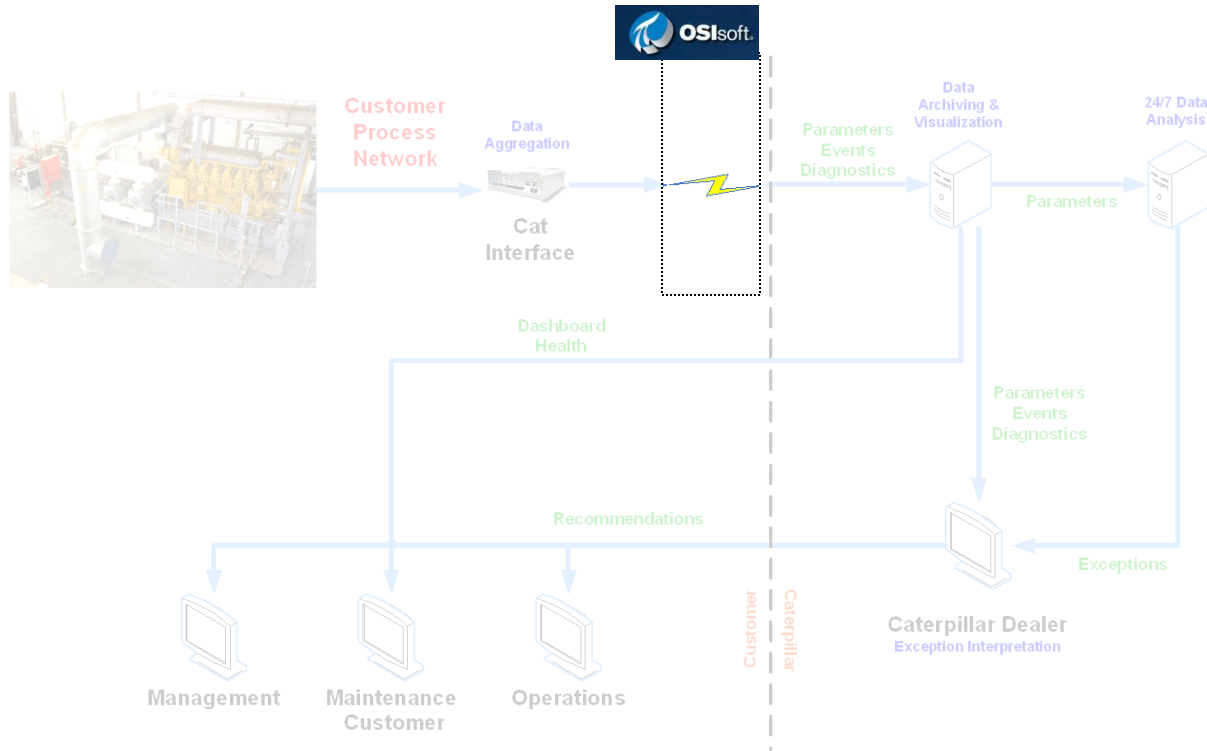


Solution Using the PI System



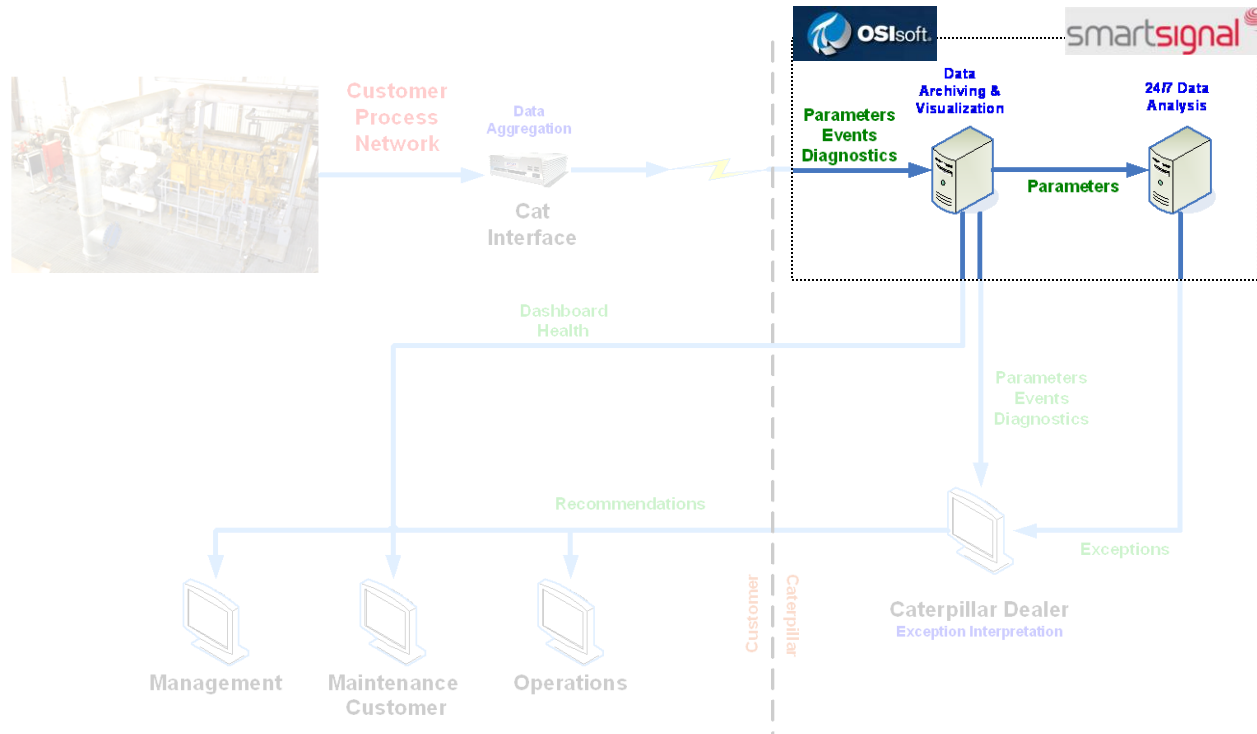
- PI Modbus Interface
- PI OPC Interface

Solution Using the PI System



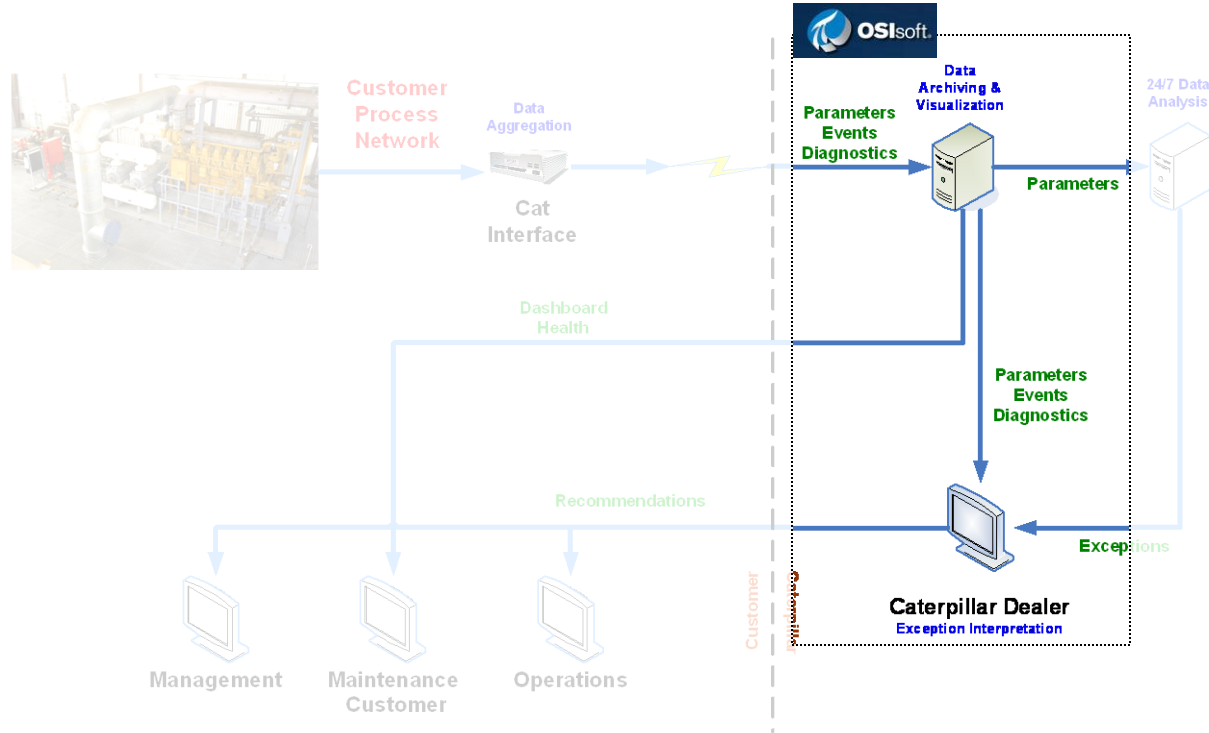
- Cell to Caterpillar PI Server
- DSL to Caterpillar PI Server
- PI to PI Interface
- Other Historian to PI Server

Solution Using the PI System



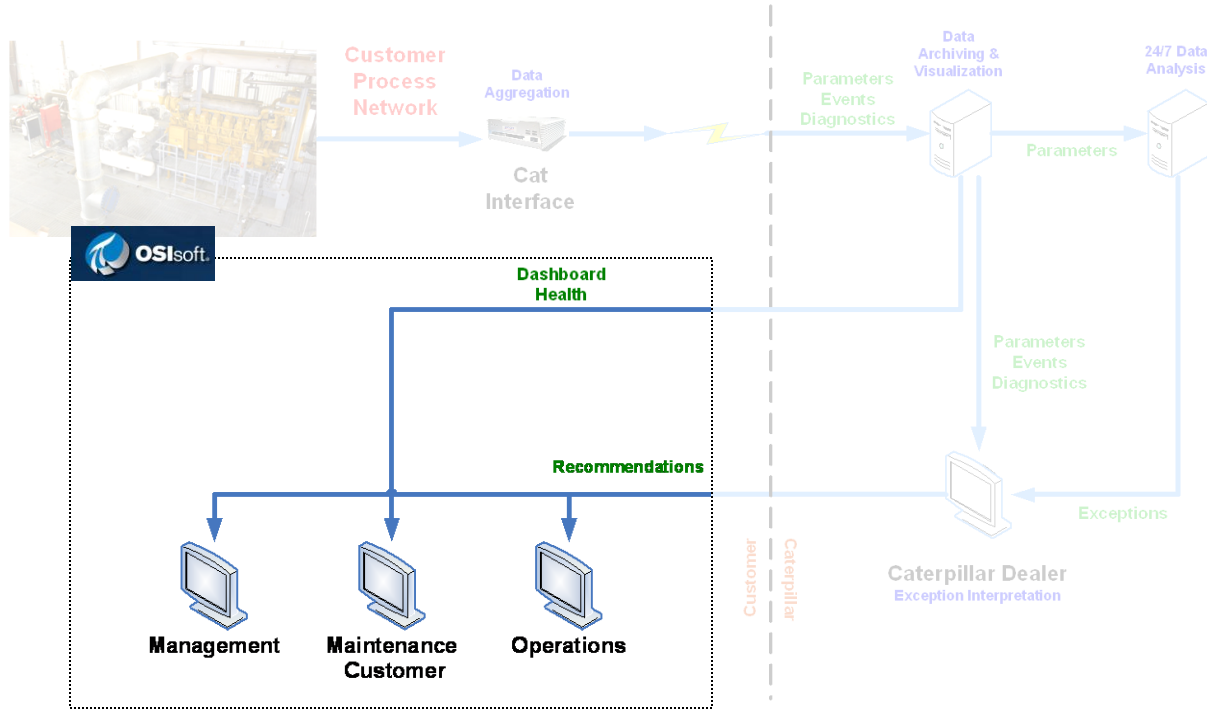
- PI SDK – PI Server to SmartSignal EPI Center
- Identify exceptions to obtain early warning of pending failures

Solution Using the PI System



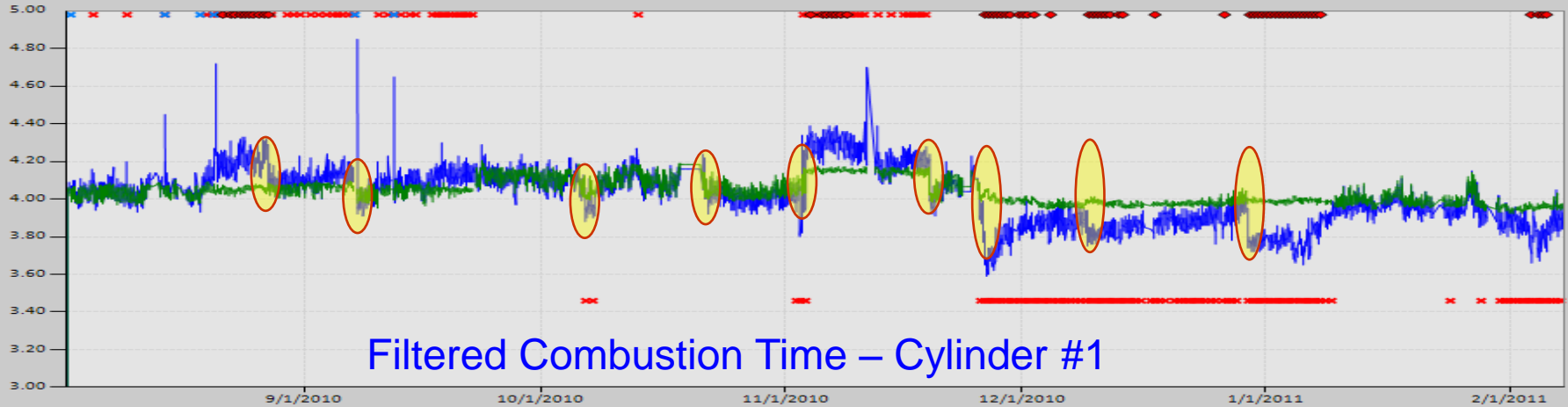
- PI AF
- PI ProcessBook
- PI DataLink
- PI WebParts
- PI SMT
- PI ACE
- PI Notifications

Solution Using the PI System



- PI AF
- PI WebParts
- PI ACE
- PI Notifications

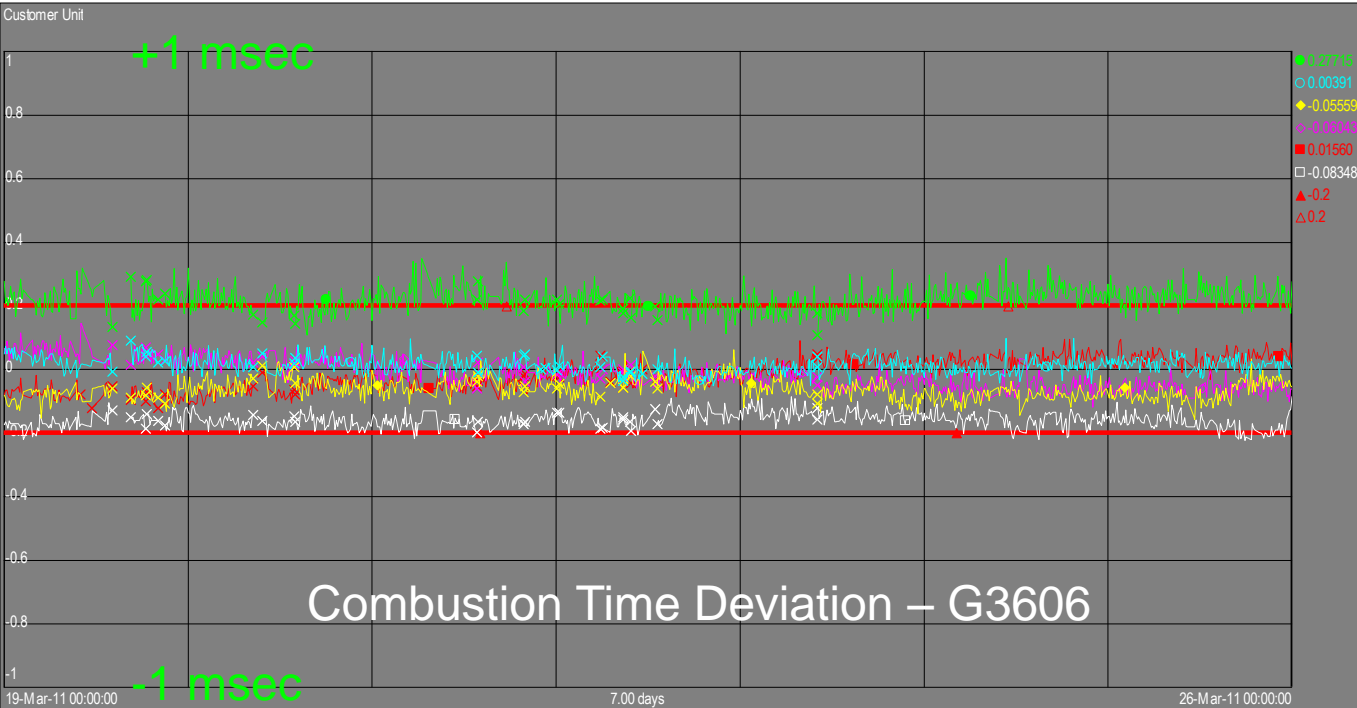
Solution – Early Warning of Developing Failures



← 6 months →

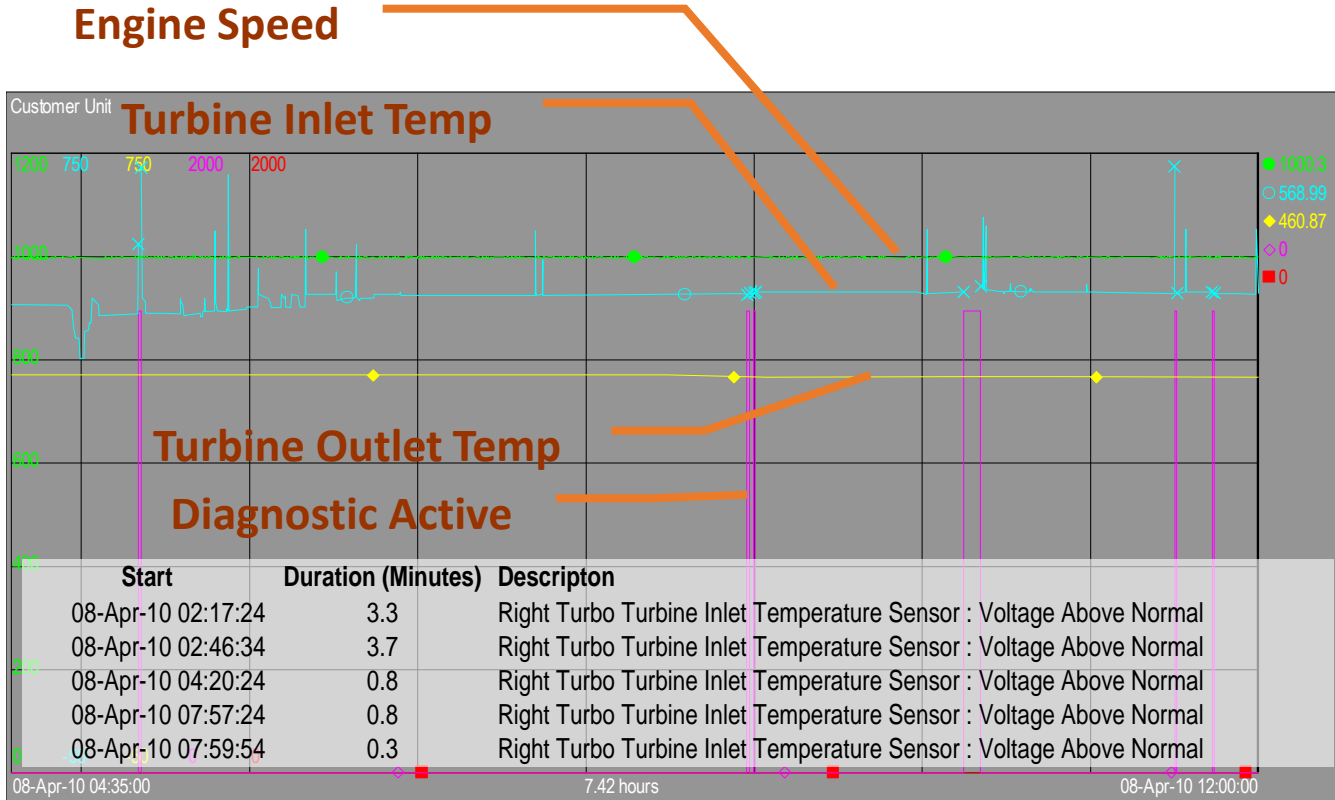
- Recommended Action – Visually inspect cylinder head at next out of service PM.
- Found eroded pre-chamber
- Avoided Potential Piston/Liner and Turbocharger Failure

Solution – Drill Down – PI WebParts



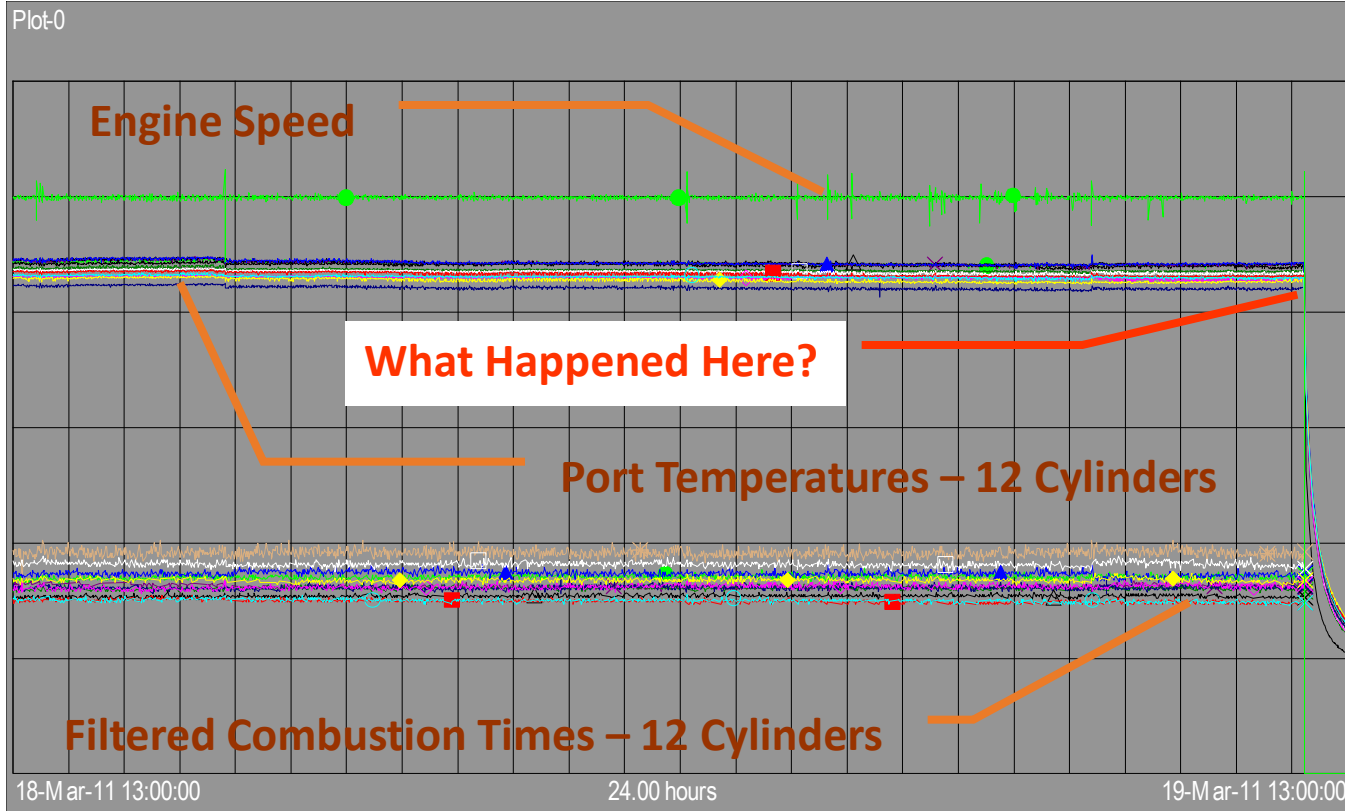
- Used to assess incidents reported by EPI Center
- Where is engine relative to expected performance?

Solution – ECM Event & Diagnostics – PI WebParts



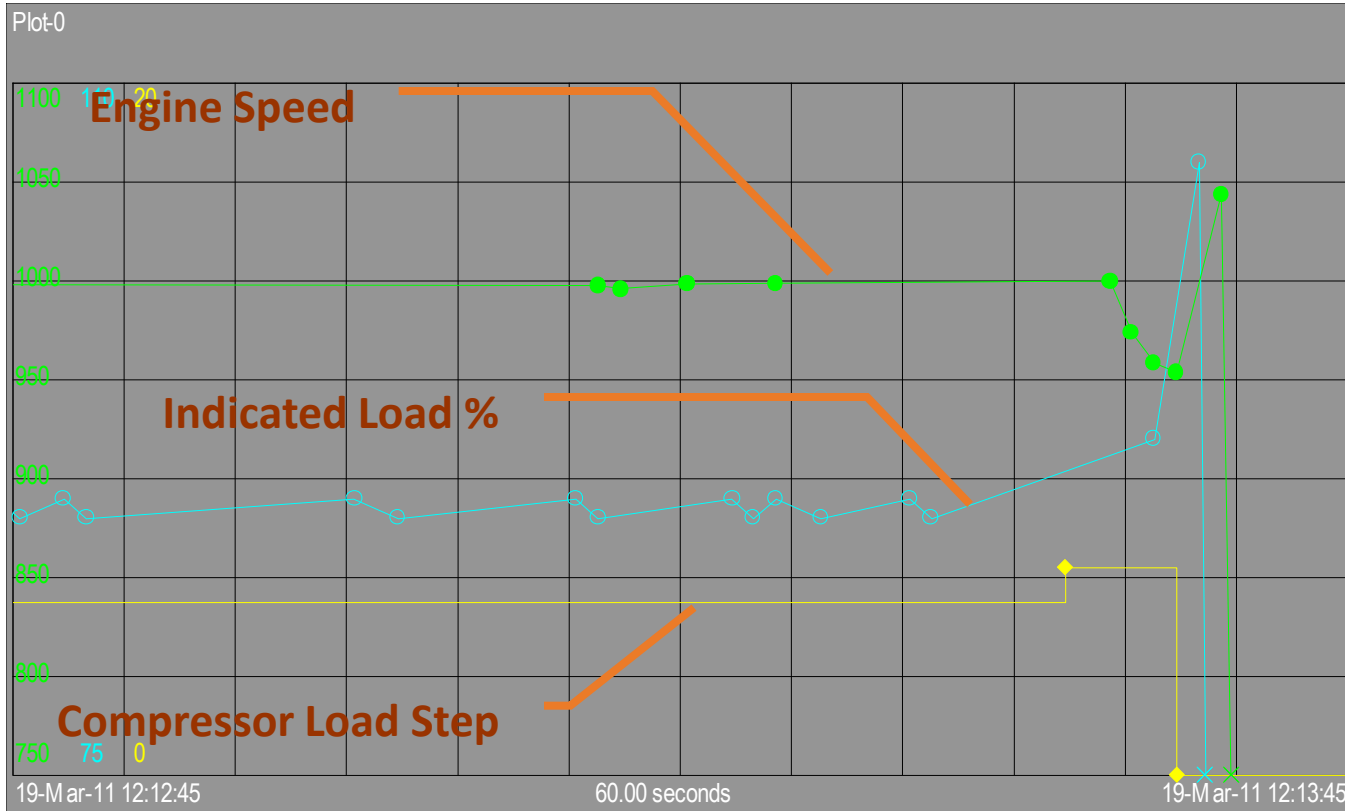
- Used to detect short duration, intermittent events prior to failure
- Link diagnostics to observed behaviors to identify mode.

Solution – High Fidelity Capability



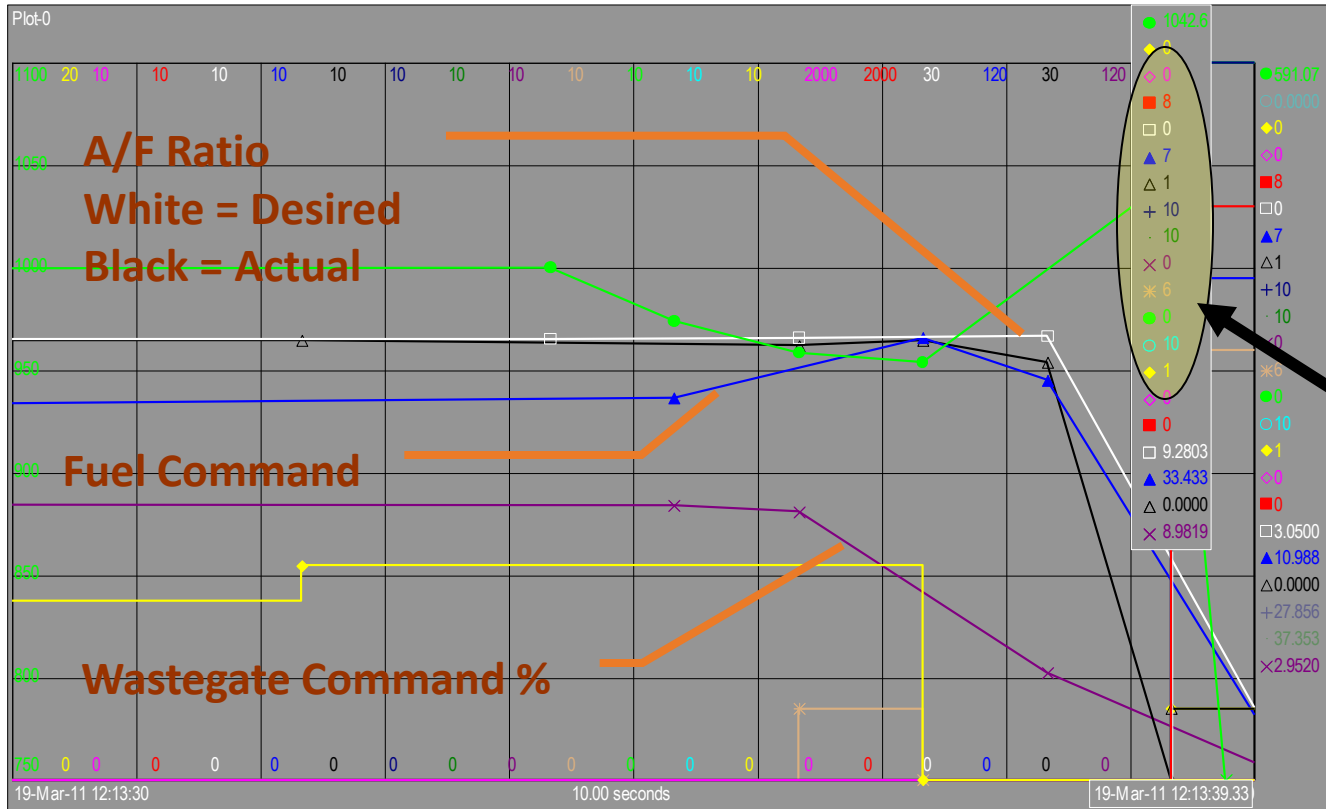
- High fidelity data for most of operation.
- But low fidelity could miss important events.

Solution – High Fidelity Capability



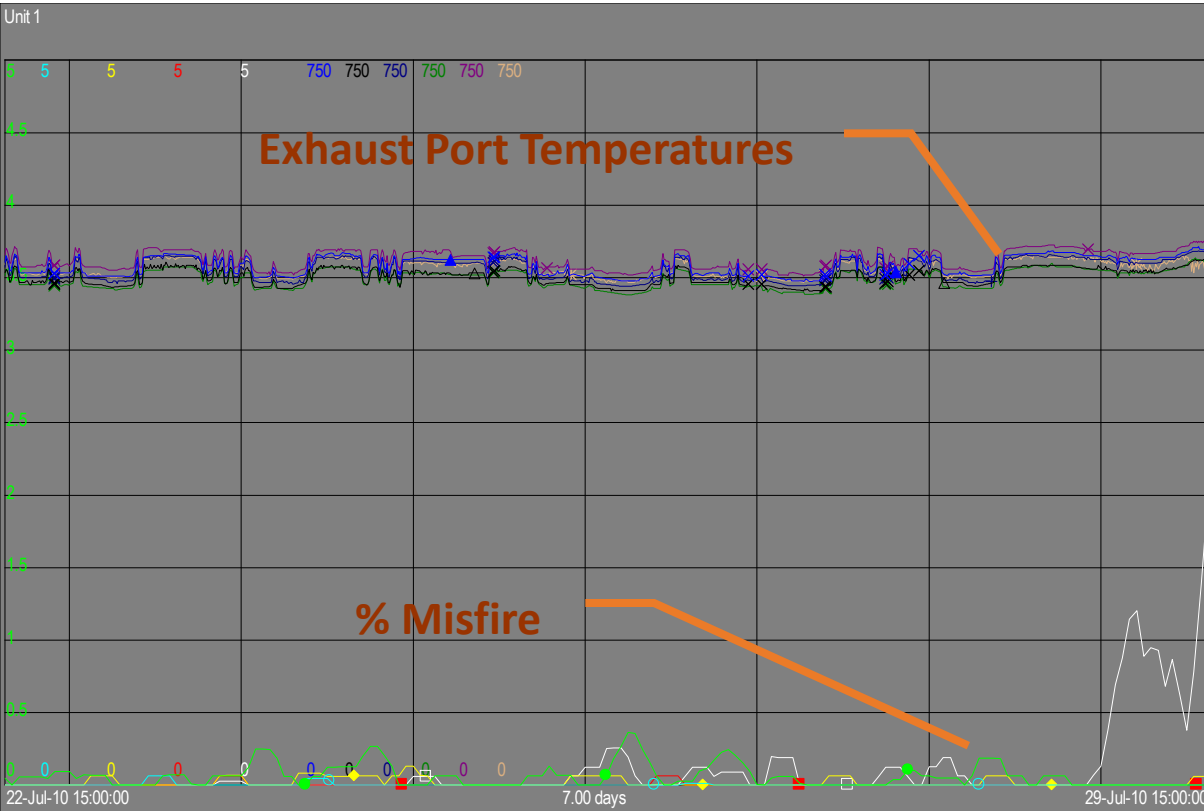
- UCP automatically loads compressor up to next load step
- Engine speed droops.
- Indicated load increases
- UCP unloads compressor after 5 seconds
- Engine is stopped after 7 seconds.

Solution – High Fidelity Capability



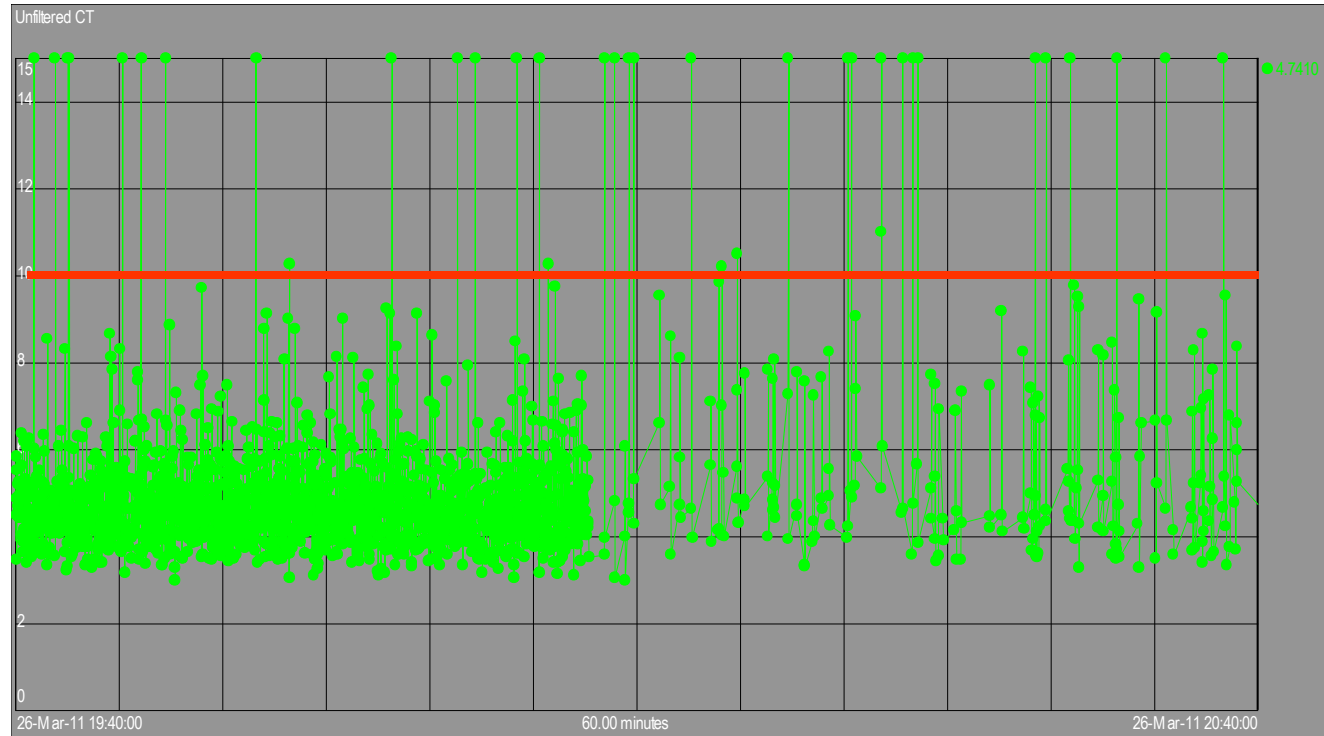
- Governor racks fuel
- Wastegate closes to maintain air/fuel ratio.
- Turbo lag causes mixture to go rich.
- Multiple cylinders detonate

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

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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Marine & Petroleum Power Division - Petroleum Group

Caterpillar, Inc.

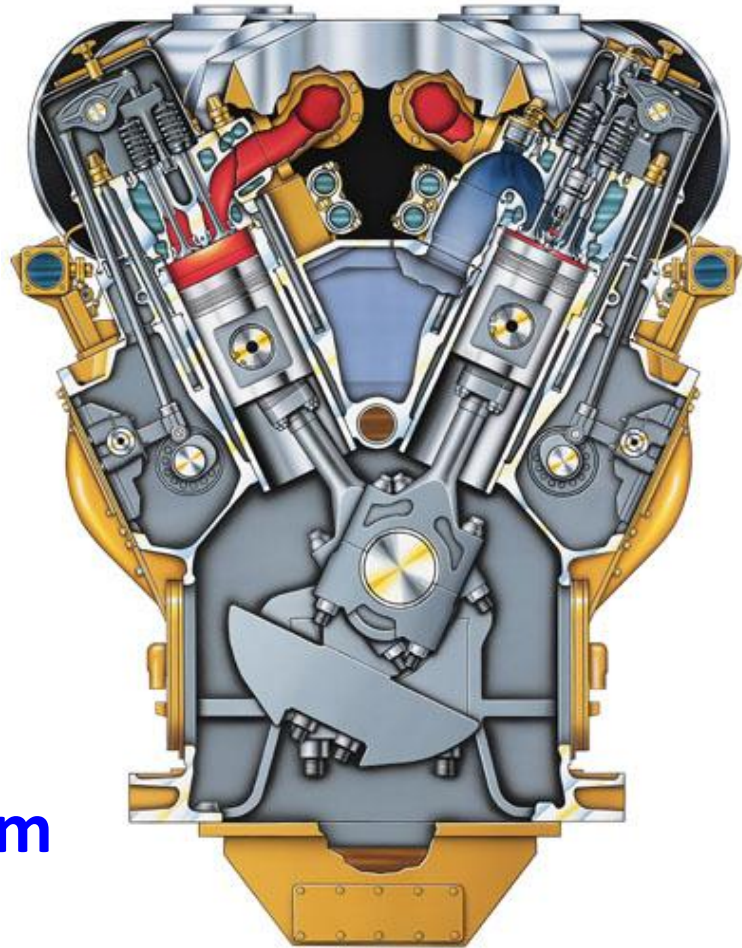
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Thank you

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