smartsignal.
ELIMINATE FAILURE_

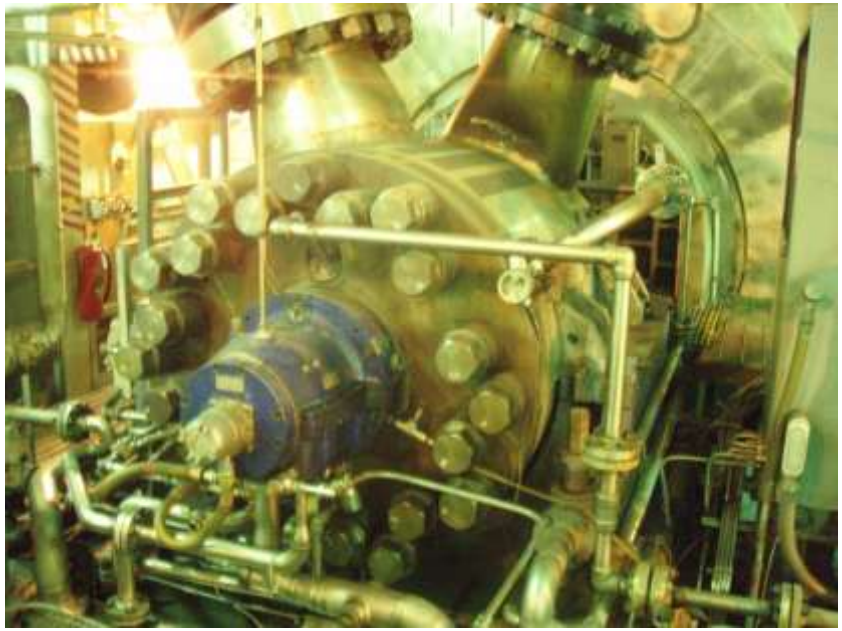
SmartSignal Predictive Analytics – OSIsoft Anchorage Regional Seminar

Nick Perkins – Solution Architect – September 16, 2010

What Happened to Nick?

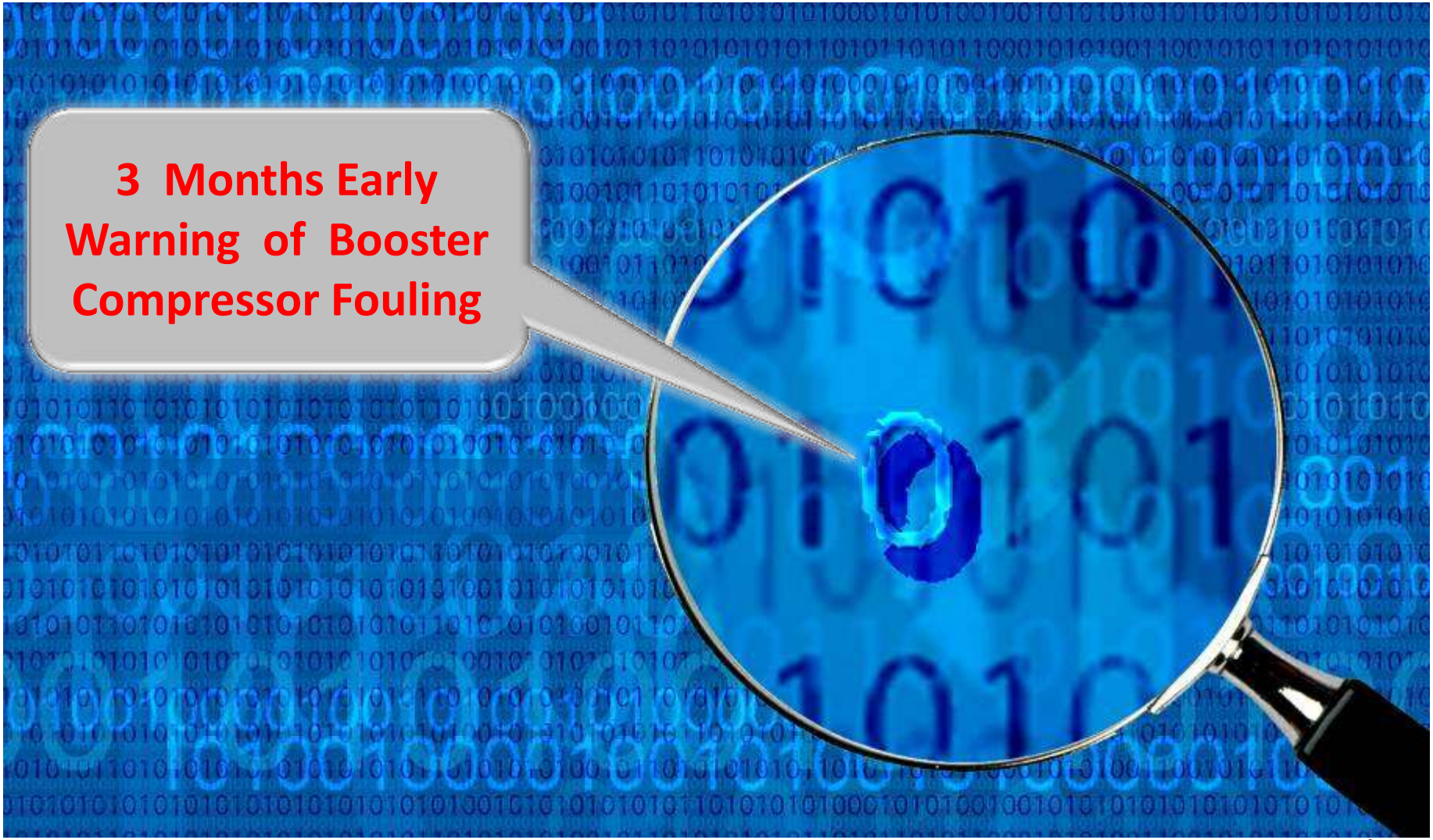
Goal: Operate Safely – while meeting Production & Profit Targets …



- Increasing equipment availability
- Preventing unsafe situations
- Beating financial expectations

Data Rich, But Information Poor?



Agenda

- Overview of SmartSignal
- How the Technology Works
- Examples from BP Alaska

Benefits

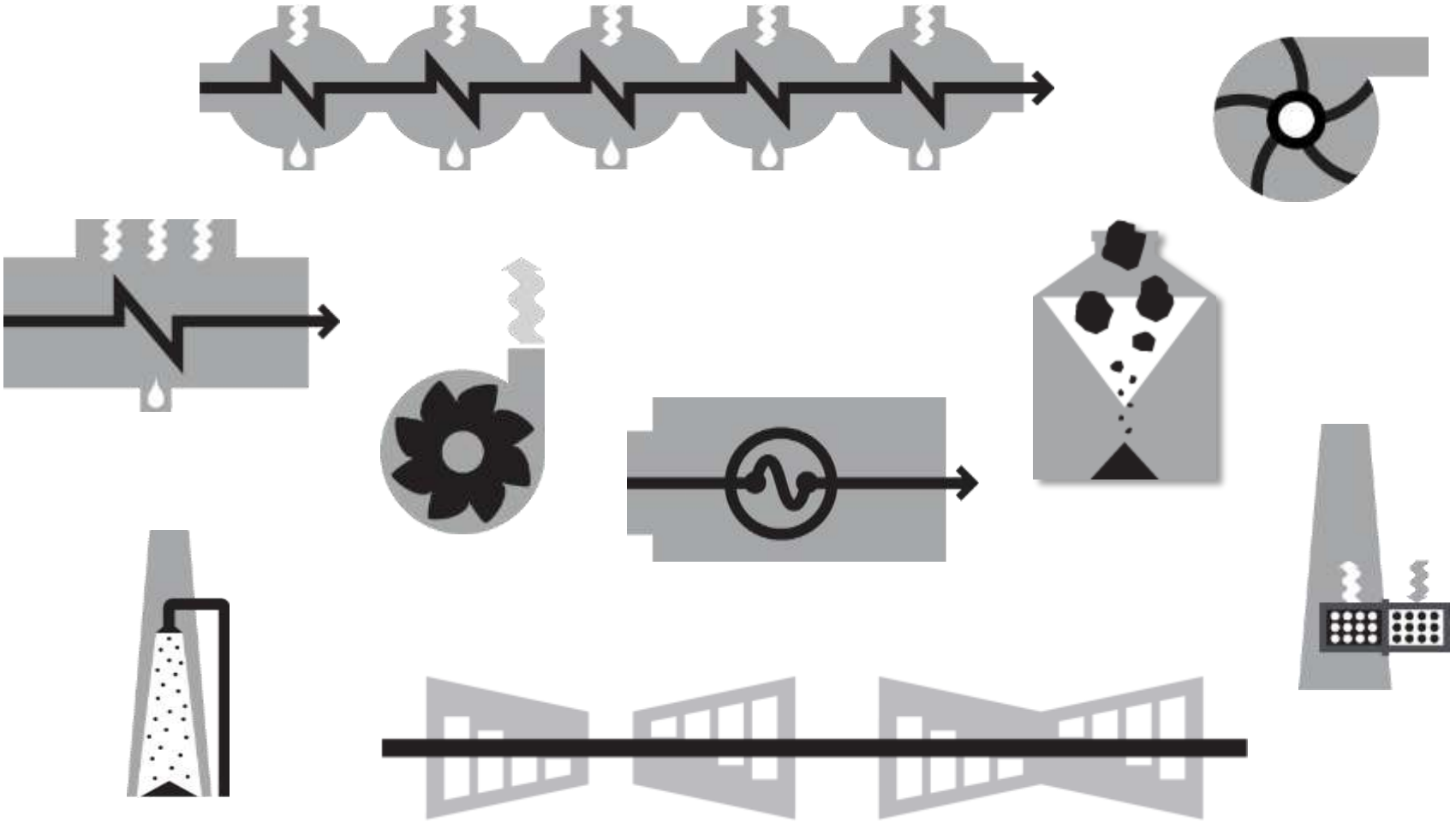
- Avoid Surprises

- Reduce Production Losses

- Reduce Risk of Recordable Incidents

395 days without a recordable incident

Any Equipment, Any OEM



Client Success:

New Markets, Adapting to Their Needs, Results Achieved

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DELTA

- Halved mid-air events
- $1.5M annual maintenance reduction
- $millions in avoided/reduced engine failures

8yrs

Entergy

- Central monitoring of entire fleet
- $millions annually, in routine catches

6

bp

- $M in documented catches

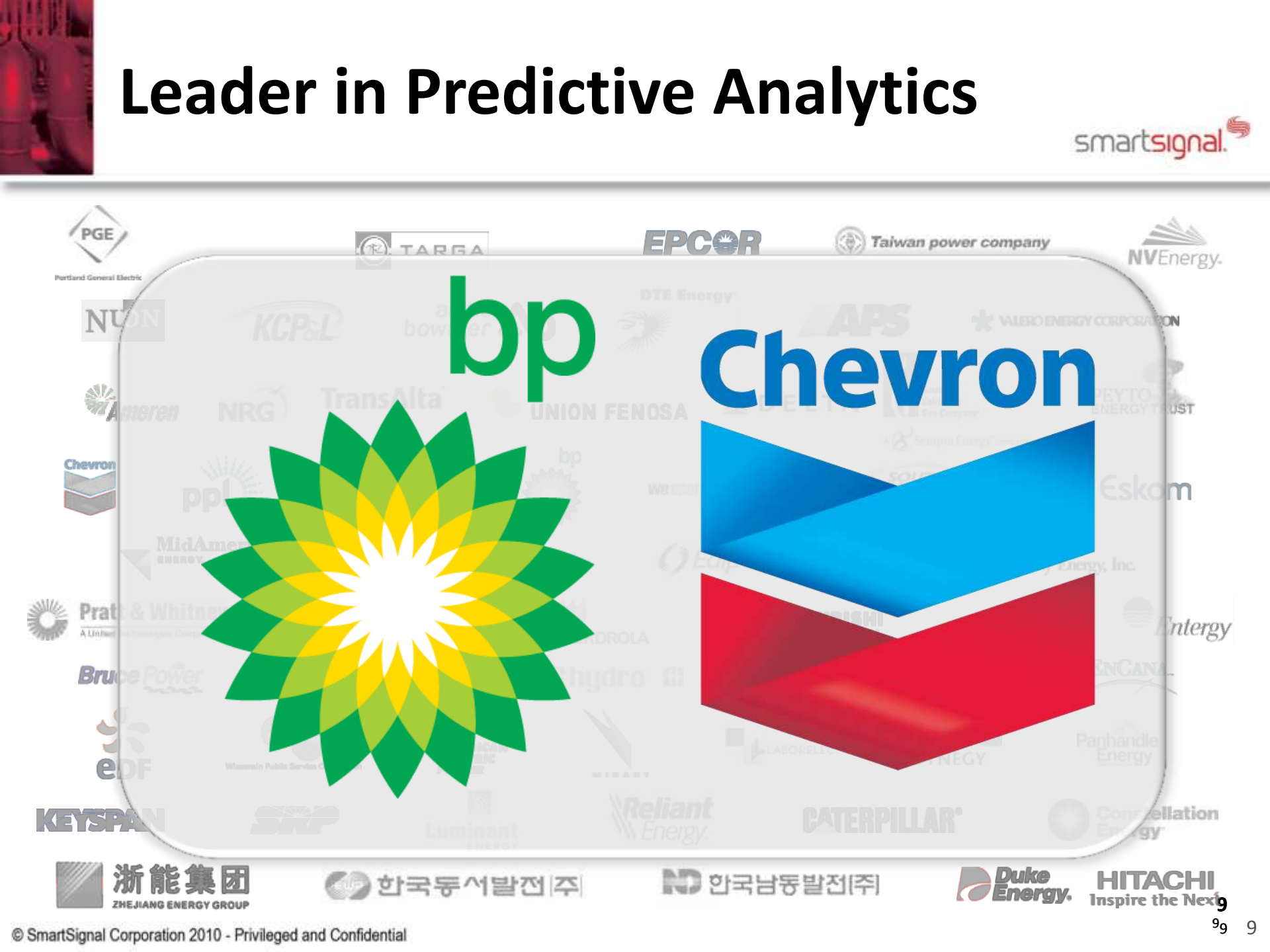
4

Invenergy

- 975 Wind Turbines
- Substantial catches

Leader in Predictive Analytics

smartsignal.



BP Deployments

- Upstream:
  - **Prudhoe Bay, Alaska**
  - **Gulf of Mexico**
  - **North Sea**
  - **Alternative Energy:** SilverStar wind farm (24 wind turbines)
- Refining
  - Global license with rollout on critical equipment
    - 2+ Year, comprehensive evaluation and pilots at multiple sites
    - Initial trials generated >$5 MM in measurable benefits
    - Deployed in 5 refineries

BP Alaska

- Deployed on 102 large rotators
- Includes:
  - Gas Turbines
    - GE Frames
    - GE Aero Derivatives
    - Solar
    - Rolls Royce
    - Ruston
  - Centrifugal Compressors
  - Pumps
  - Generators
  - Motors
  - Gearboxes

SmartSignal Covers a Range of E&P Processes and Equipment

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Rotating Equipment

- **Engines**
  - Gas turbine
  - Reciprocating
- **Compressors**
  - Reciprocating
  - Centrifugal
  - Axial flow
  - Screw
- **Centrifugal Pumps**
  - Single or multi-stage
  - Various seal flush plans
- **Turbines**
  - Steam turbines
  - Power recovery turbines
- **Generators**
- **Auxiliary systems**

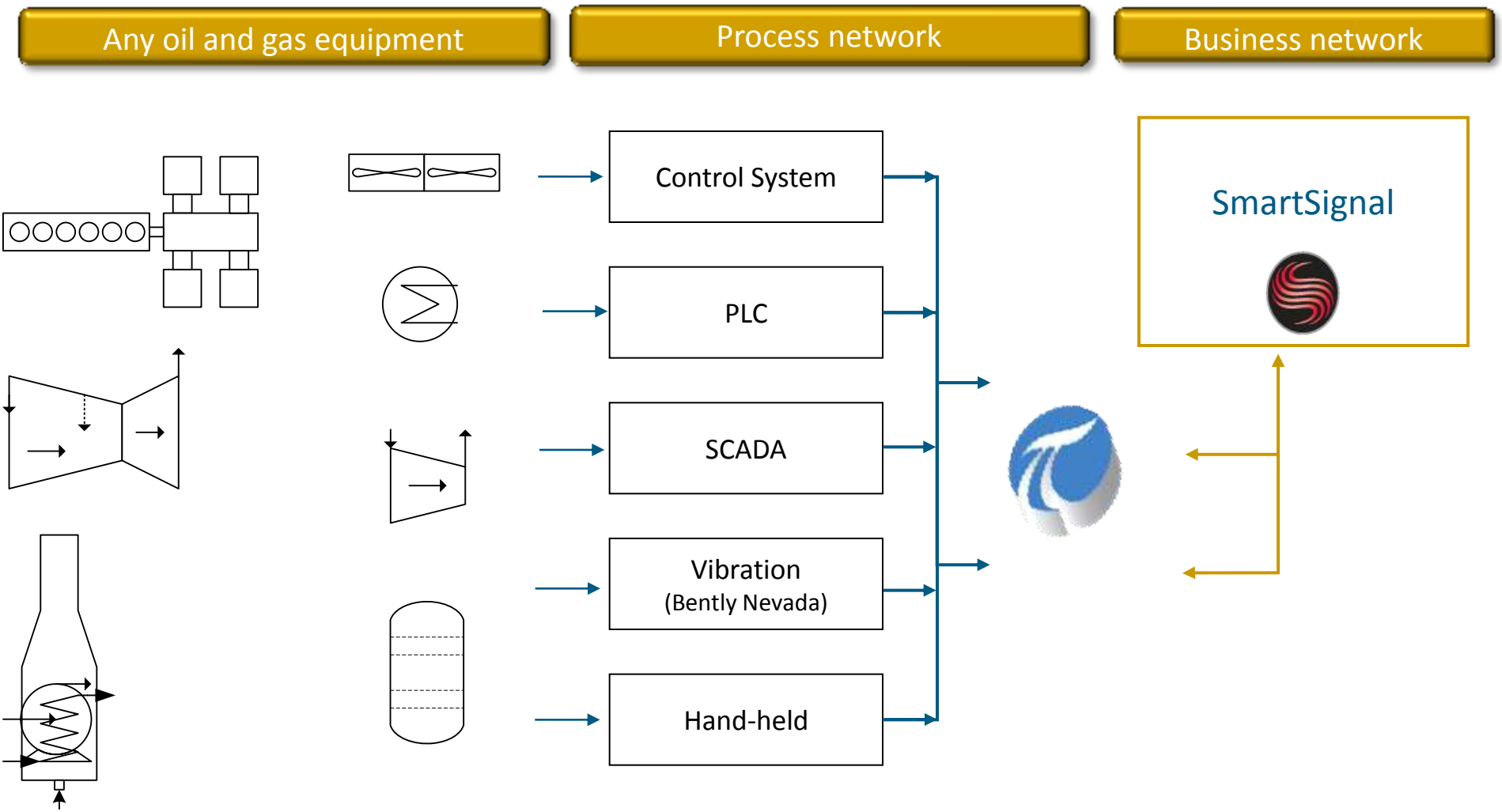
Processing Equipment

- **Gas-Liquid Contact**
  - Glycol Dehydration
  - Amine Sweetening
- **Heat exchangers**
- **Separators / Scrubbers**
- **Boilers**
- **Waste heat recovery systems**
- **Fired heaters**

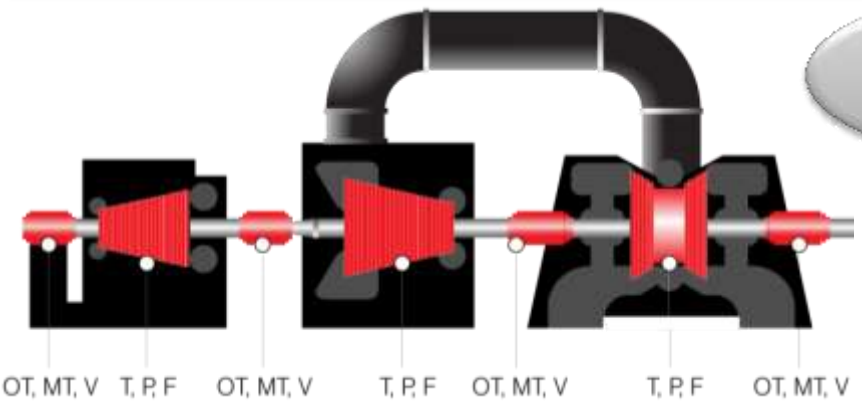
Examples of Early Warnings

Equipment	Examples of Failure Modes
All Rotating Equipment	Bearing and Lubrication Degradation
Gas Turbine Engine	Fuel Nozzle Plugging; Compressor Fouling, Blade Failure, Combustion Liner Deterioration
Internal Combustion Engine	Detonation; Spark Plug Failure, Valve Problems, Performance
Centrifugal Compressor	Rotor Fouling, Seal Degradation, Performance
Reciprocating Compressor	Valve Problems, Rod Drop, Rider Band Wear, Performance
Centrifugal Pump	Cavitation, Performance, Seal Degradation
Suction Scrubber	Liquid Carryover; Demister Pad Plugging
Heat Exchanger	Fouling; Tube Leaks
Gas Treating	Solvent Carryover; Absorber / Stripper Flooding, Glycol Carryover
Power Generator	Stator Temperature Excursion, Rotor Problems

Utilizes Existing Instrumentation, Controls, and Data Infrastructure



How SmartSignal Works



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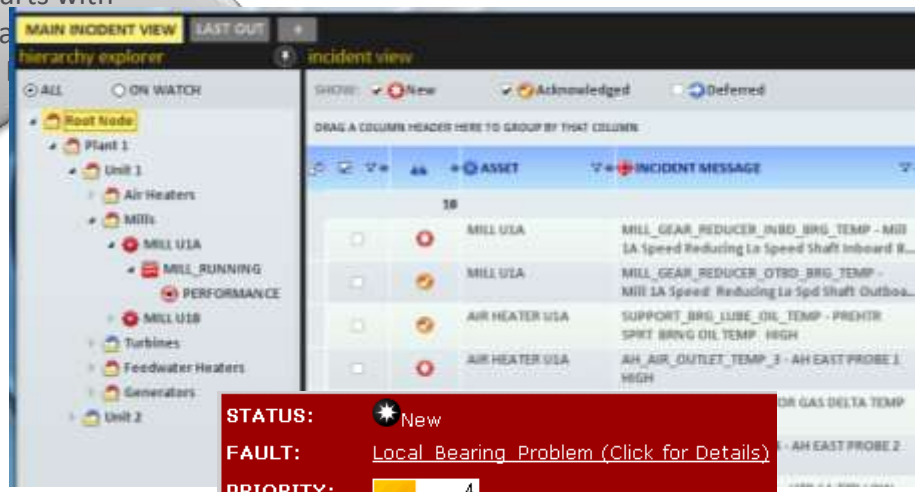
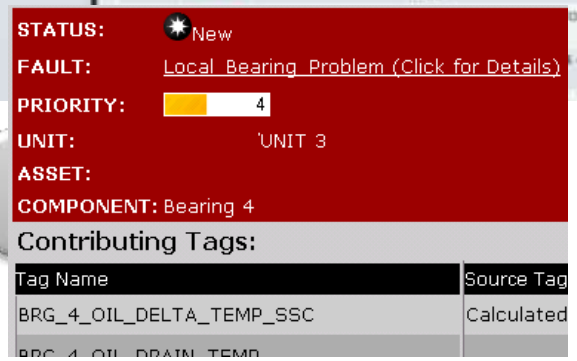
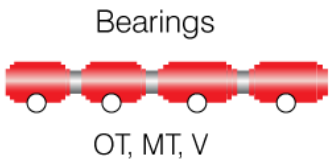
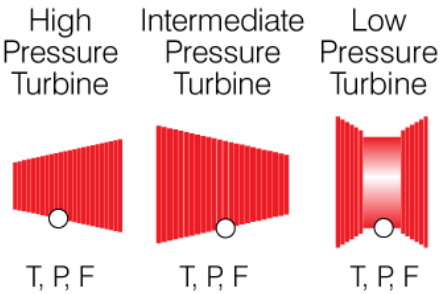








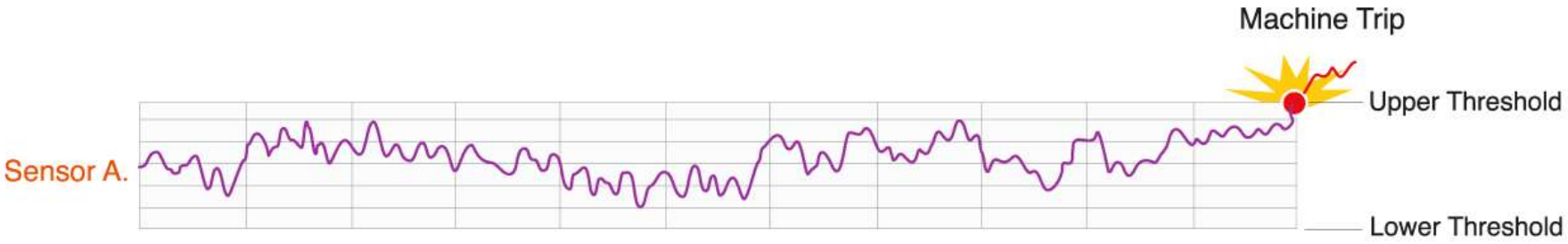
Personalized Empirical Models

Posts anomalous behavior to Monitoring App

Samples

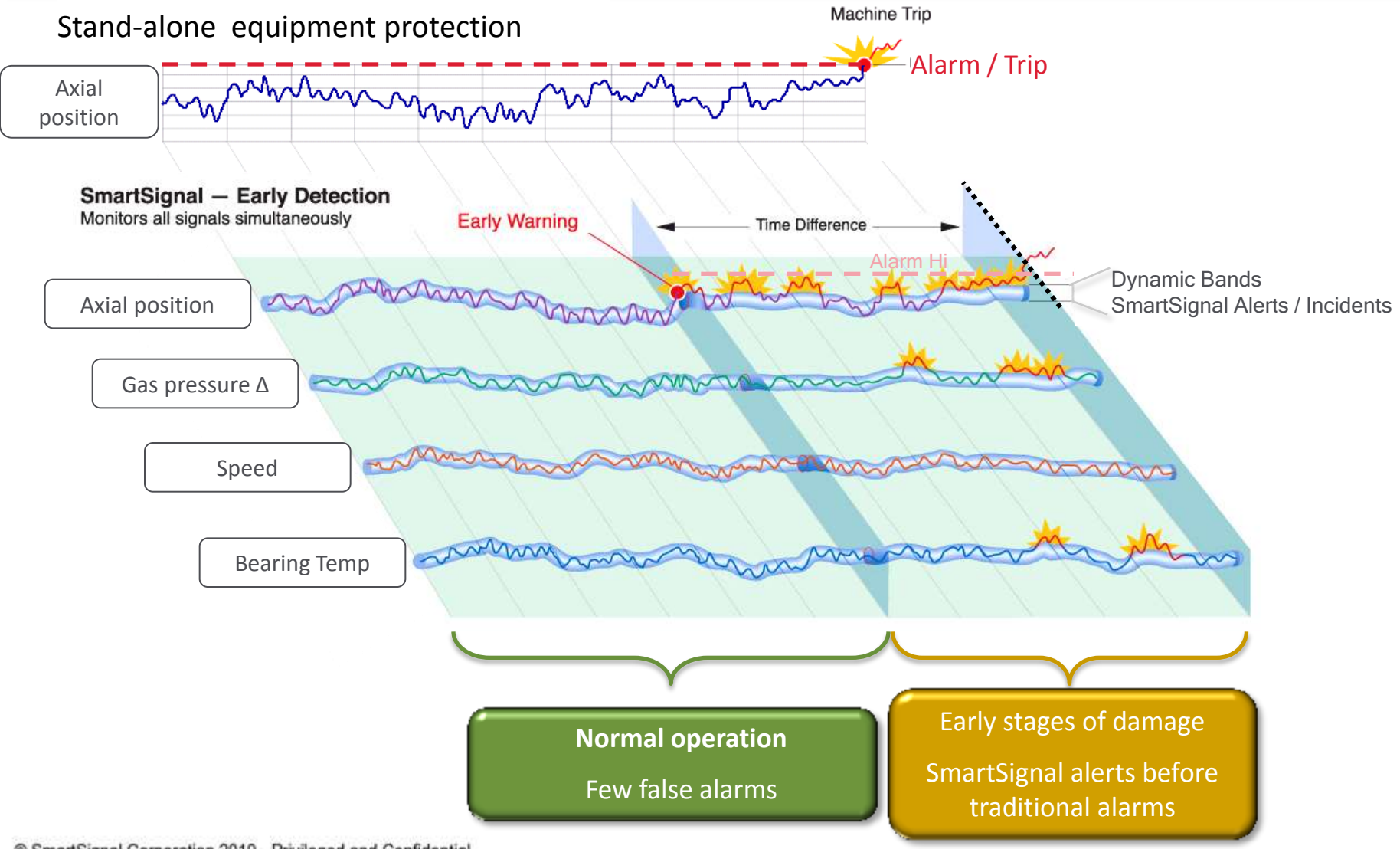
Conventional Monitoring

- Most conventional monitoring methods use threshold limits on each sensor
- Levels chosen must cover all operational ranges and be applicable for all ambient conditions
- Traditional monitoring techniques are limited in their ability to identify failures proactively

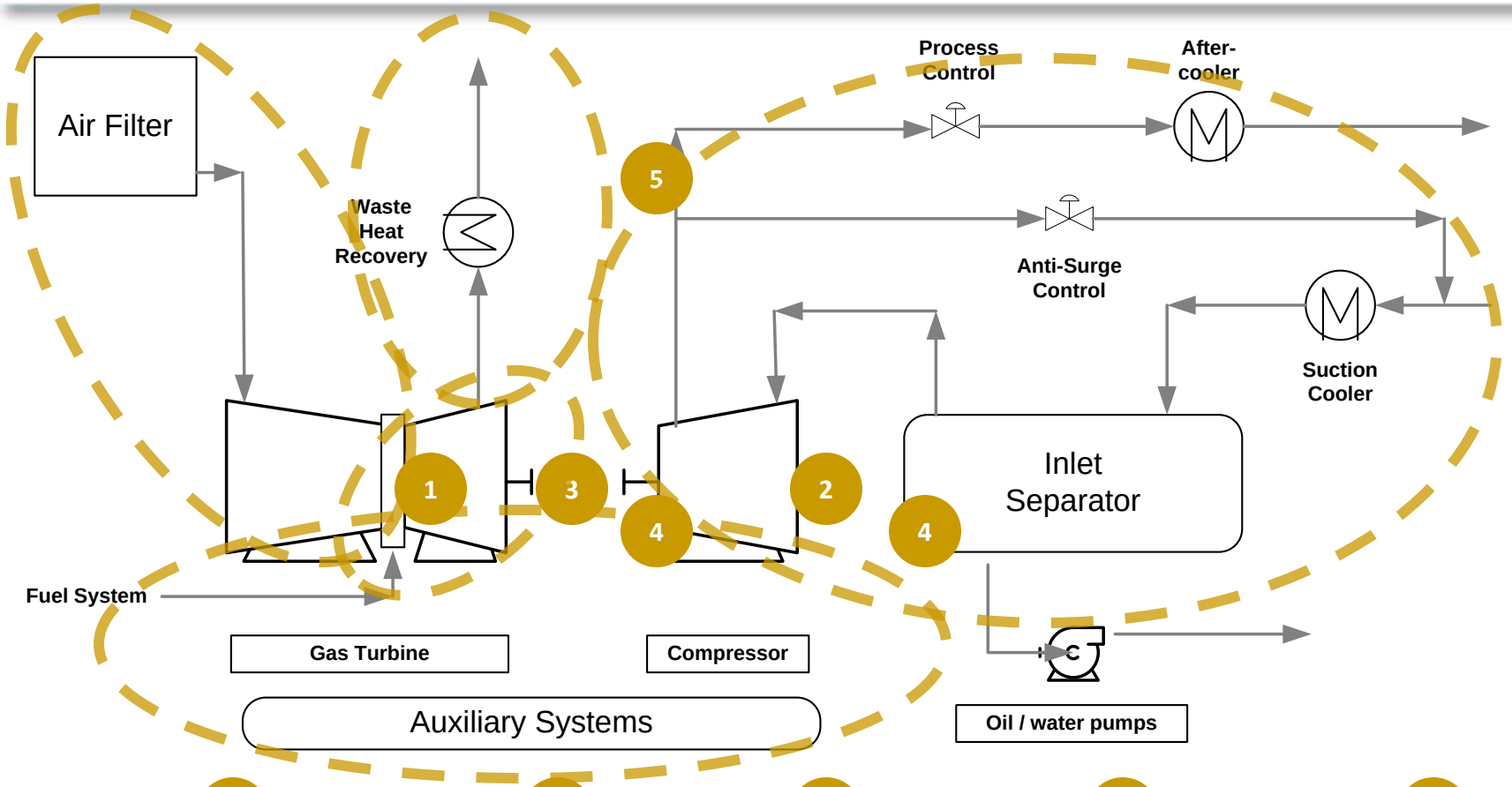


SmartSignal Approach

Enabled by Modeling Related Sensors



The Model



1	2	3	4	5
Gas turbine compressor section: Performance model	Load compressor: Performance model	Gas turbine combustion/exhaust: Performance model	Rotor dynamics & auxiliaries: Mechanical model	Waste heat recovery or emissions: Performance model



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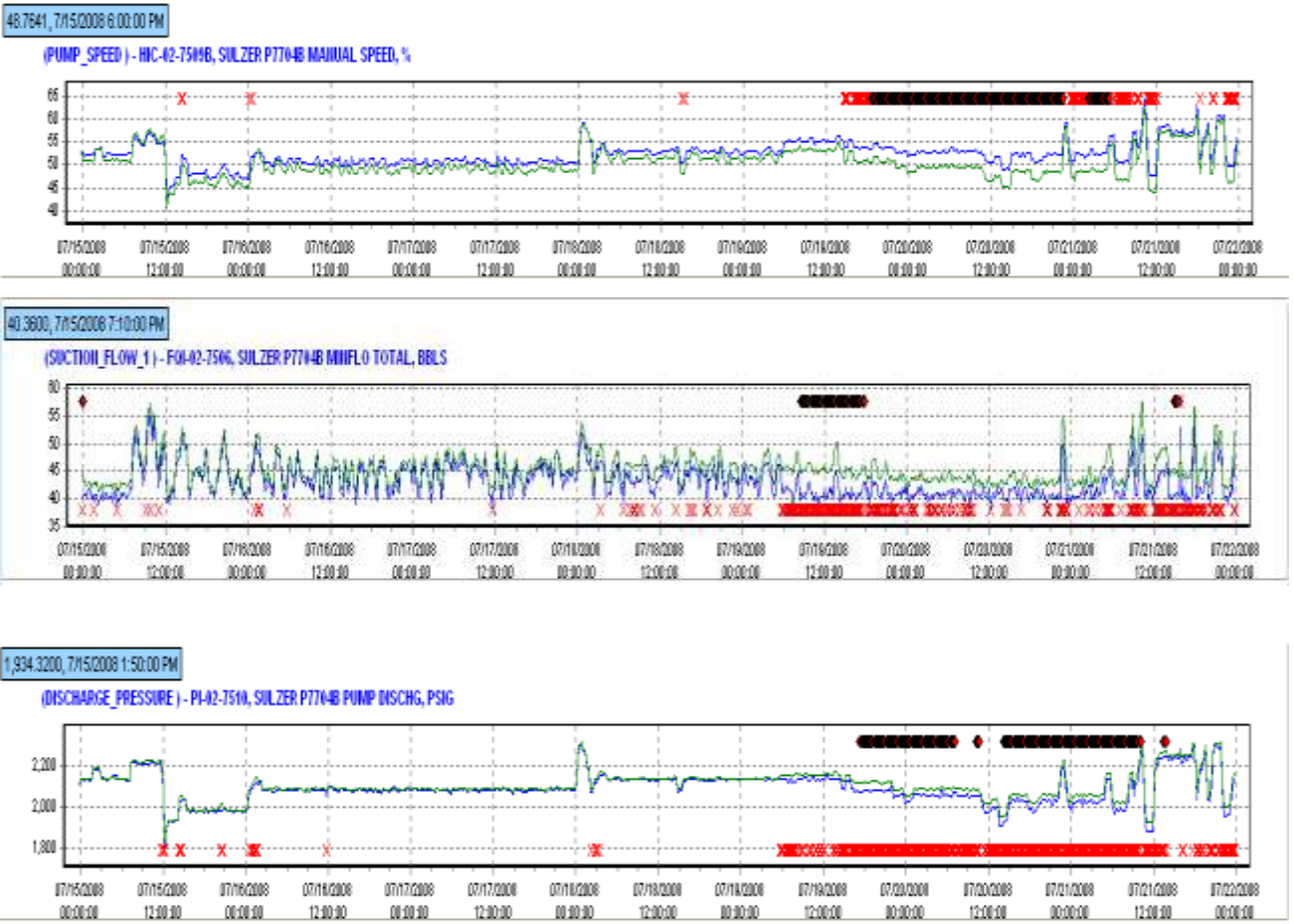
Examples from BP Alaska

GC2 P7704B Pump – July 2008 Notification – to BP Reliability Group



- Pump operating at or near minimum flow, low discharge pressure and high speed
- Recommendation: Check field for filter plugging or obstructions.

GC2 P-7704B Pump – Action Summary

- Reliability Engineer started investigation with field Reliability Tech
- Believed there may be a problem with the pump bundle
- Upcoming S/D, so Overhaul ordered a complete pump bundle to have on standby
- On the scheduled S/D, 5 minute boroscope inspection revealed significant wear / damage
- Based on the condition of the bundle, it was changed out, minimized production impact

FS2 – 1802 Inboard Seal Issue

BP Exploration Alaska SmartSignal Monitoring Report 5/17/2010

smartsignal Availability & Performance Center

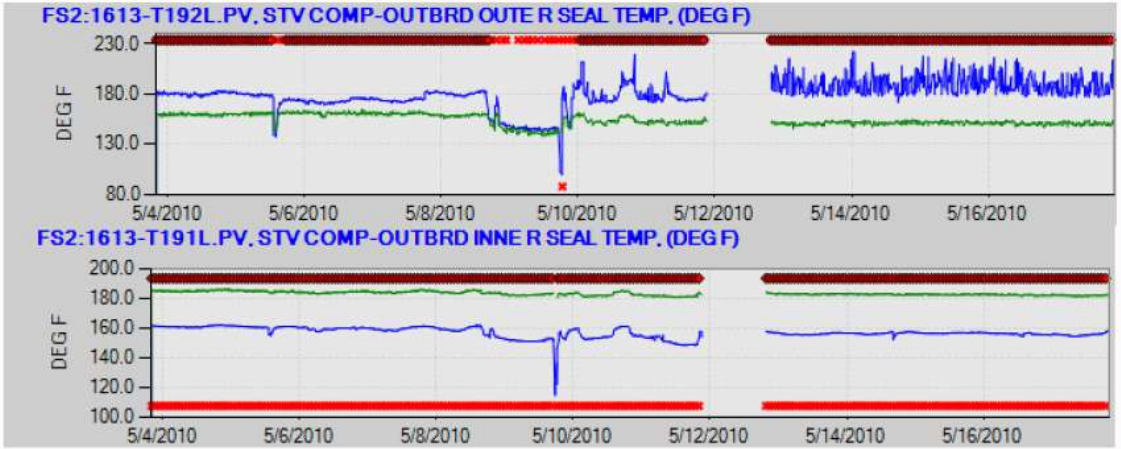
FS2
FS2 16-1802
Possible seal issue

Status: 01) Notification to Customer
Date of Notification: 5/17/2010 12:00:00 AM
Equipment Tag: Outboard seal temperature
Category:

Description:
Seal temperature spiking following a step change

Diagnosis:
Possible seal issue

Customer Response:



Gas Camera Results

Questions?

Nick Perkins

nperkins@smartsignal.com

Phone 630.829.3230

FS3 14-15188

BP Exploration Alaska SmartSignal Monitoring Report

9/14/2010

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Availability & Performance Center

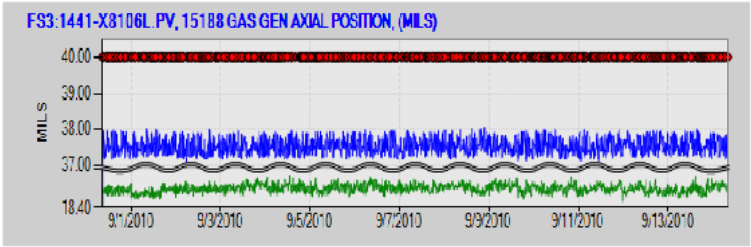
FS3
FS3 14-15188
Report 579 -Update- Gen axial position - positive residuals

Issue Tracking Number: 579
Status: 01) Notification to Customer
Date of Notification: 6/23/2010 12:00:00 AM
Equipment Tag: 1441-X8106L
Category:

Description:
Shifted back up to previous reading
Shift in position from 39 to 21 was moore card changed is this the new condition

Diagnosis:
Possible moore card failure again
Bad or damaged instrument.

Customer Response:
. It is likely that this issue is due to problems with the Moore card system work order to repair
What I get out of the email from John (vibe tech) is that this may be a Moore card issue that is causing the 39 mil axial reading on FS3 15188. Sounds like it should be reading about 8 mils.



GC2 02-7000

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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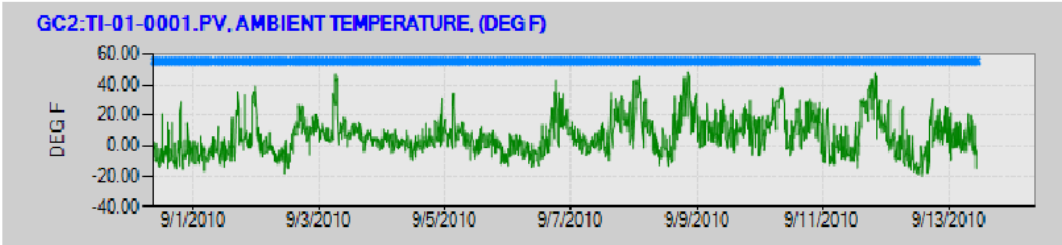
GC2
GC2 02-7000
Report 640-Update-
Ambient temperature - bad sensor

Issue Tracking Number: 640
Status: 01) Notification to Customer
Date of Notification: 8/3/2010 12:00:00 AM
Equipment Tag: TI-01-0001.PV
Category:

Description:
The ambient temperature tag has stopped retuning data

Diagnosis:
Sensor/data issue

Customer Response:



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FS3 14-1801

BP Exploration Alaska SmartSignal Monitoring Report

9/14/2010

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Availability & Performance Center

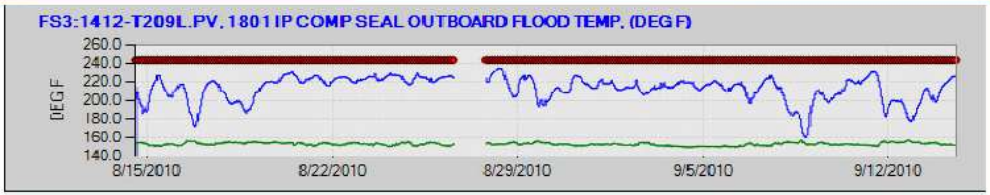
FS3
FS3 14-1801
Report 653-Update-Comp seal outboard flood temp - positive residuals

Issue Tracking Number: 653
Status: 01) Notification to Customer
Date of Notification: 8/17/2010 12:00:00 AM
Equipment Tag: 1412-T209L.PV
Category:

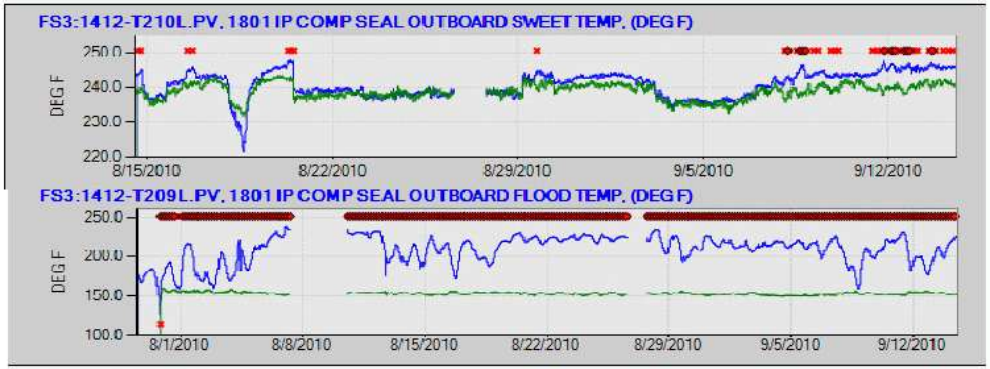
Description:
Condition continues axial position indicating surging causing temperatures to swing, Working on a detailed report on this issue Since starting back up the compressor seal outboard flood temperature has increased from 190 degF to 235 degF. We have seen a drop in the seal outboard sweet temperature. Shift in compressor since the trip and restart on 8/4, Data feed issue at FS3 at time of report being worked

Diagnosis:
Possible flow control issue
possible seal issue , seal hanging up, surging causing temperatures to swing Check outboard flood TI runing around 235

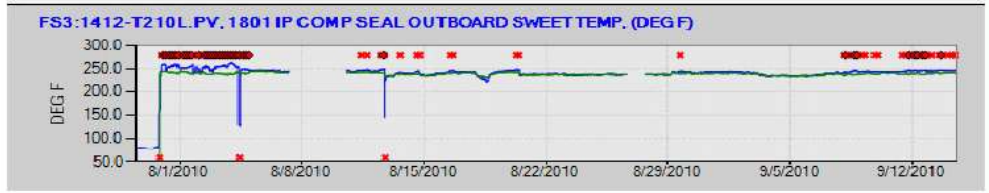
Customer Response:



ASSET MECHANICAL TAG 32



ASSET MECHANICAL TAG 32



CCP 18-1810

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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CCP
CCP 18-1810
Report-676-Update-Low speed gear inboard journal temp - positive residuals

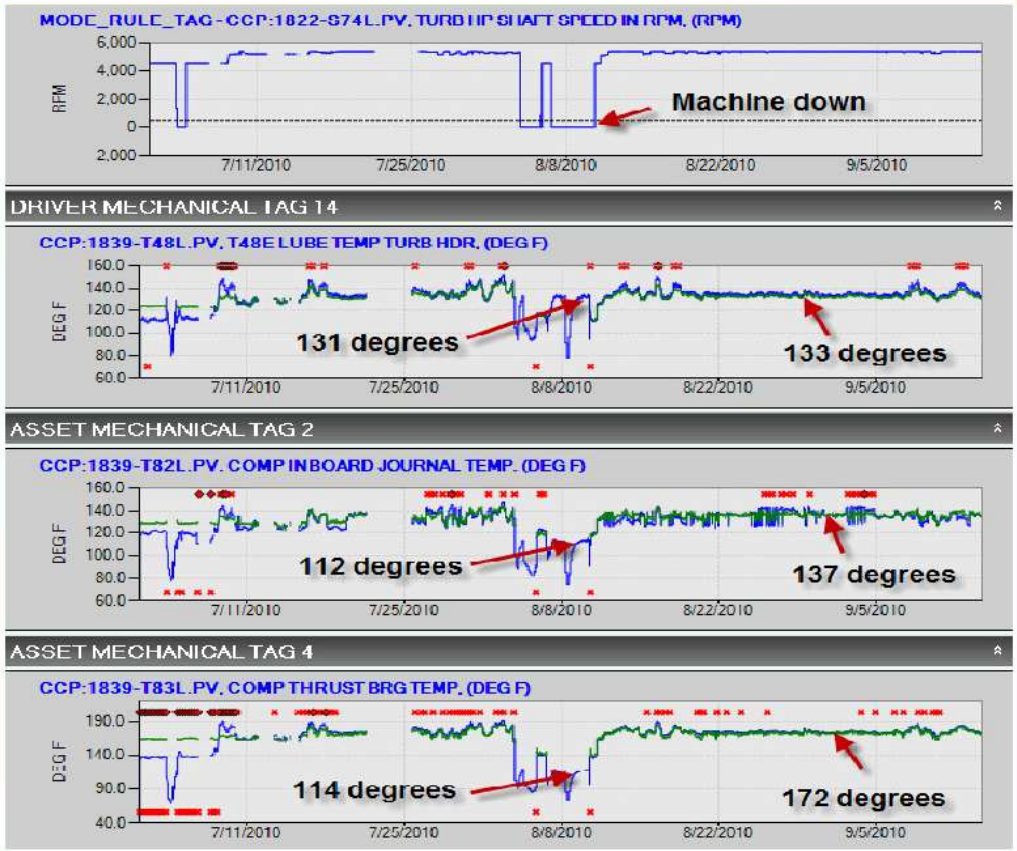
Issue Tracking Number: 676
Status: 01) Notification to Customer
Date of Notification: 8/17/2010 12:00:00 AM
Equipment Tag: CCP:1839-T75L.PV
Category:

Description:

Up to a 40 degree spread across bearings when machine is down additional chart next slide We are seeing the inboard journal bearing temperature approximately 20 degF above model predictions. We have not seen an increase in the low speed outboard journal temperature.

Diagnosis:
Data issue moore cards Possible bearing issue
Possibly increase lube oil pressure

Customer Response:



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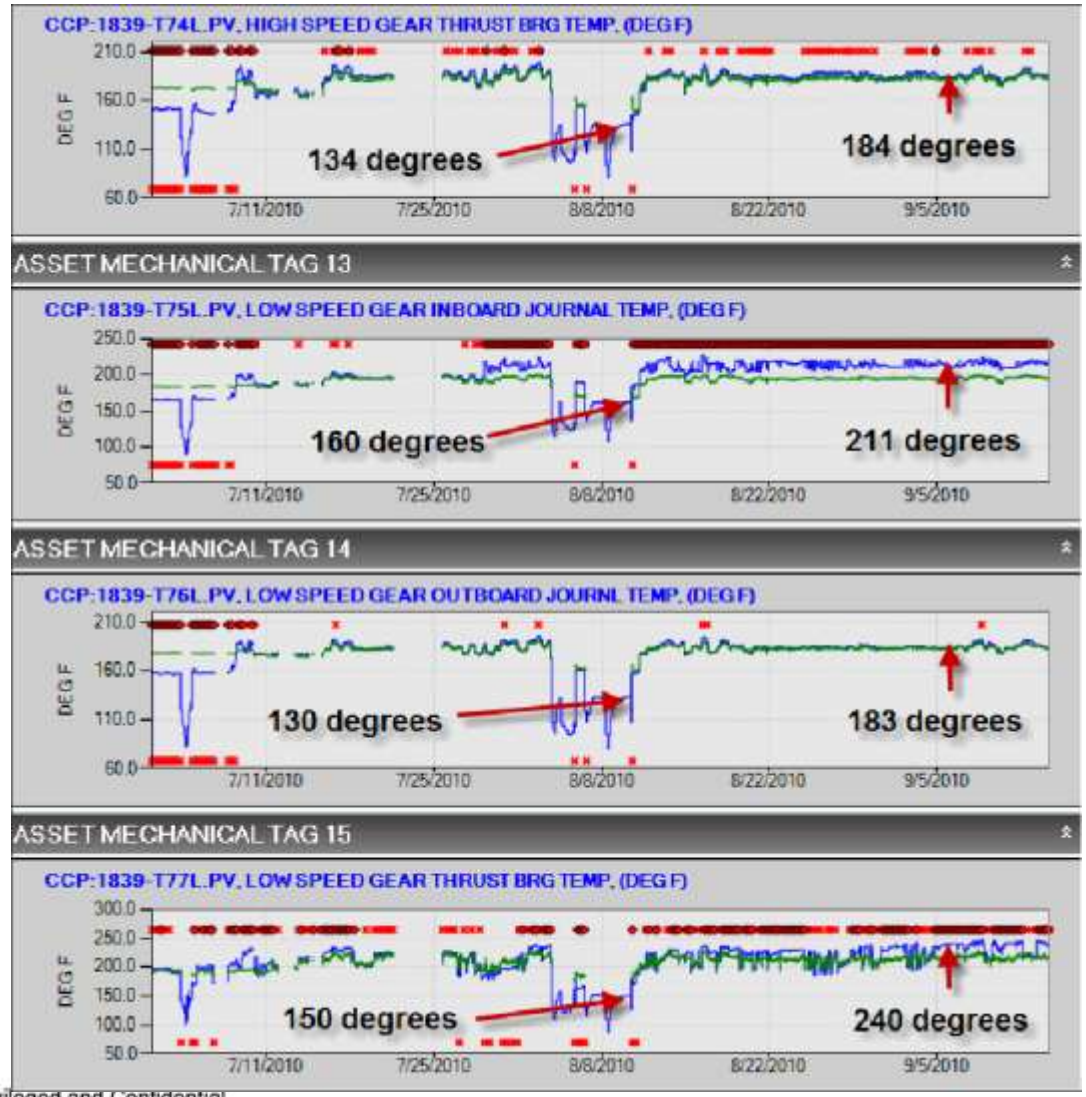
CCP 18-1810 (cont)



CCP 18-1804

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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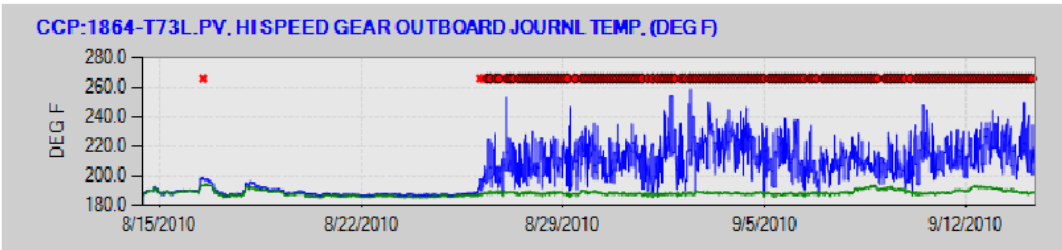
CCP
CCP 18-1804
Report -684-Update-High speed gear outboard journal temperature - positive residuals

Issue Tracking Number: 684
Status: 01) Notification to Customer
Date of Notification: 8/27/2010 12:00:00 AM
Equipment Tag: 1864-T73L.PV
Category: 01) Instrumentation

Description:
Beginning 8/26 the high speed gear outboard journal bearing temperature ahd increased from 186 degF to 215 degF. We did not see any changed on the high speed gear inboard journal bearing temperature or other temperatures.

Diagnosis:
Without other corroborating sensors it appears to be more of a sensor issue than bearing issue/damage.

Customer Response:



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FS1 15-1802

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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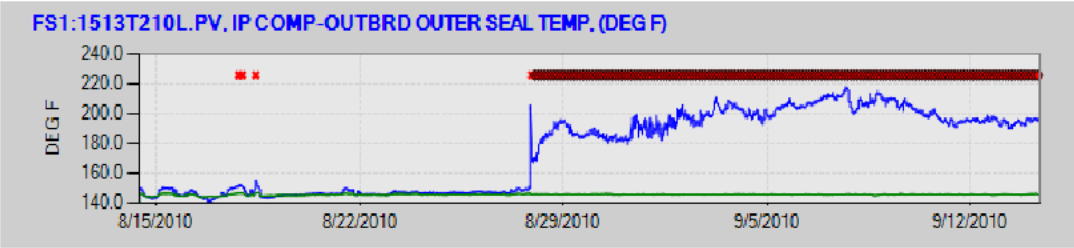
FS1
FS1 15-1802
Report-685-Update-
Outboard outer seal temperature - positive residuals

Issue Tracking Number: 685
Status: 01) Notification to Customer
Date of Notification: 8/31/2010 12:00:00 AM
Equipment Tag: 1513T210L
Category:

Description:
Condition continues
On 8/27 the outer seal temperature increased from 148 degF to 194 degF wit spike to 205. We did not see any changes in the outboard innder seal temperature, or other seal temperatures

Diagnosis:
Possible seal flush restriction or sensor issue

Customer Response:



FS1 15-1804

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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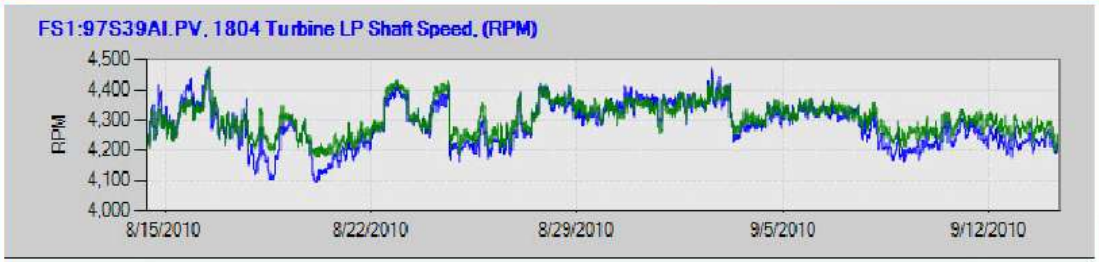
FS1
FS1 15-1804
Report-Update-689-shaft 2 bearing vibrations

Issue Tracking Number: 689
Status: 01) Notification to Customer
Date of Notification: 8/31/2010 12:00:00 AM
Equipment Tag: fs1:97X178I.PV
Category:

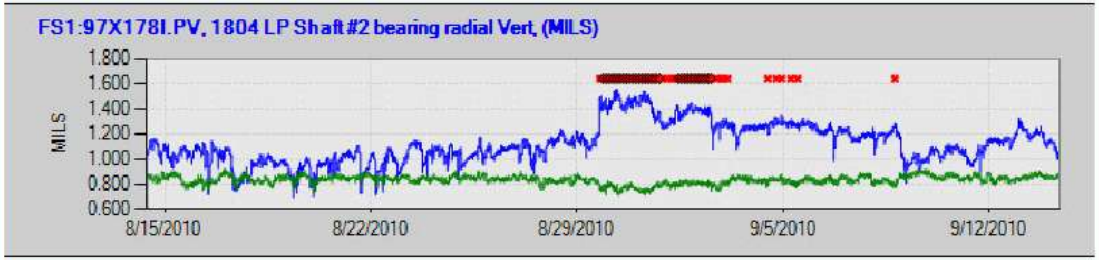
Description:
Condition has improved with decreased speed
There is increased bearing vibrations with constant turbine shaft speed starting on 8/29.

Diagnosis:
Possible bearing issue

Customer Response:



DRIVER MECHANICAL TAG 15



DRIVER MECHANICAL TAG 16

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CCP 18-1812

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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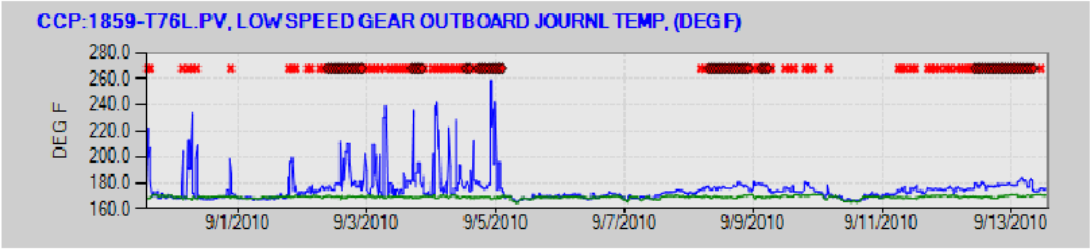
CCP
CCP 18-1812
Report-700-Outboard journal bearing temp spiking

Issue Tracking Number: 700
Status: 01) Notification to Customer
Date of Notification: 9/13/2010 12:00:00 AM
Equipment Tag: Low speed gear outboard journal temp
Category:

Description:
Tenperature was spiking at this time it has steading out possibly a conection issue will add to sensor list

Diagnosis:
Sensor issue

Customer Response:



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CCP 18-1812

BP Exploration Alaska SmartSignal Monitoring Report 9/14/2010

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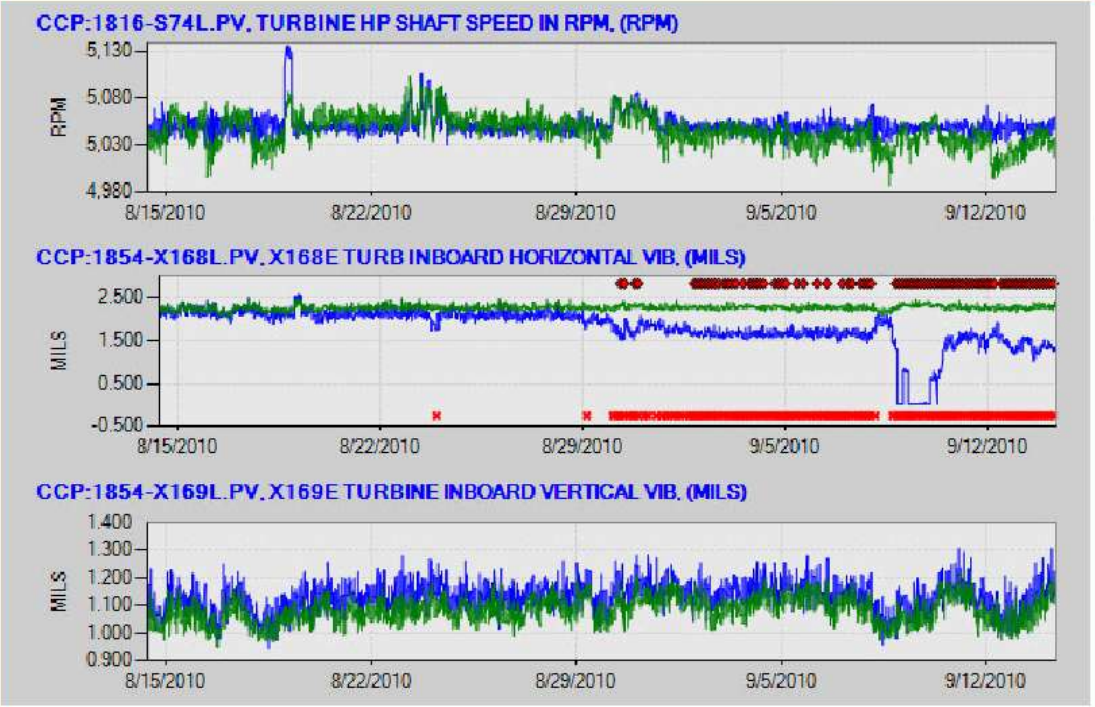
CCP
CCP 18-1803
Report-705-TURBINE INBOARD HORIZONTAL VIB - Low residuals

Issue Tracking Number: 705
Status: 01) Notification to Customer
Date of Notification: 9/14/2010 12:00:00 AM
Equipment Tag: CCP:1854-X168L.PV
Category:

Description:
Since 8/29 inboard horizontal vibration reading has been shifted lower from tracking accurately around 2.3 Mils down to 1.4 Mils (on 9/14). It also appear that on 9/9 reading dropped down to 0.02 Mils.

Diagnosis:
Possible moore card issue

Customer Response:



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