AVEVAWORLD

ACCELERATE INDUSTRIAL INTELLIGENCE

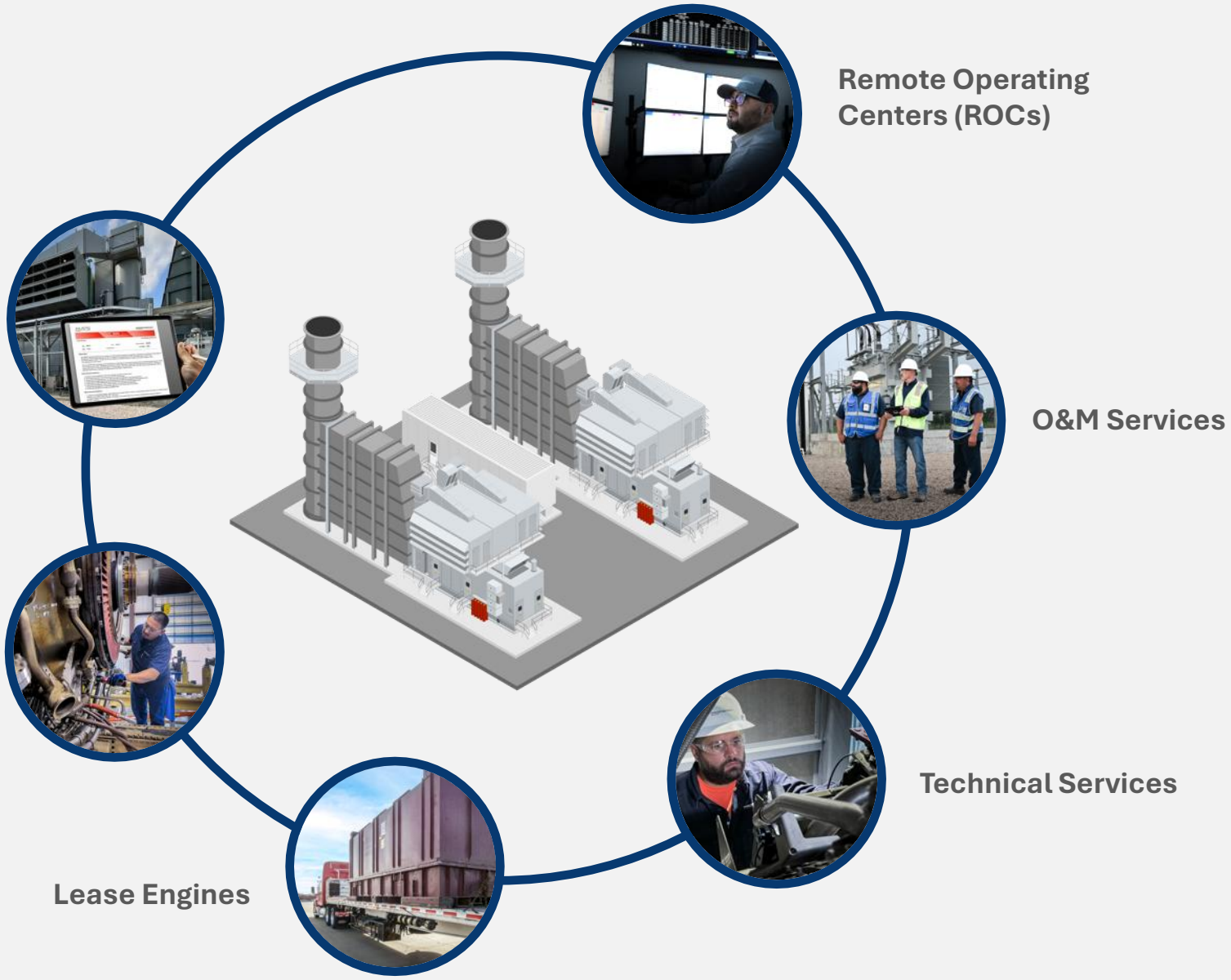
Predictive Analytics
PE6000 | LM6000 | LM2500

Brian Roth
VP O&M

PROENERGY

LIFECYCLE CARE

For the Life of the Turbine



THE NEED TO DEVELOP TECHNOLOGY

Operating the World's Largest Aero Fleet and More

HO Clarke
384 MW

Mark One
384 MW

Topaz
480 MW

Brotman
384 MW

Braes Bayou
384 MW

Remy Jade
384 MW

Reliability

99%

Across 6 sites in 2025

Starts

11,000

MWh Generated

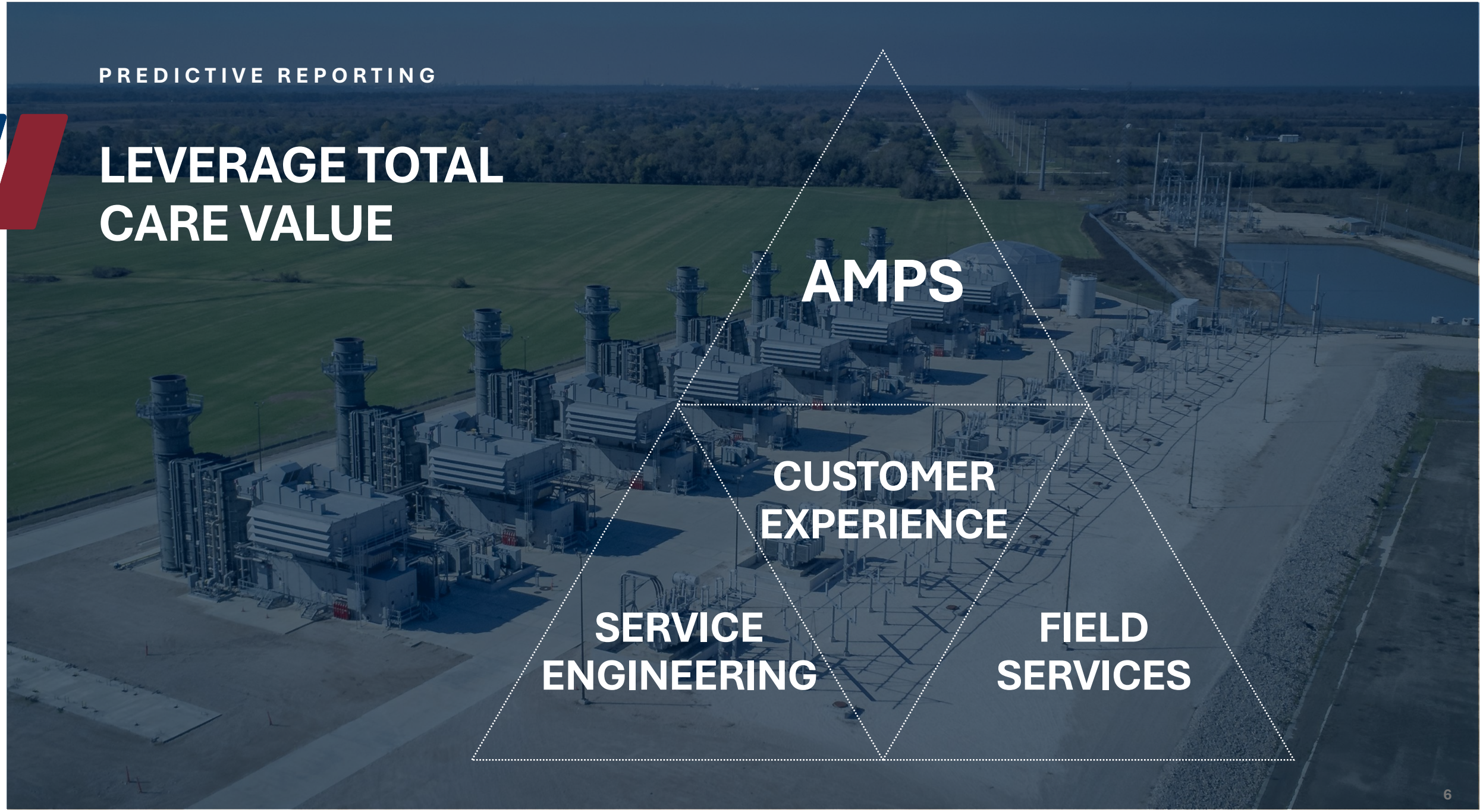
2.7M+

AVEVA™ Solutions

- AVEVA™ PI System™
- AVEVA™ Predictive Analytics
- AVEVA™ PI Vision™
- AVEVA™ PI DataLink™
- CONNECT Data Services

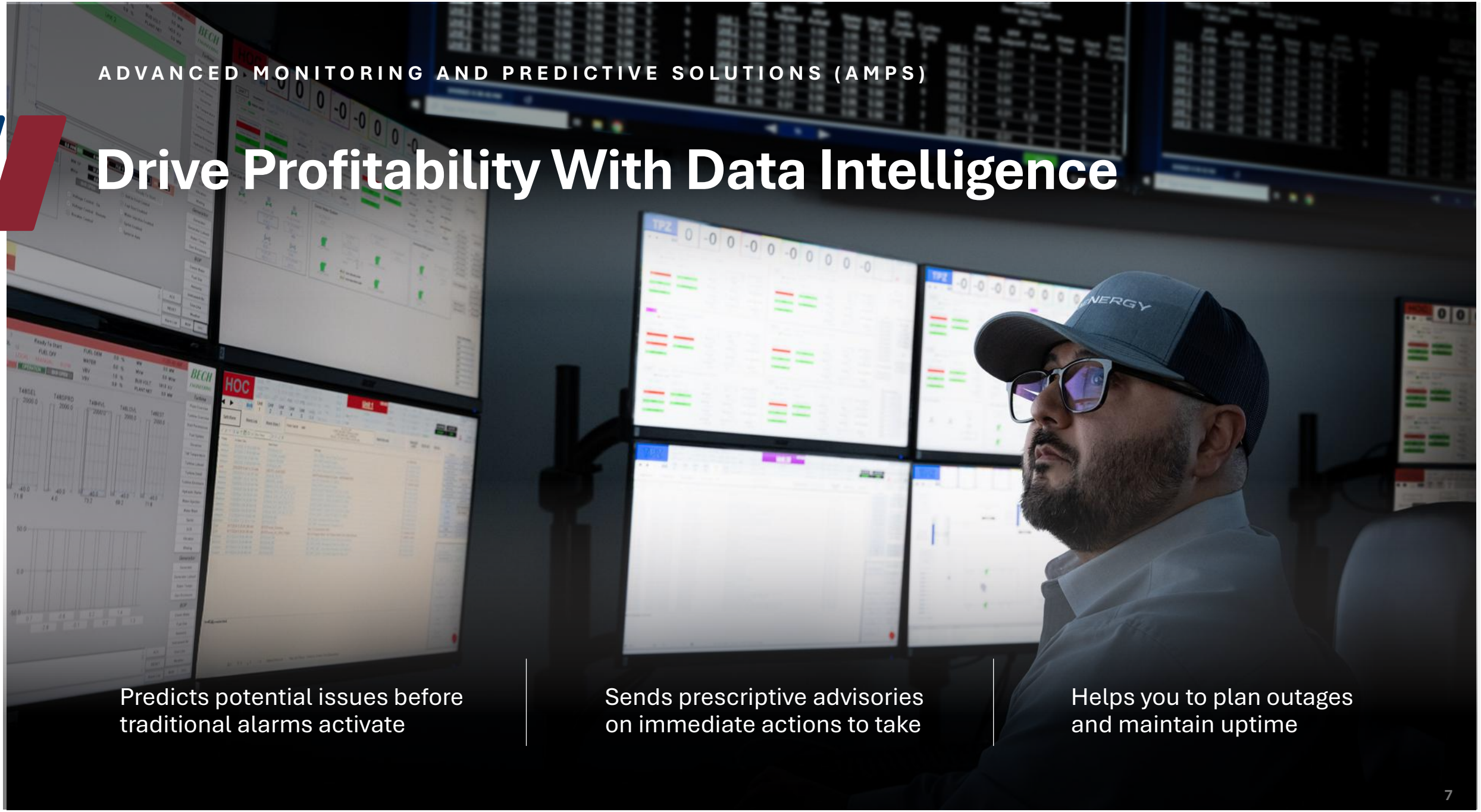
PREDICTIVE REPORTING

LEVERAGE TOTAL CARE VALUE



ADVANCED MONITORING AND PREDICTIVE SOLUTIONS (AMPS)

Drive Profitability With Data Intelligence



Predicts potential issues before traditional alarms activate

Sends prescriptive advisories on immediate actions to take

Helps you to plan outages and maintain uptime

Advanced Monitoring

Alerts Before Alarms

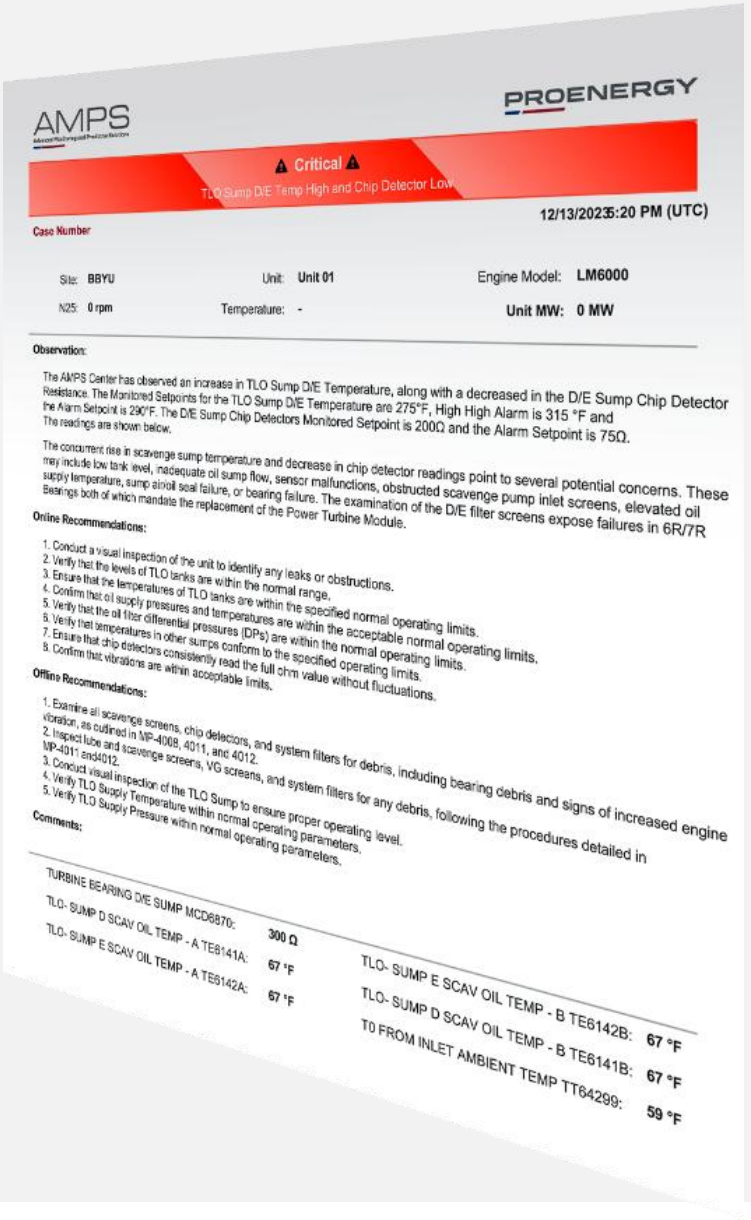
70+ analytics

Automated Notifications

Operational & Trip Advisories

Encourage Dialogue

Feedback process



AMPS

PROENERGY

Critical

TLO Sump D/E Temp High and Chip Detector Low

12/13/2023 5:20 PM (UTC)

Case Number

Site: BBYU Unit: Unit 01 Engine Model: LM6000

N25: 0 rpm Temperature: - Unit MW: 0 MW

Observation:

The AMPS Center has observed an increase in TLO Sump D/E Temperature, along with a decreased in the D/E Sump Chip Detector Resistance. The Monitored Setpoints for the TLO Sump D/E Temperature are 275°F, High High Alarm is 315 °F and the Alarm Setpoint is 290°F. The D/E Sump Chip Detectors Monitored Setpoint is 200Ω and the Alarm Setpoint is 75Ω. The readings are shown below.

The concurrent rise in scavenge sump temperature and decrease in chip detector readings point to several potential concerns. These may include low tank level, inadequate oil sump flow, sensor malfunctions, obstructed scavenge pump inlet screens, elevated oil supply temperature, sump aircil seal failure, or bearing failure. The examination of the D/E filter screens expose failures in 6R/7R Bearings both of which mandate the replacement of the Power Turbine Module.

Online Recommendations:

1. Conduct a visual inspection of the unit to identify any leaks or obstructions.
2. Verify that the levels of TLO tanks are within the normal range.
3. Ensure that the temperatures of TLO tanks are within the specified normal operating limits.
4. Confirm that oil supply pressures and temperatures are within the acceptable normal operating limits.
5. Verify that the oil filter differential pressures (DPs) are within the normal operating limits.
6. Verify that temperatures in other sumps conform to the specified operating limits.
7. Ensure that chip detectors consistently read the full ohm value without fluctuations.
8. Confirm that vibrations are within acceptable limits.

Offline Recommendations:

1. Examine all scavenge screens, chip detectors, and system filters for debris, including bearing debris and signs of increased engine vibration, as outlined in MP-4008, 4011, and 4012.
2. Inspect lube and scavenge screens, VG screens, and system filters for any debris, following the procedures detailed in MP-4011 and4012.
3. Conduct visual inspection of the TLO Sump to ensure proper operating level.
4. Verify TLO Supply Temperature within normal operating parameters.
5. Verify TLO Supply Pressure within normal operating parameters.

Comments:

TURBINE BEARING D/E SUMP MCD6870:	300 Ω		
TLO- SUMP D SCAV OIL TEMP - A TE6141A:	67 °F	TLO- SUMP E SCAV OIL TEMP - B TE6142B:	67 °F
TLO- SUMP E SCAV OIL TEMP - A TE6142A:	67 °F	TLO- SUMP D SCAV OIL TEMP - B TE6141B:	67 °F
		T0 FROM INLET AMBIENT TEMP TT64299:	59 °F

Predictive Solutions

Modeling

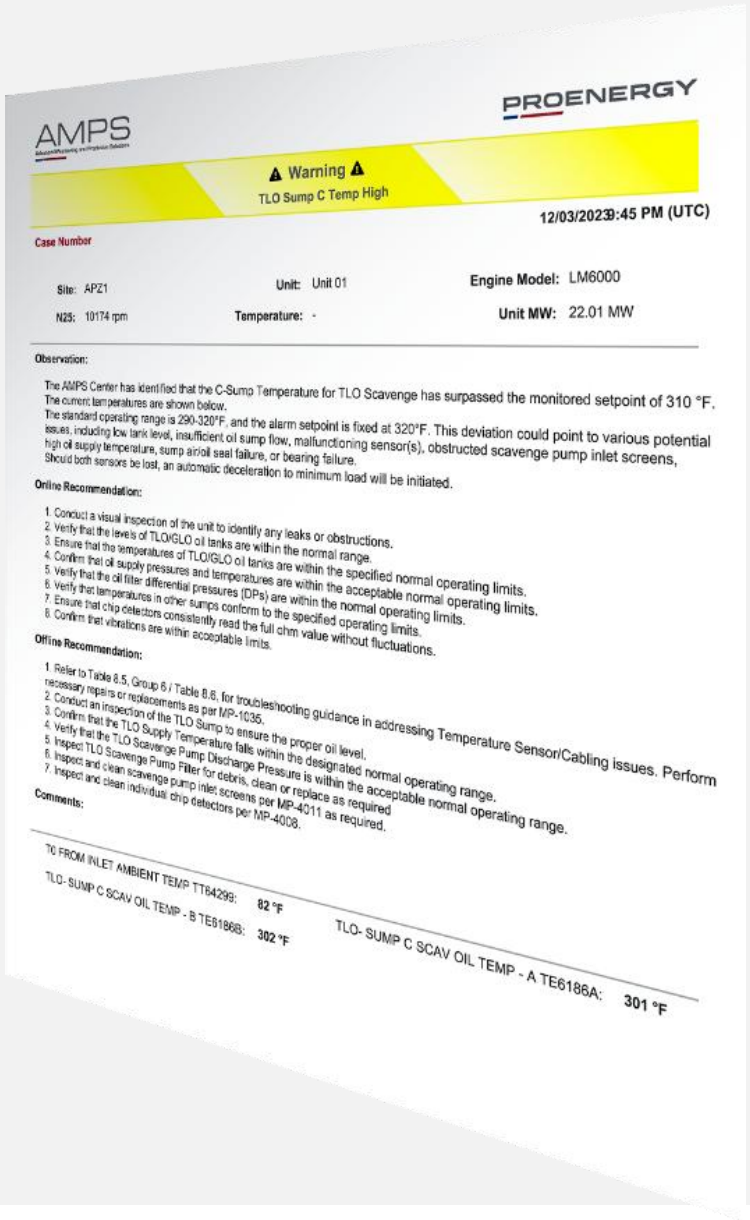
Engines individually

Engineering Alert

Service Engineering Involvement

Solution Delivery

Plan + Execution



AMPS

PROENERGY

⚠ Warning ⚠

TLO Sump C Temp High

12/03/2023 3:45 PM (UTC)

Case Number

Site: APZ1 Unit: Unit 01 Engine Model: LM6000

N2S: 10174 rpm Temperature: - Unit MW: 22.01 MW

Observation:

The AMPS Center has identified that the C-Sump Temperature for TLO Scavenge has surpassed the monitored setpoint of 310 °F. The current temperatures are shown below.
The standard operating range is 290-320°F, and the alarm setpoint is fixed at 320°F. This deviation could point to various potential issues, including low tank level, insufficient oil sump flow, malfunctioning sensor(s), obstructed scavenge pump inlet screens, high oil supply temperature, sump airoil seal failure, or bearing failure.
Should both sensors be lost, an automatic deceleration to minimum load will be initiated.

Online Recommendation:

1. Conduct a visual inspection of the unit to identify any leaks or obstructions.
2. Verify that the levels of TLO/GLO oil tanks are within the normal range.
3. Ensure that the temperatures of TLO/GLO oil tanks are within the specified normal operating limits.
4. Confirm that oil supply pressures and temperatures are within the acceptable normal operating limits.
5. Verify that the oil filter differential pressures (DPs) are within the normal operating limits.
6. Verify that temperatures in other sumps conform to the specified operating limits.
7. Ensure that chip detectors consistently read the full ohm value without fluctuations.
8. Confirm that vibrations are within acceptable limits.

Offline Recommendation:

1. Refer to Table 8.5, Group 6 / Table 8.6, for troubleshooting guidance in addressing Temperature Sensor/Cabling issues. Perform necessary repairs or replacements as per MP-1035.
2. Conduct an inspection of the TLO Sump to ensure the proper oil level.
3. Confirm that the TLO Supply Temperature falls within the designated normal operating range.
4. Verify that the TLO Scavenge Pump Discharge Pressure is within the acceptable normal operating range.
5. Inspect TLO Scavenge Pump Filter for debris, clean or replace as required
6. Inspect and clean scavenge pump inlet screens per MP-4011 as required.
7. Inspect and clean individual chip detectors per MP-4008.

Comments:

TO FROM INLET AMBIENT TEMP TT84299: 82 °F

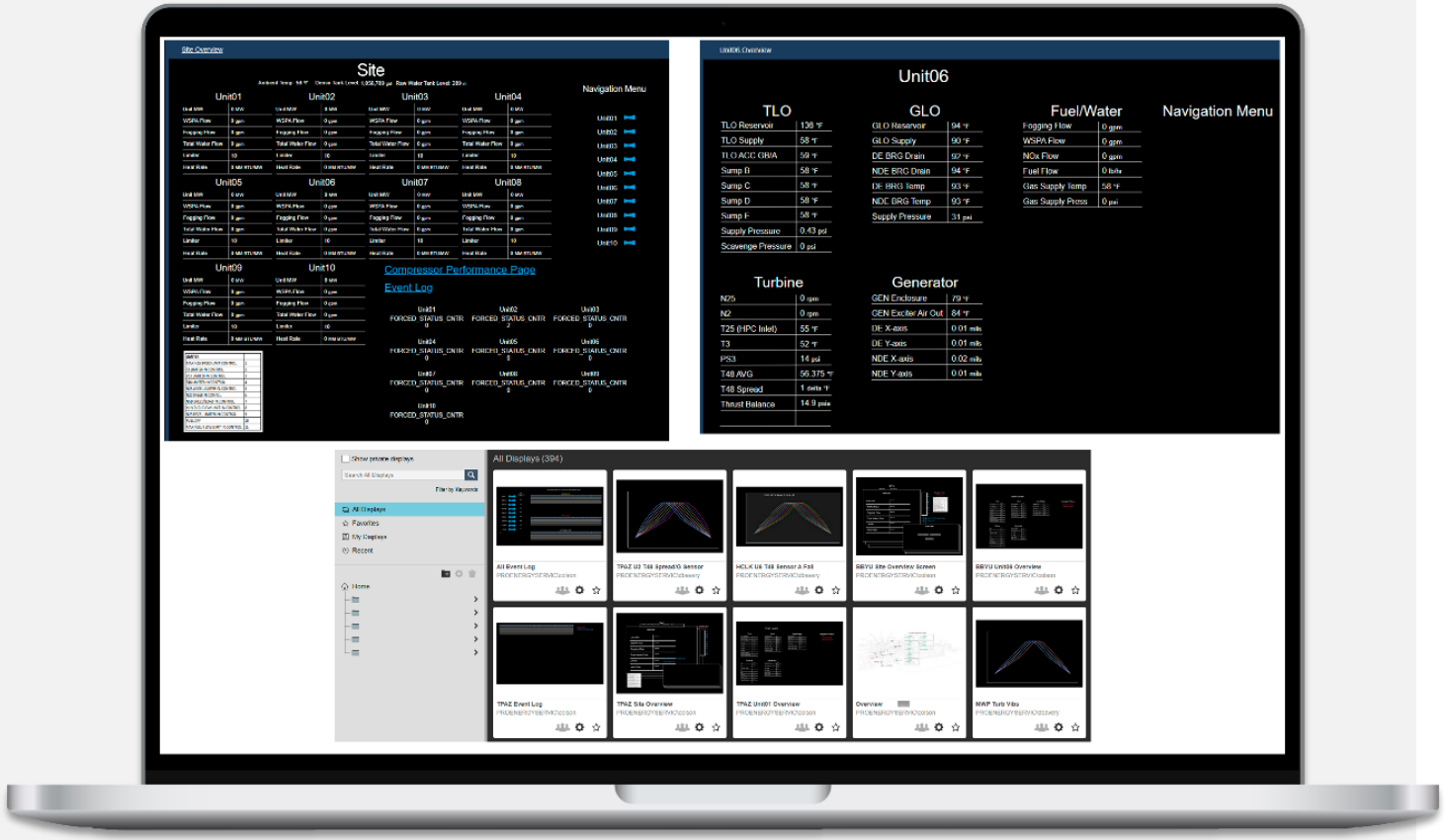
TLO- SUMP C SCAV OIL TEMP - B TE6186B: 302 °F

TLO- SUMP C SCAV OIL TEMP - A TE6186A: 301 °F

PREDICTIVE ANALYTICS

CHALLENGES

- **Wrong Expectations**
  - Solve all our problems
- **Incomplete Staff**
  - Generalist vs Specialist
- **Poor Execution**
  - Accountability for the alerts



CASE STUDIES

A NEW BUSINESS INPUT

PREDICTIVE SOLUTIONS

Detected Failures >30 Days Early In Peaking Units

Key points in the compressor showed degradations from normal operations.

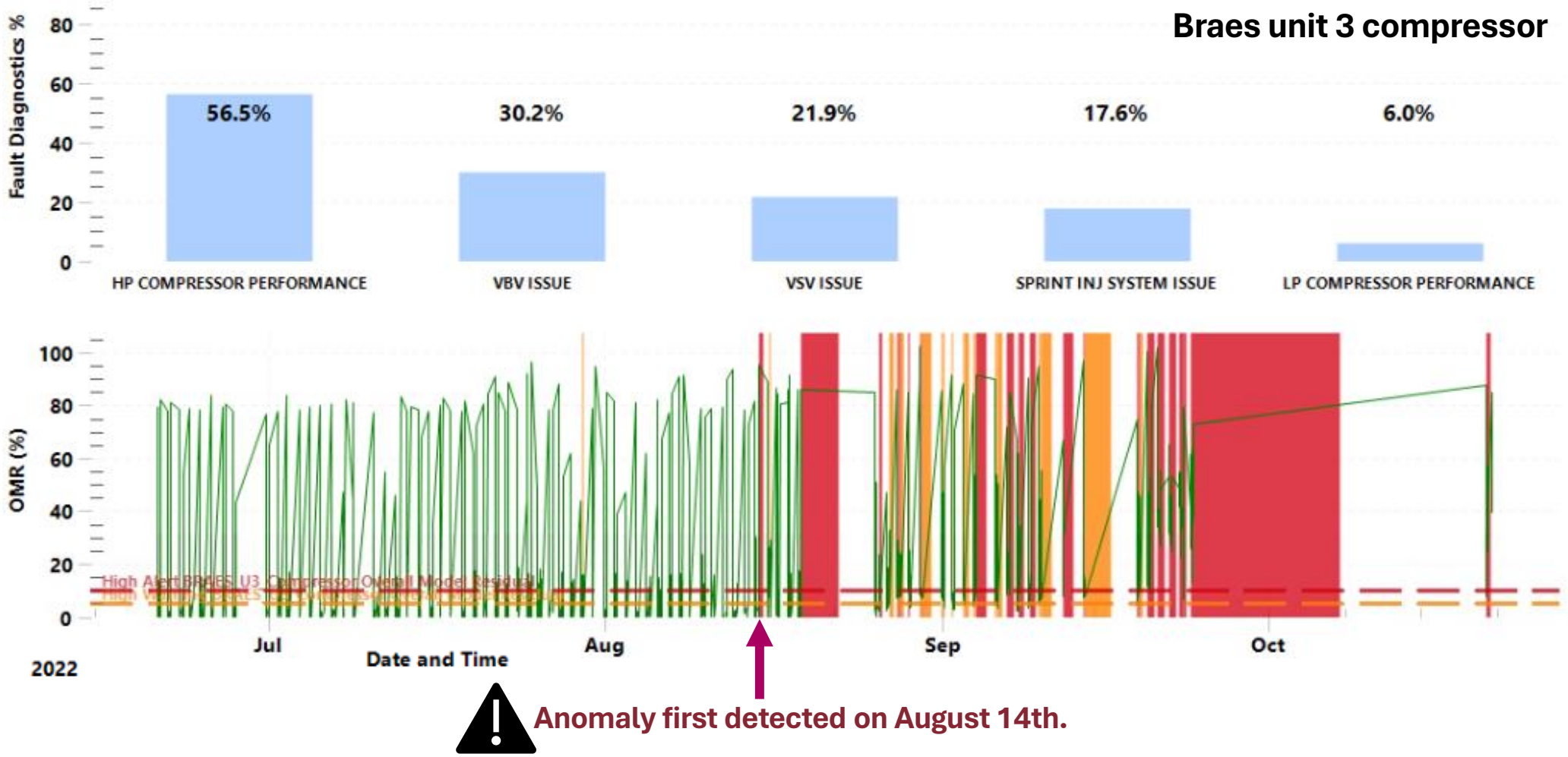
- Pressures
- Temperatures
- VG systems
- Measured from June 20 to Nov. 15, 2022
  - 1 minute frequency
  - 135 variables for each of the 2 units

Asset Name	Description	Identified by Predictive Analytics	Early Warning
BRAES Unit 3	HP Compressor Performance	Yes	38 Days
BRAES Unit 4	HP Compressor Performance	Yes	34 Days

CASE STUDY #1

Compressor Issue Detected 38 Days Early

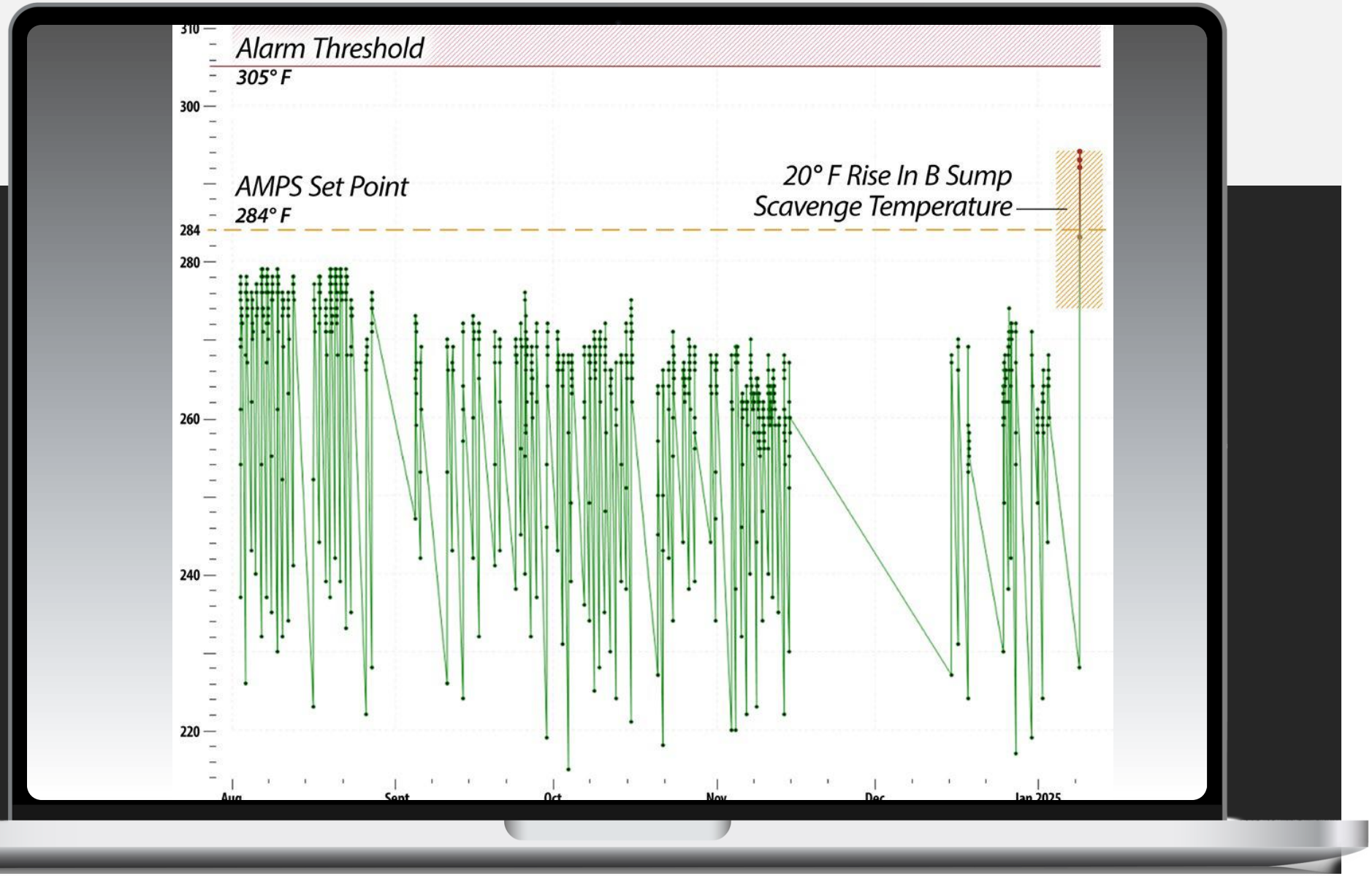
Braes unit 3 compressor



CASE STUDY #2

Alert:

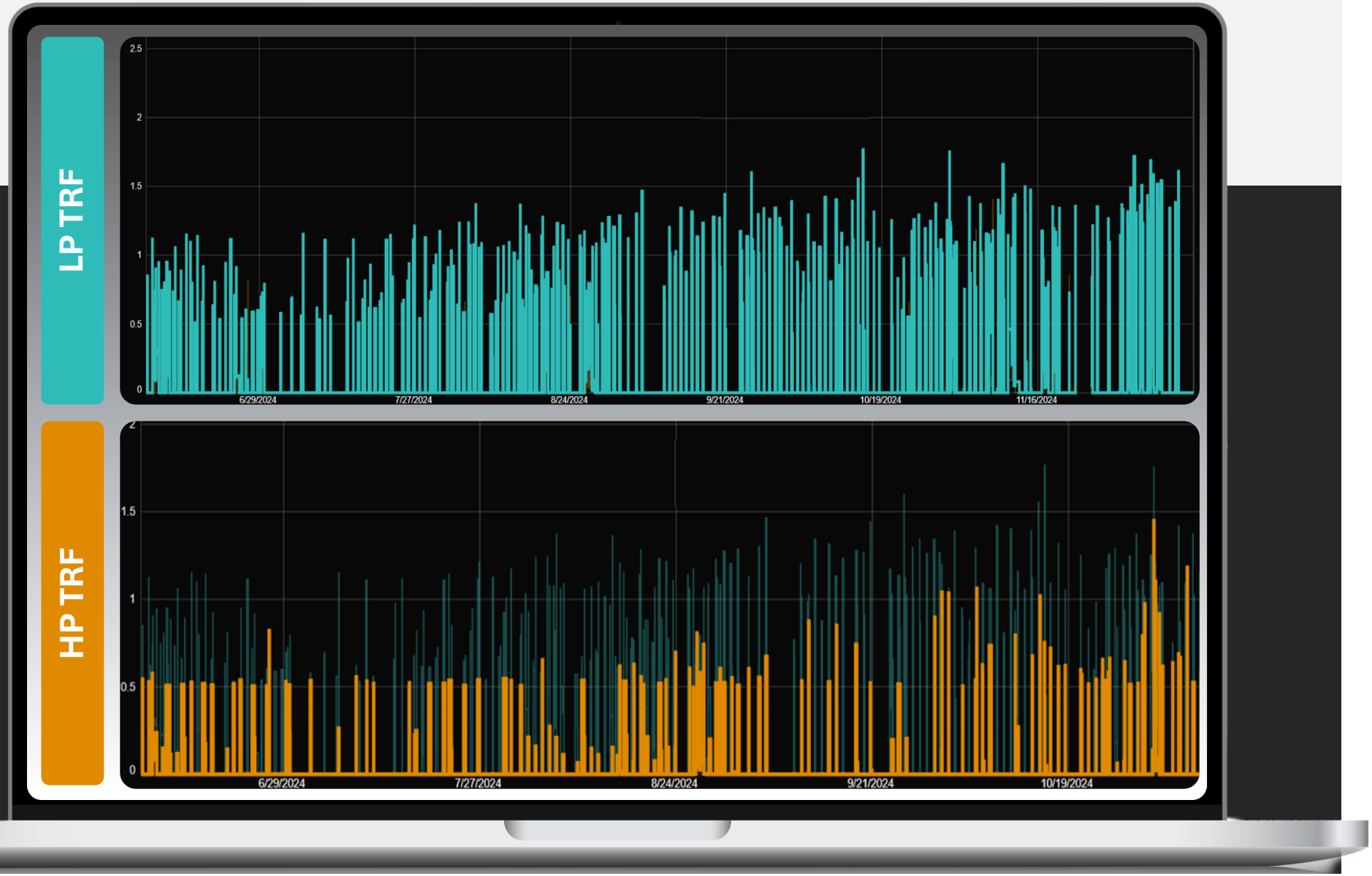
B SUMP SCAVENGE TEMPERATURES ROSE ABOVE NORMAL.



CASE STUDY #3A

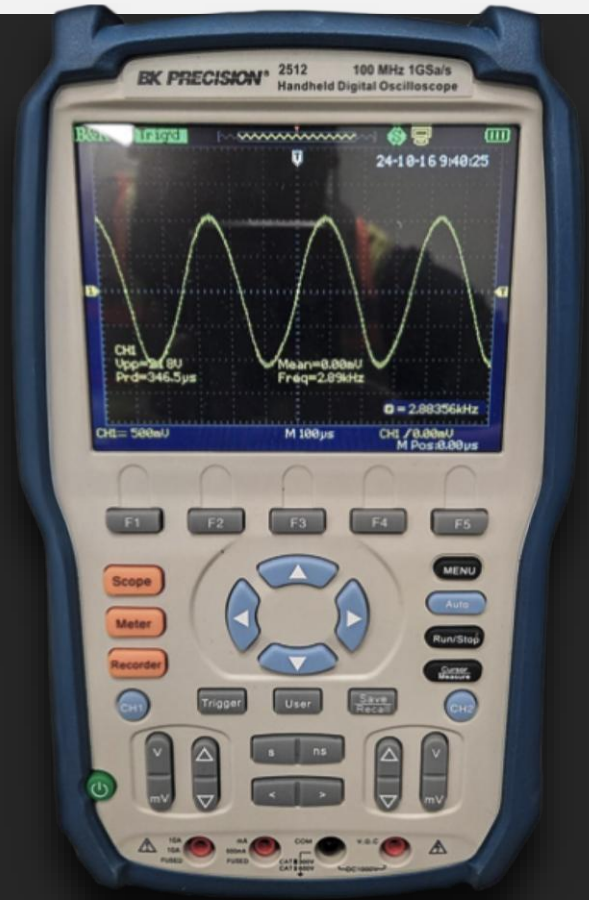
Alert:

WIDE-BAND TRF VIBRATION INCREASING WITH T3 TEMPERATURE



CASE STUDY #3A

Result: Preventive Maintenance Saves $425K



Procedure No. MP-4004 Gas Turbine Exhaust Inspection
Gas Turbine Exhaust System Inspection Unit 8 *Rev. 1.0*

NOTE: Exhaust duct alignment should be checked after final full engine alignment is complete.

1. Measure and record dimension A and dimension B at eight equally spaced locations around circumference of exhaust duct. Calculate X as follows:

   XA = AMAX - AMIN

2. Refer to table 1 for the applicable limits. If dimensions exceed the table maximum or minimum values, then adjust the exhaust diffuser. Refer to packager's manual.

Table 1. Exhaust System Limits

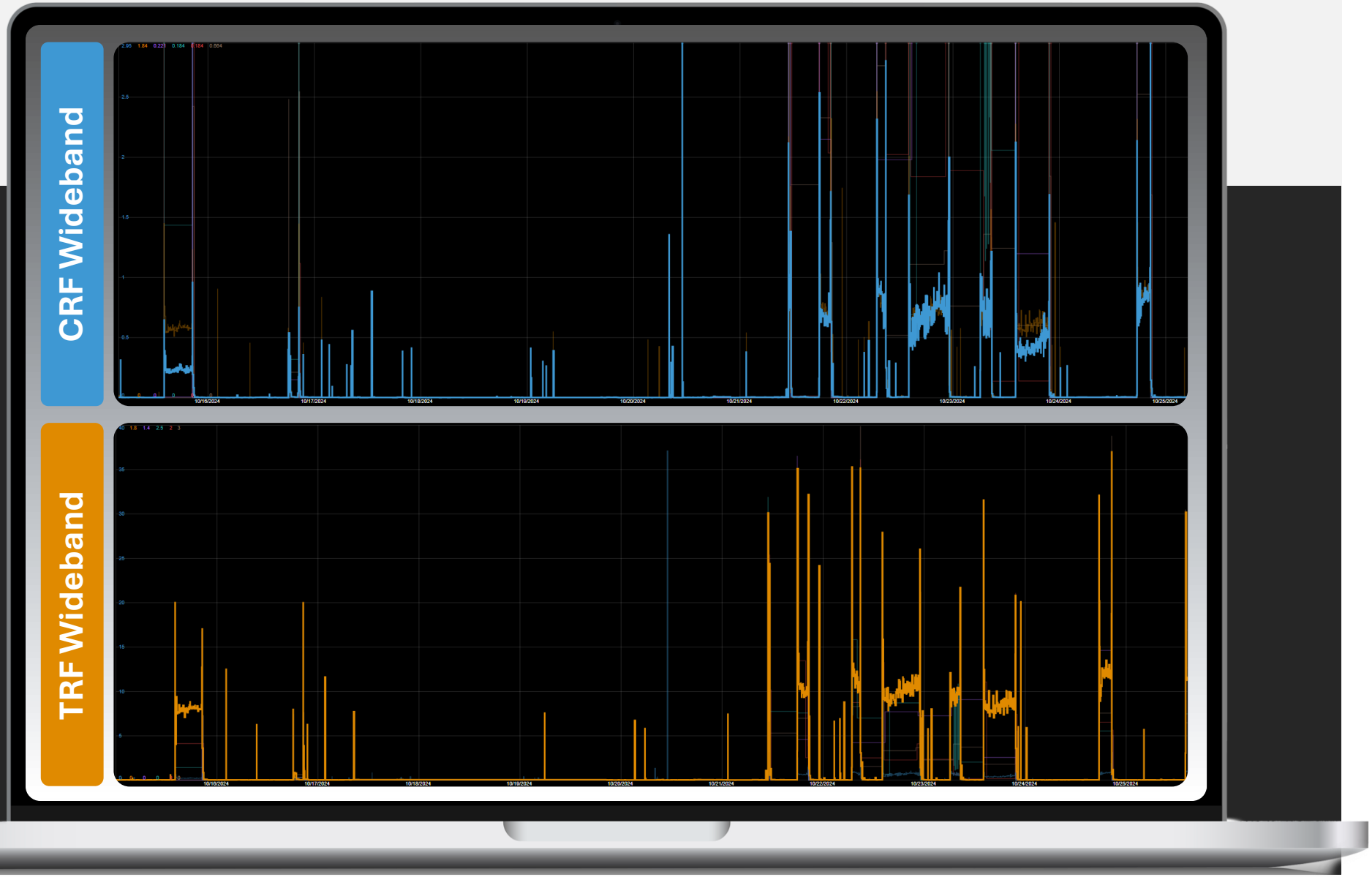
	Minimum Value	Maximum Value	Maximum X_A
Dimension A (Measured at Outer Piston Ring)	2.775 in. (70.49 mm)	N/A	0.25 in. (6.35 mm)
Dimension B	0.14 in. (3.56 mm)	N/A	N/A

DIM A	DIM B
1. 2.775	1. .250
2. 2.780	2. .250
3. 2.780	3. .200
4. 2.790	4. .105
5. 2.790	5. .105
6. 2.800	6. .090
7. 2.790	7. .105
8. 2.775	8. .225
9. AVG 2.785	9. AVG .153

CASE STUDY #3B

Alert:

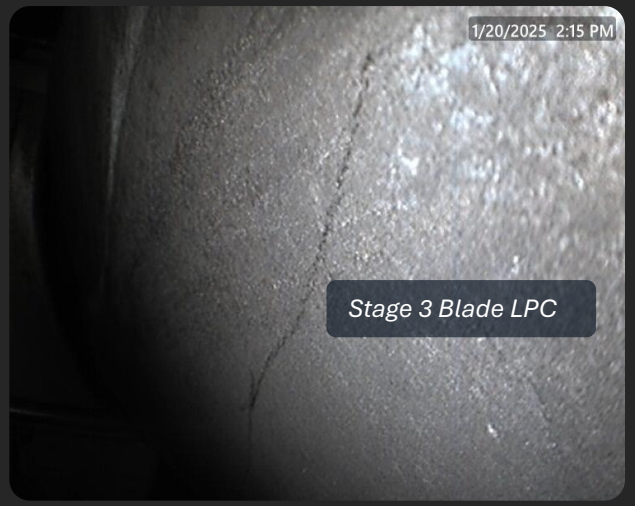
SIGNIFICANT SPIKE IN VIBRATION DURING STARTUP AND SHUTDOWN



CASE STUDY #3B

Result: HPC and Midshaft Warning Saves $2.5M

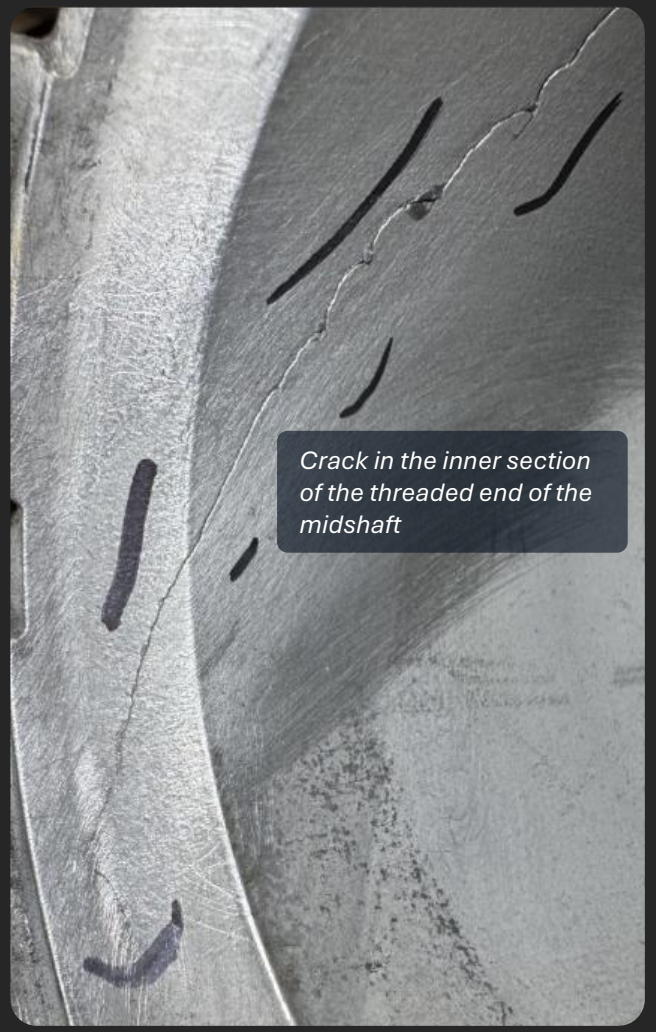

Stage 5 HPC Blades

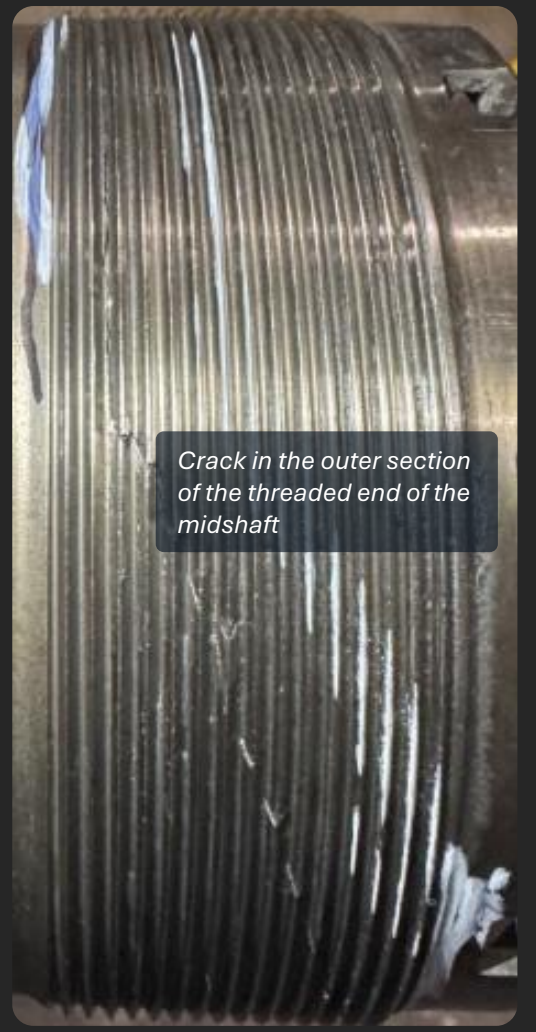


Stage 3 Blade LPC

Stage 8 HPC Blades


Rotor spool vane contact


Crack in the inner section of the threaded end of the midshaft


Crack in the outer section of the threaded end of the midshaft

PROENERGY enables predictive decision making in reactive peaking operations

Challenge

- Dispatch uncertainty and frequent starts drove a reactive operating model
- Engines with existing hours and incomplete pedigree increased reliability risk
- Alarm-based monitoring identified problems too late for preventive intervention
- Staffing focus and alert execution initially limited the impact of early analytics

Solution

- ProEnergy used AVEVA™ PI System™, AVEVA™ Predictive Analytics, AVEVA™ PI Vision™, AVEVA™ PI DataLink™, and CONNECT data services to detect issues earlier and guide proactive operational decisions.

Results

- **Detected compressor degradation and emerging failures more than 30 days earlier than traditional alarm-based approaches**
- **Avoided a major high-pressure compressor and midshaft failure valued at $2.5M**
- **Prevented additional damage events delivering $425K–$600K in cost avoidance across multiple units**
- **Improved operational confidence by enabling earlier, better-informed maintenance and business decisions.**

Thank You