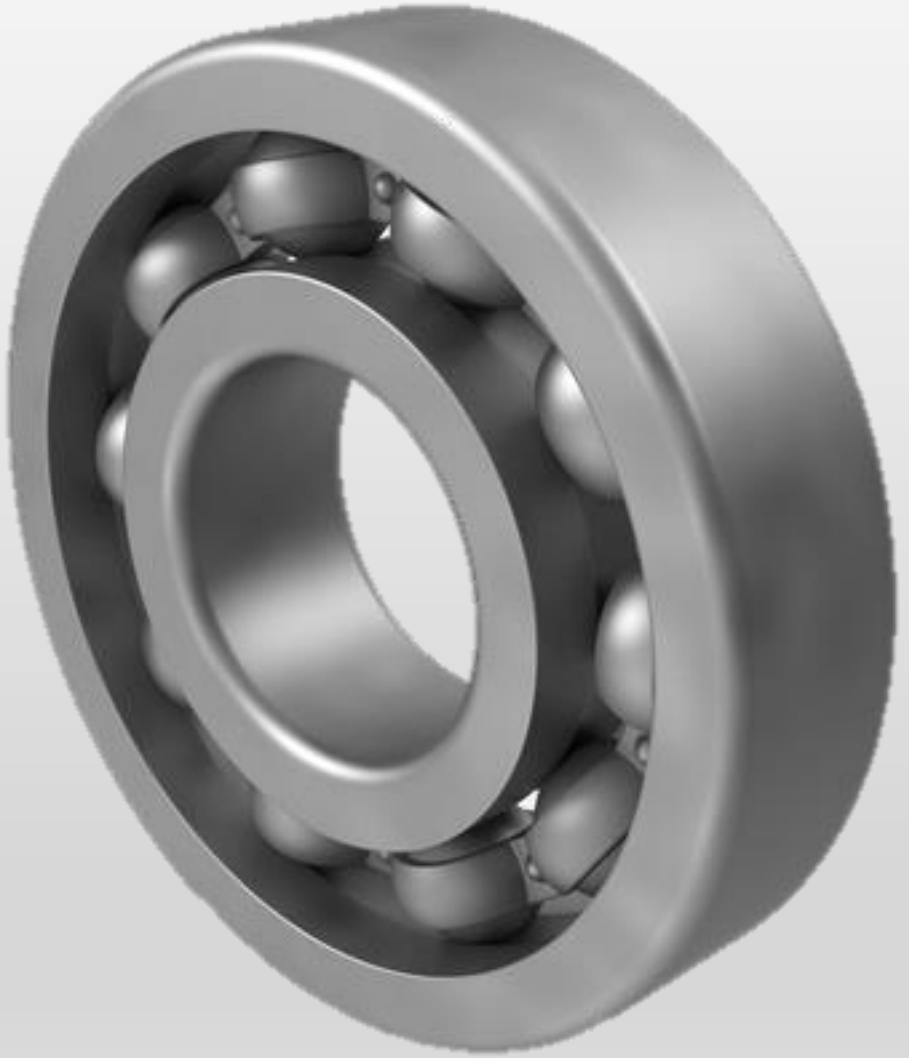
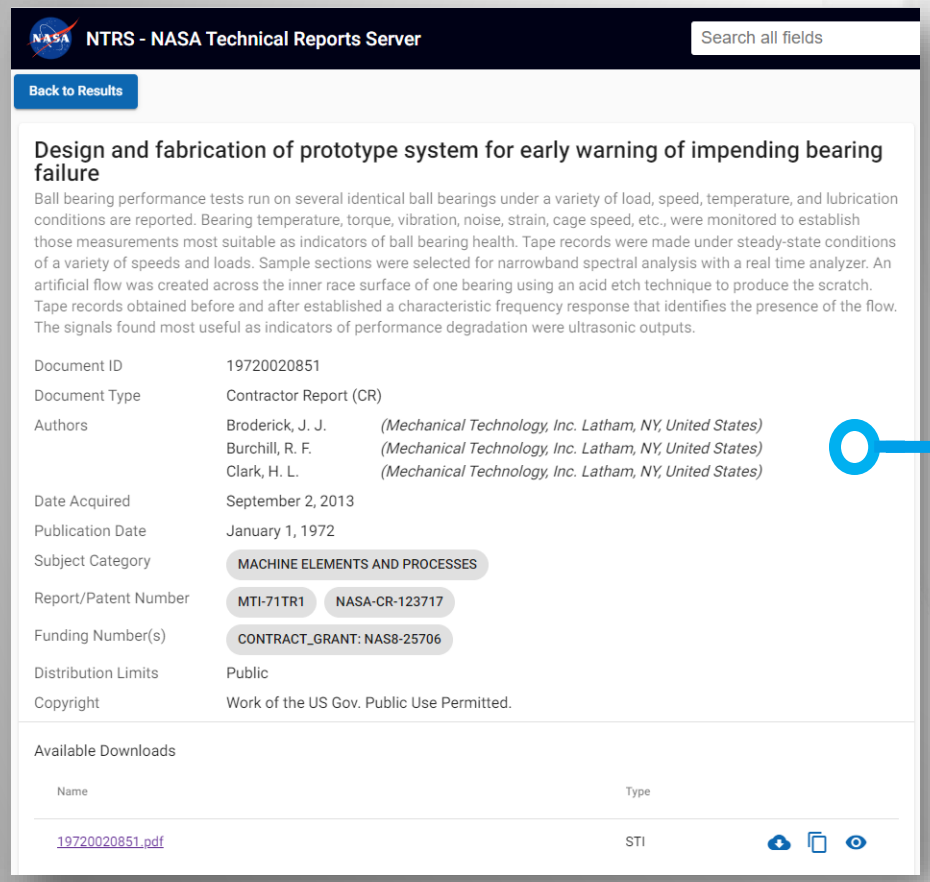
MEASURING BEARING *FRICTION* IN REAL-TIME

WHAT 8.5 BILLION FRICTION DATA POINTS HAS TAUGHT US.



WHY WE MEASURE **FRICTION**



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Design and fabrication of prototype system for early warning of impending bearing failure

Ball bearing performance tests run on several identical ball bearings under a variety of load, speed, temperature, and lubrication conditions are reported. Bearing temperature, torque, vibration, noise, strain, cage speed, etc., were monitored to establish those measurements most suitable as indicators of ball bearing health. Tape records were made under steady-state conditions of a variety of speeds and loads. Sample sections were selected for narrowband spectral analysis with a real time analyzer. An artificial flow was created across the inner race surface of one bearing using an acid etch technique to produce the scratch. Tape records obtained before and after established a characteristic frequency response that identifies the presence of the flow. The signals found most useful as indicators of performance degradation were ultrasonic outputs.

Document ID	19720020851
Document Type	Contractor Report (CR)
Authors	Broderick, J. J. *(Mechanical Technology, Inc. Latham, NY, United States)* Burchill, R. F. *(Mechanical Technology, Inc. Latham, NY, United States)* Clark, H. L. *(Mechanical Technology, Inc. Latham, NY, United States)*
Date Acquired	September 2, 2013
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Report/Patent Number	MTI-71TR1 NASA-CR-123717
Funding Number(s)	CONTRACT_GRANT: NAS8-25706
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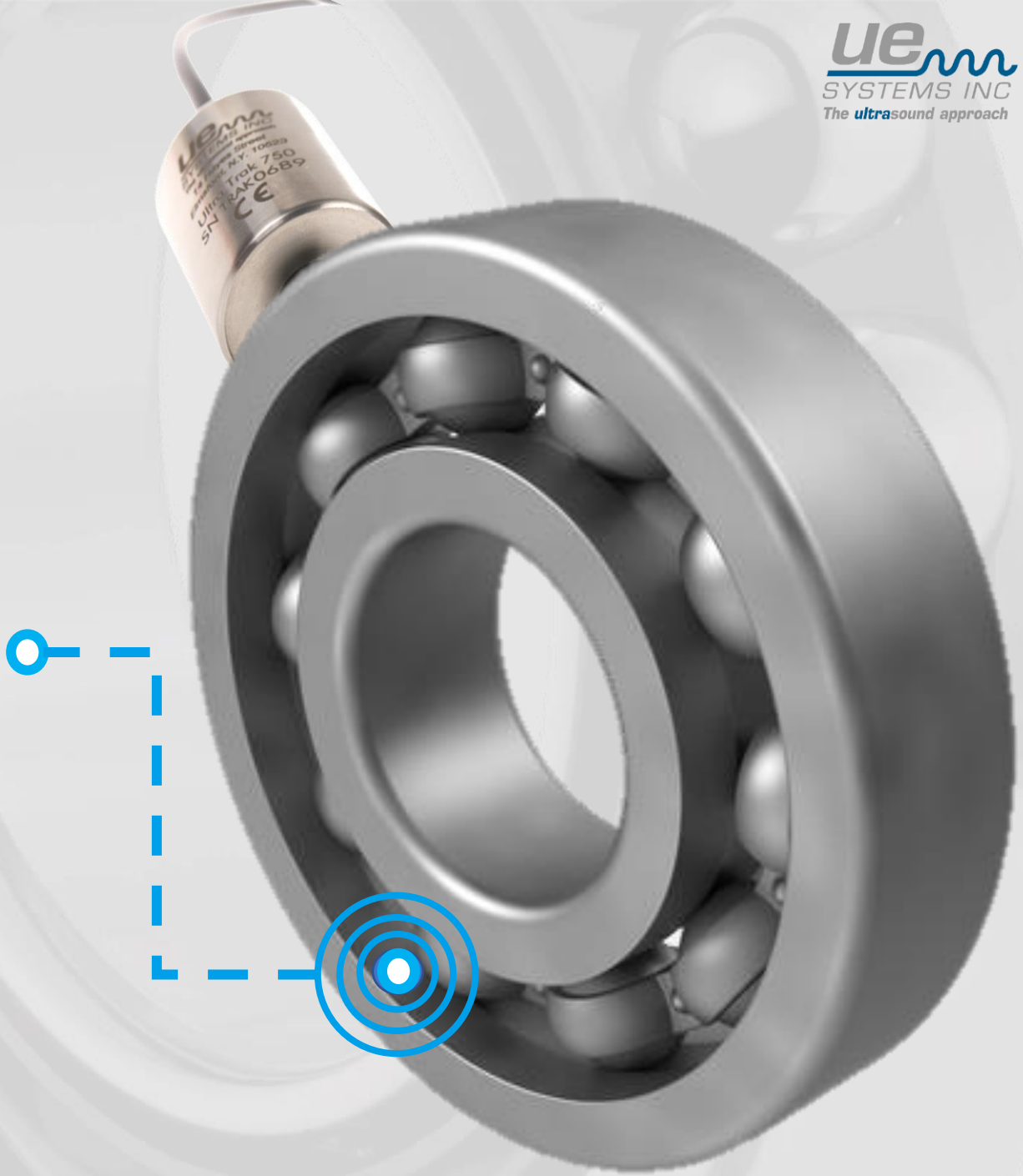
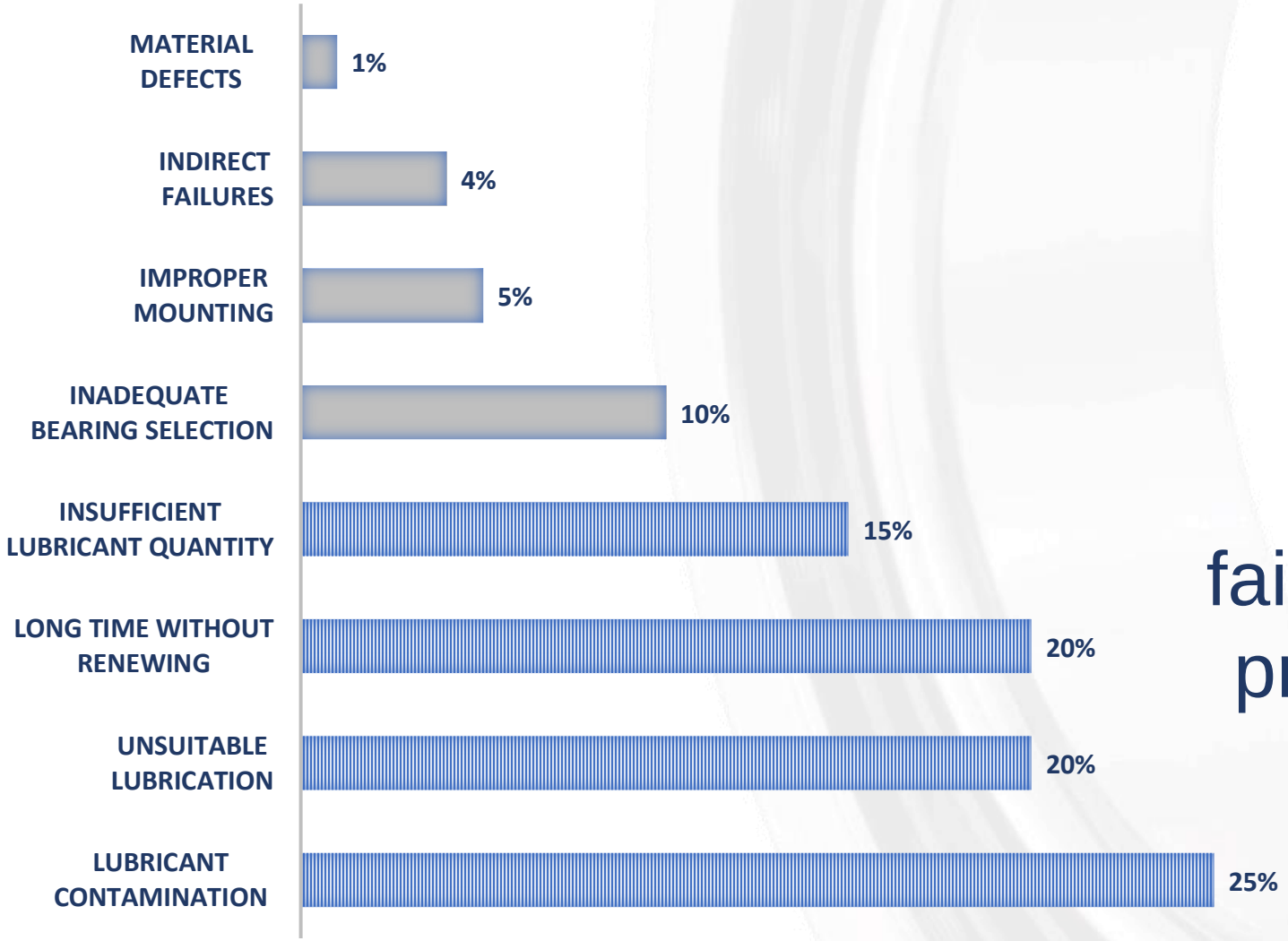
“The signals found most useful as indicators of performance degradation were ultrasonic outputs.”

The ultrasonic signal will appear prior to a temperature rise or increase in driving torque.”

HOW WE MEASURE **FRICTION**

IT IS SIMPLE, AS THE FRICTION IN THE BEARING INCREASES DUE TO LUBRICATION ISSUES OR THE ONSET OF FAILURE, THERE WILL BE A CORRESPONDING RISE IN ULTRASOUND (dB)





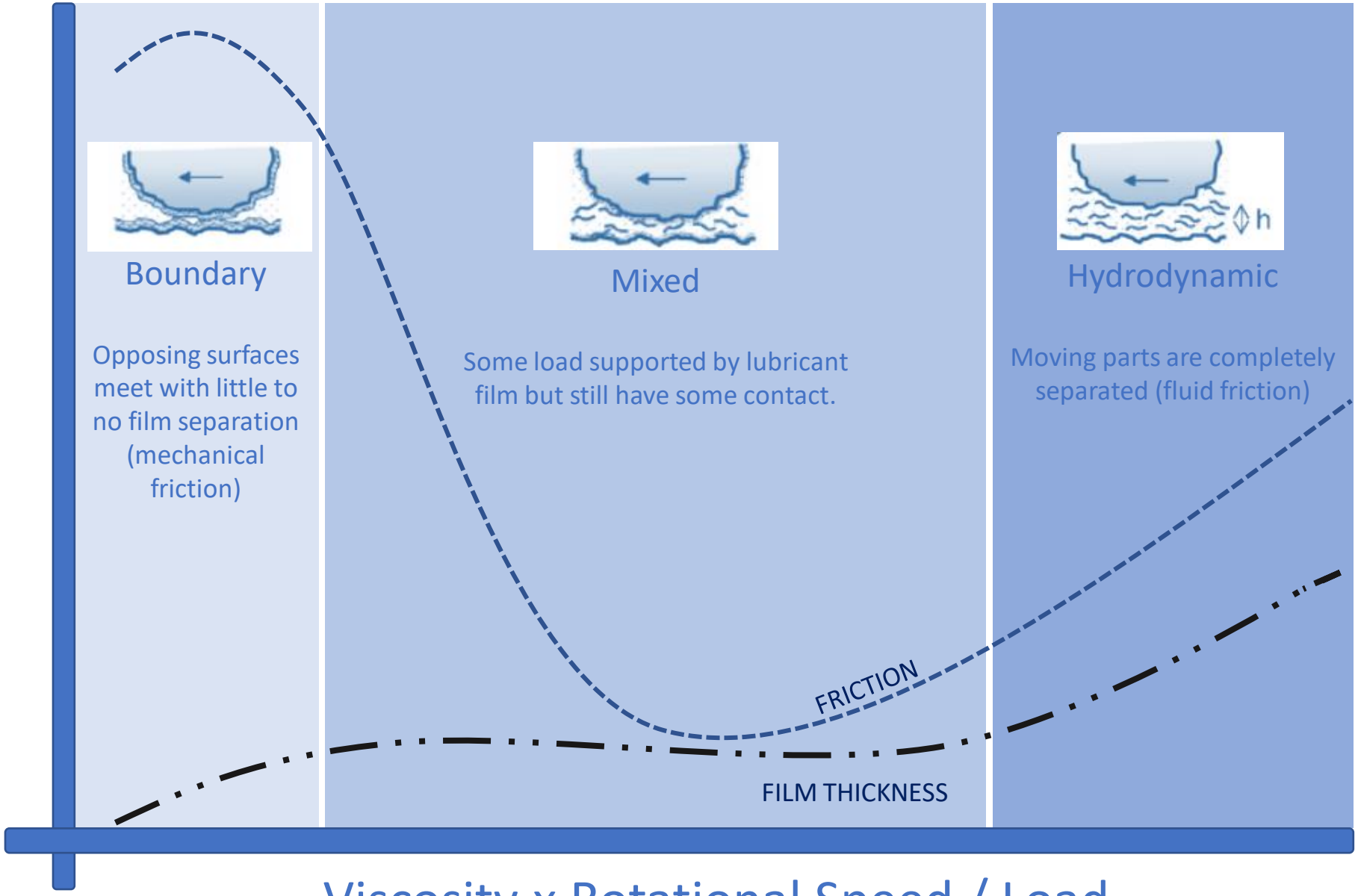
Up to

80%

of premature bearing failures can be traced to a problem with lubrication.

** SKF Bearing Corporation, Bearing Failures and Their Causes*

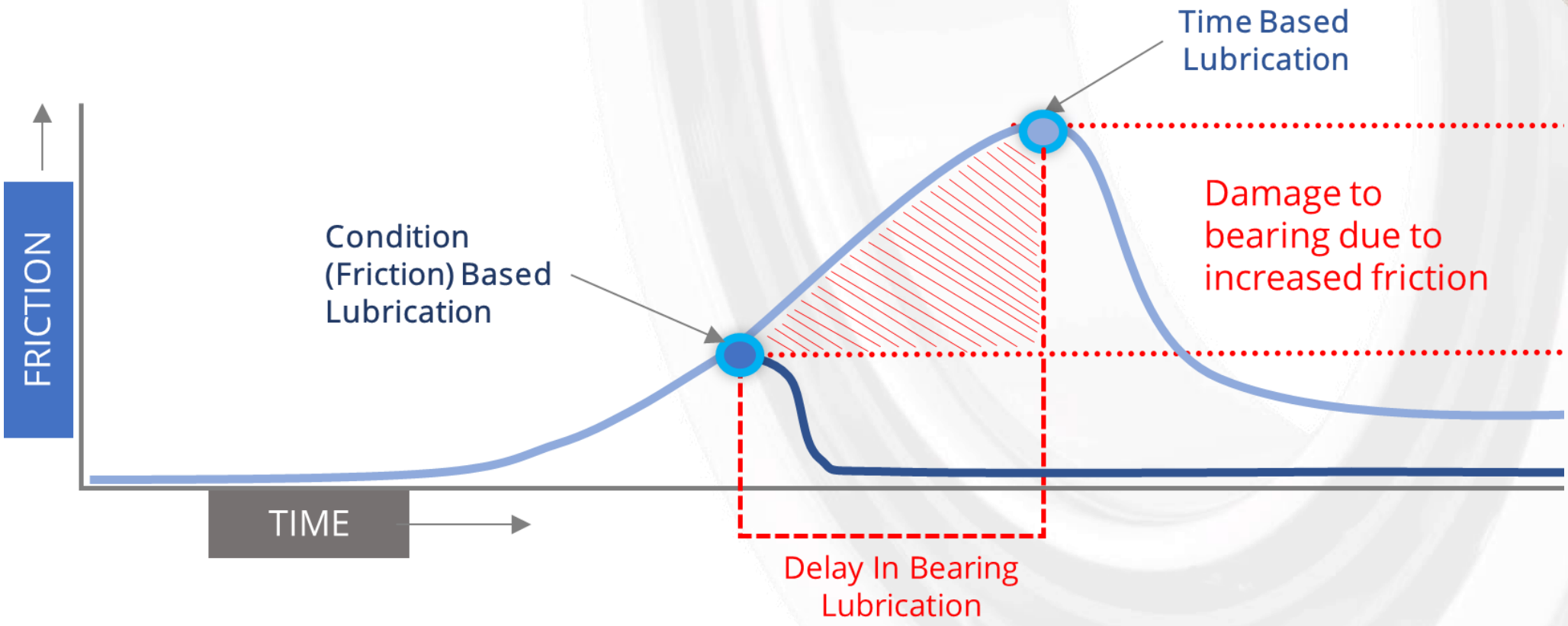
Coefficient of
FRICTION



Viscosity x Rotational Speed / Load

USING **ULTRASOUND TECHNOLOGY** TO CONTINUOUSLY MONITOR THE **BEARING FRICTION**

- **KNOW WHEN GREASED IS REQUIRED**
- **KNOW PRECISELY HOW MUCH IS REQUIRED**



MONITOR AND TREND DECIBEL LEVELS CAUSED BY FRICTION - ISO29821-1

UE SYSTEMS INC
The ultrasound approach

+8dB

ABOVE BASELINE INDICATES A LACK OF LUBRICATION.

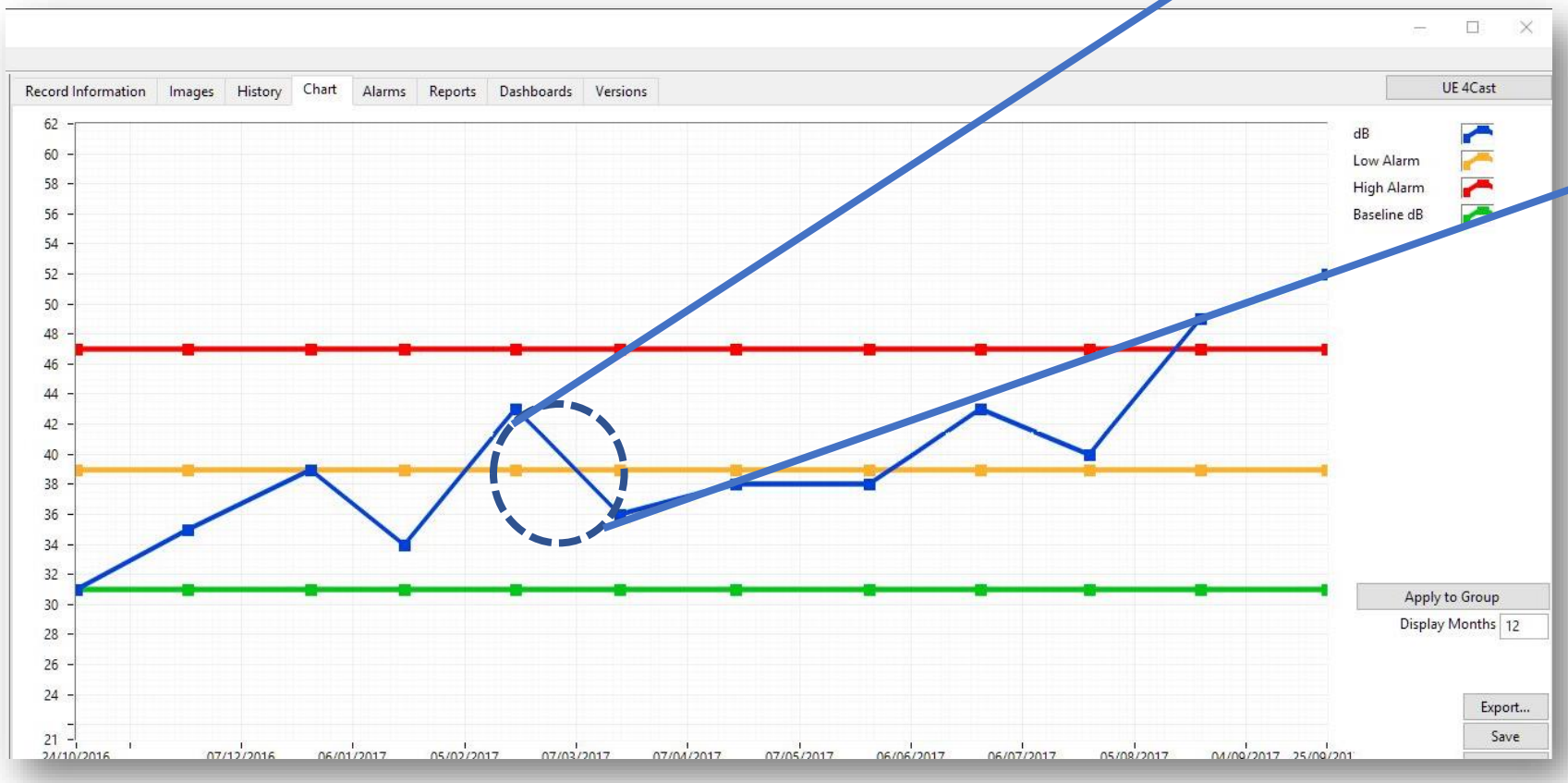
+16dB

ABOVE BASELINE INDICATES DAMAGE TO THE BEARING – A FAILURE MODE BEYOND LUBRICATION ALONE.

+35dB

ABOVE BASELINE MEANS THE ASSET IS CRITICAL – IT IS CLOSE TO FAILURE.

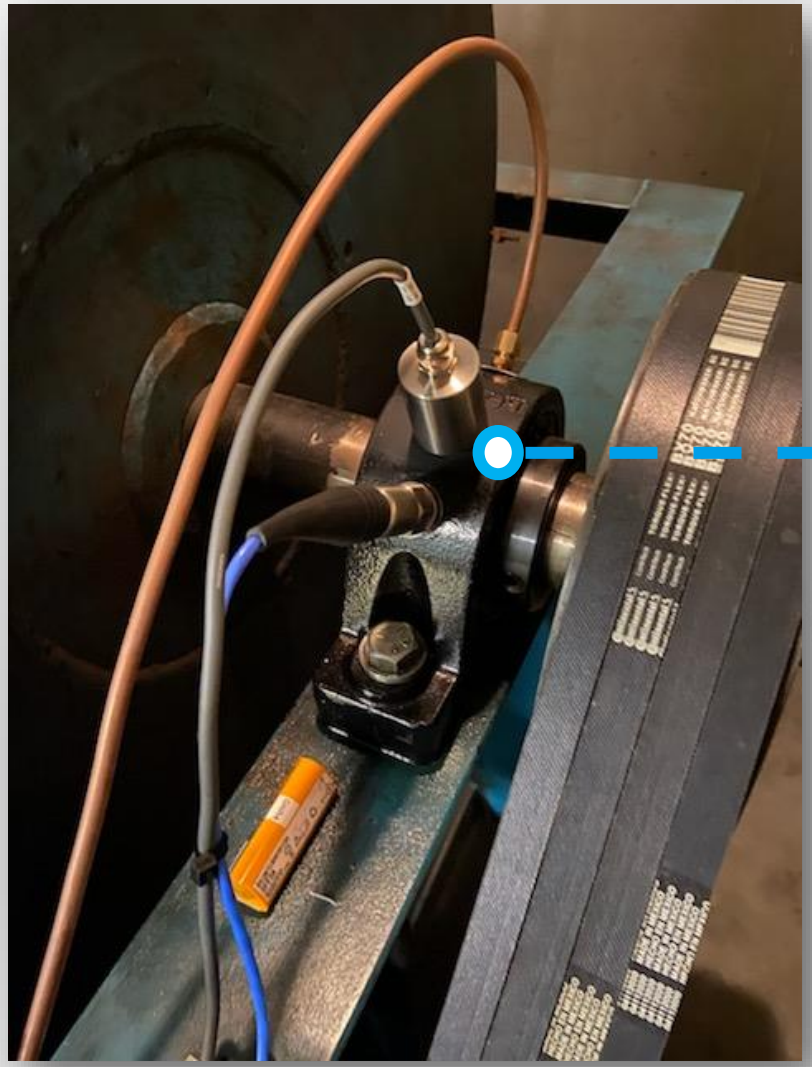
FRICTION TREND ON A **MONTHLY ROUTE**



WHAT WE HAVE LEARNED FROM MONITORING *FRICTION* IN REAL-TIME

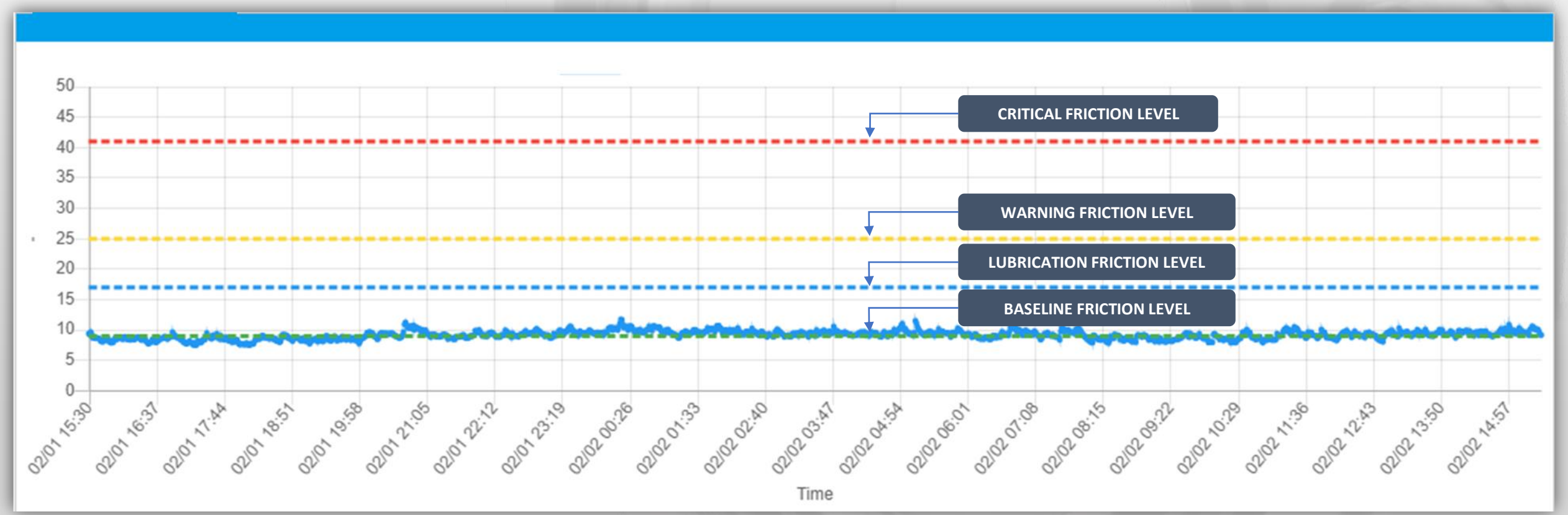
USE CASE

FAN BEARING IN AN AIR HANDLER UNIT

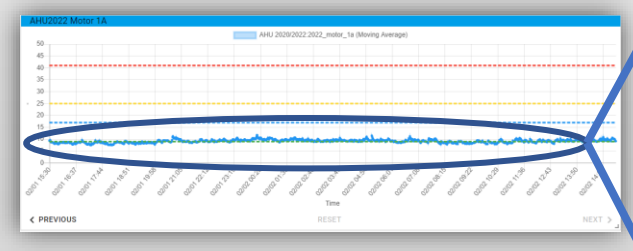


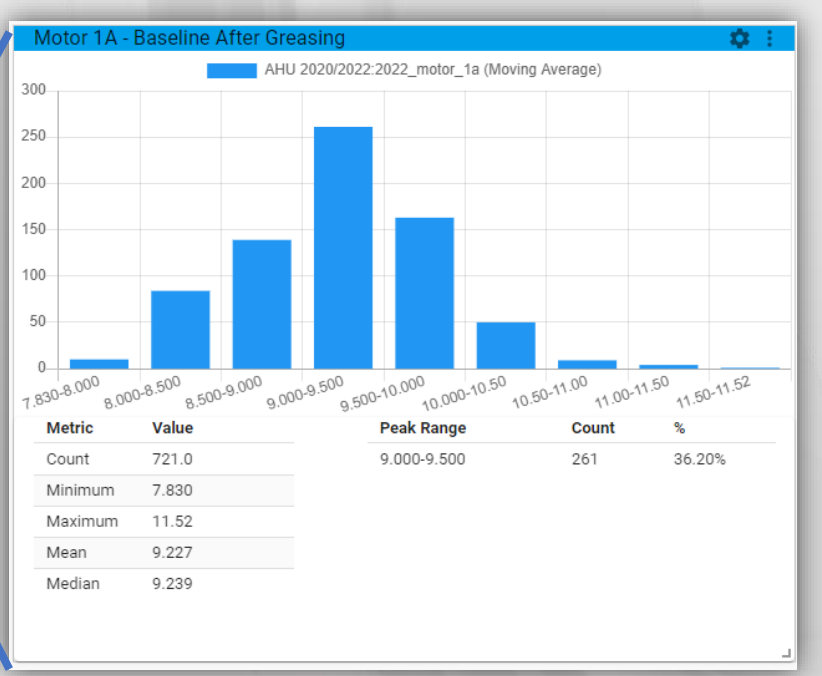
- DRIVE END OF BELT DRIVEN FAN
- VARIABLE FREQUENCY DRIVE
- ADDITIONAL VIBRATION SENSORS
- REMOTE GREASE LINE

IDEAL FRICTION TREND IN A **FAN BEARING IN AN AIR HANDLER UNIT**



IDEAL FRICTION DISTRIBUTION IN A **FAN BEARING IN AN AIR HANDLER UNIT**





Metric	Value
Count	721.0
Minimum	7.830
Maximum	11.52
Mean	9.227
Median	9.239

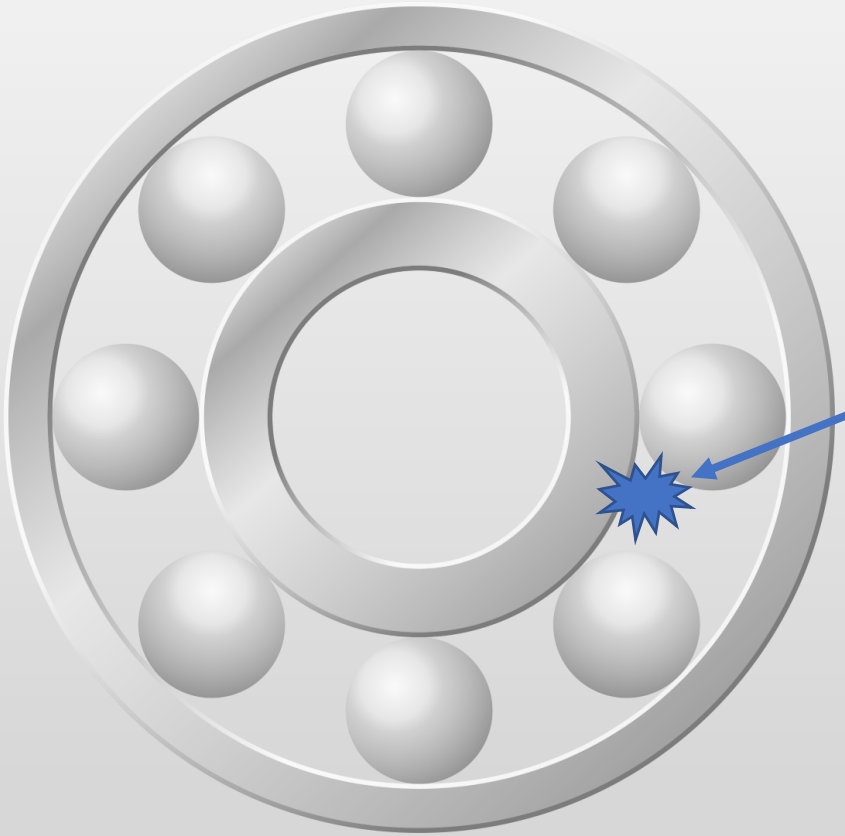
Peak Range	Count	%
9.000-9.500	261	36.20%

- **TRENDING NEAR THE BASELINE**
- **THROUGH ALL VARYING SPEEDS, THE FRICTION HAS A CONSISTENT CENTER POINT (AVERAGE)**
- **VALUES ARE NOT BOUNCING AROUND. (PEAK-TO-PEAK VALUES)**

WAIT…
DOESN'T THE FRICTION CHANGE BASED ON VARYING SPEED CONDITIONS?

YES, BUT ONLY A LITTLE…. AND THIS IS WHAT IS GREAT ABOUT ULTRASOUND AND MONITORING FRICTION. IN A HEALTHY, PROPERLY LUBRICATED BEARING THE FRICTION SHOULD NOT CHANGE DRAMATICALLY. A SLIGHT INCREASE OF 2-3DB MAY BE SEEN DEPENDING ON THE SPEED CHANGE.

IDEAL FRICTION DISTRIBUTION IN A **FAN BEARING IN AN AIR HANDLER UNIT**



- **FRICTION TRACKING WITH THE VFD. INDICATION OF ANOMALY IN THE BEARING**

USE CASE

BEARING IN ELECTRIC MOTOR

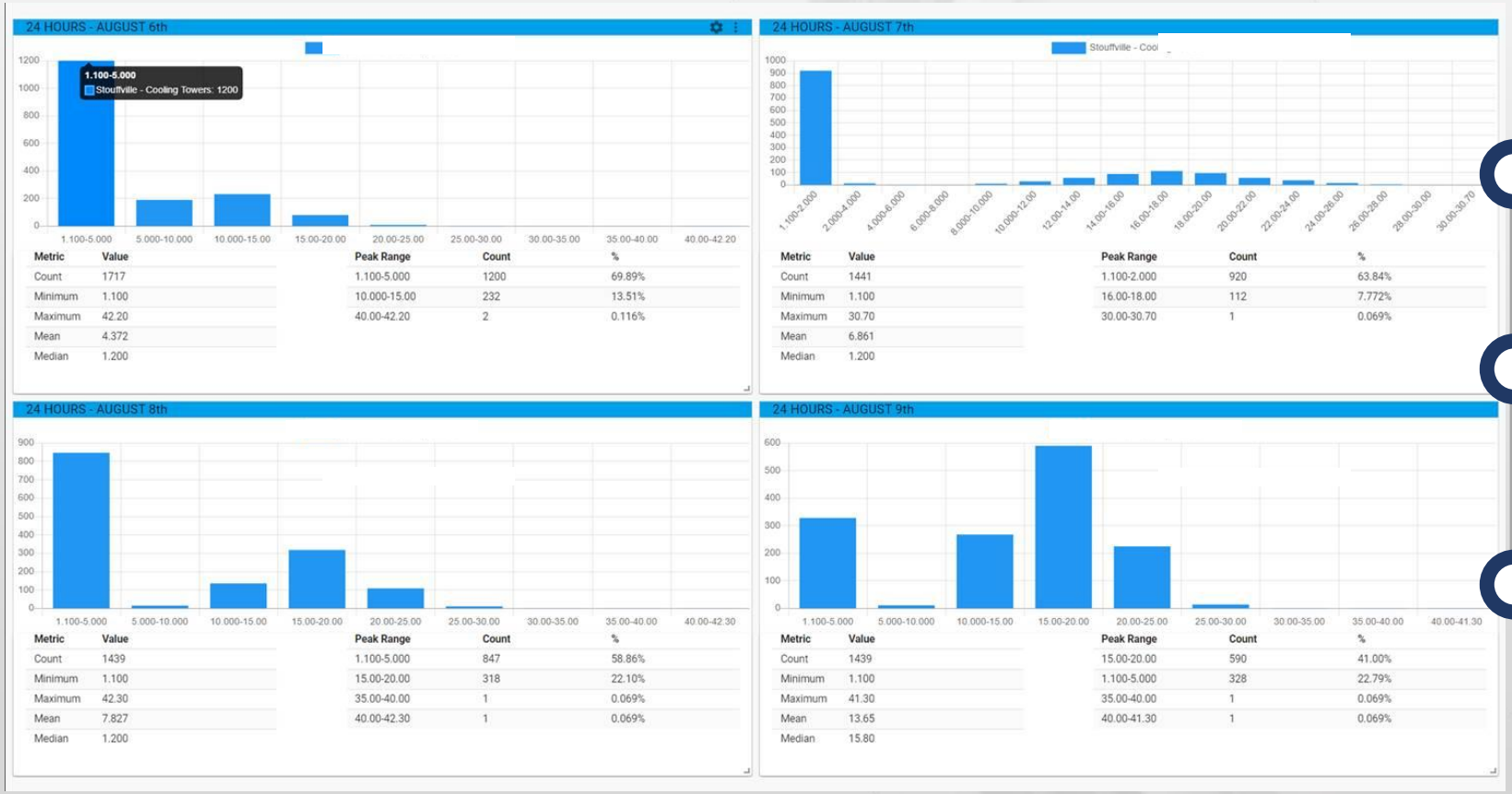
- NON-DRIVE END OF MOTOR
- USED FIN MOUNT

USE CASE

FAN BEARING IN ELECTRIC MOTOR

- NOTICEABLE IMPACTING IN THE BEARING

FRICTION DISTRIBUTION IN A BAD BEARING IN AN ECLECTIC MOTOR

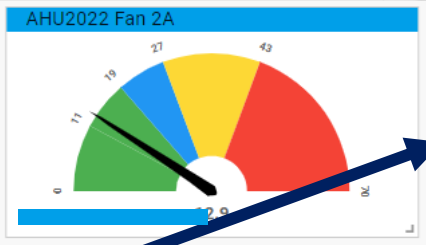


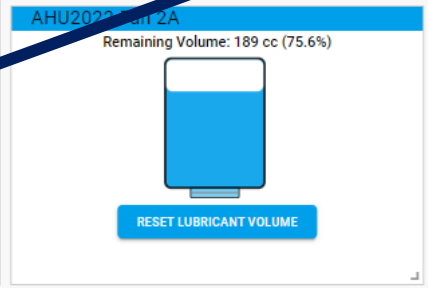
- **NOTICEABLE INCREASE IN FRICTION OVER 4 DAYS**
- **NOTICEABLE INCREASE IN THE PEAK-TO-PEAK VALUES.**
- **NO SINGLE POINT OF FRICTION LEVEL. BEARING IS BOUNCING AROUND**

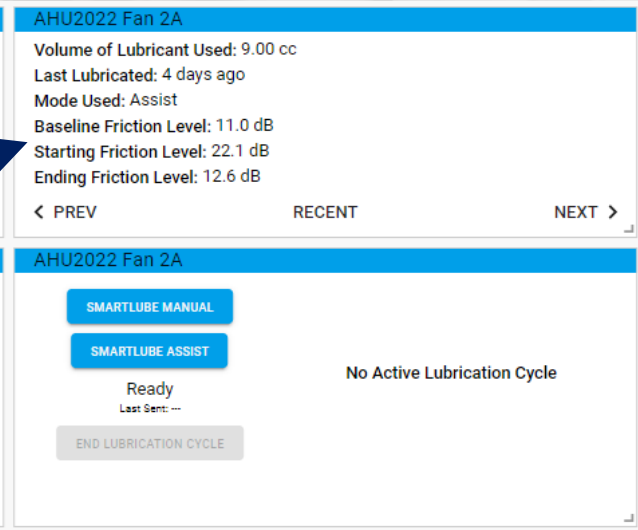
USE CASE
UNDER LUBRICATED BEARING

- DRIVE END OF MOTOR
- ONTRAK SMARTLUBE SYSTEM

USE CASE
UNDER LUBRICATED BEARING



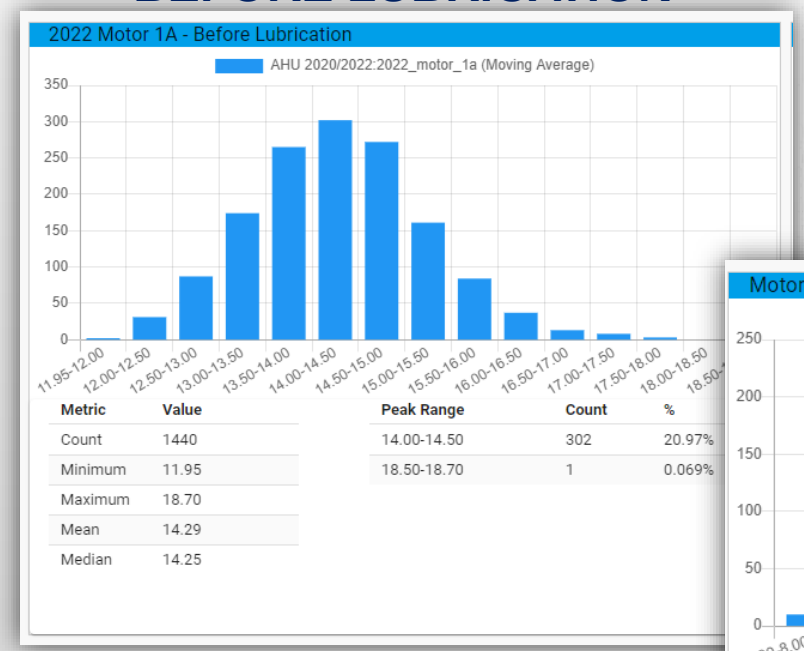




NOTICEABLE DECREASE IN FRICTION AFTER LUBRICATION

FRICTION DISTRIBUTION IN A **UNDER LUBRICATED BEARING**

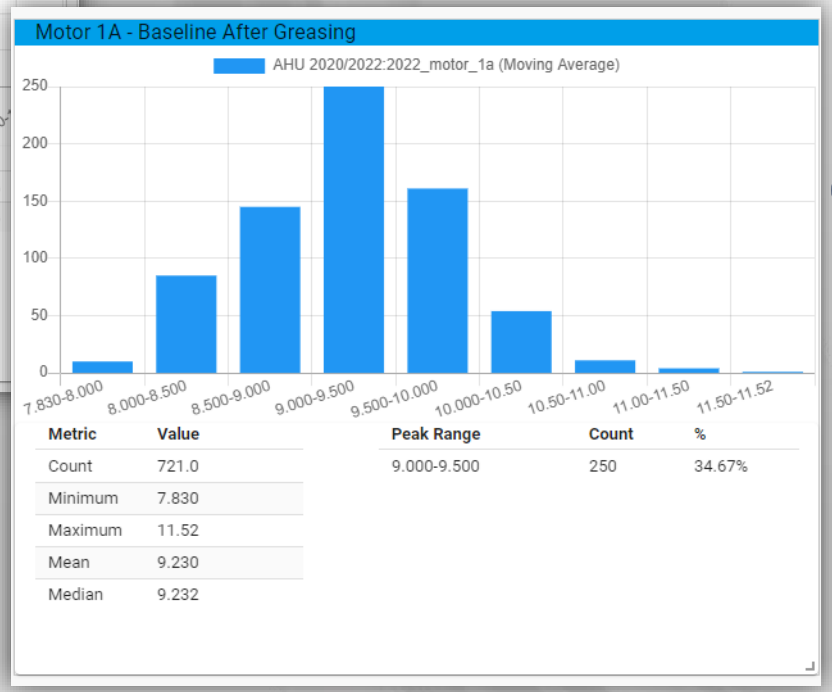
BEFORE LUBRICATION



Metric	Value
Count	1440
Minimum	11.95
Maximum	18.70
Mean	14.29
Median	14.25

Peak Range	Count	%
14.00-14.50	302	20.97%
18.50-18.70	1	0.069%

AFTER LUBRICATION

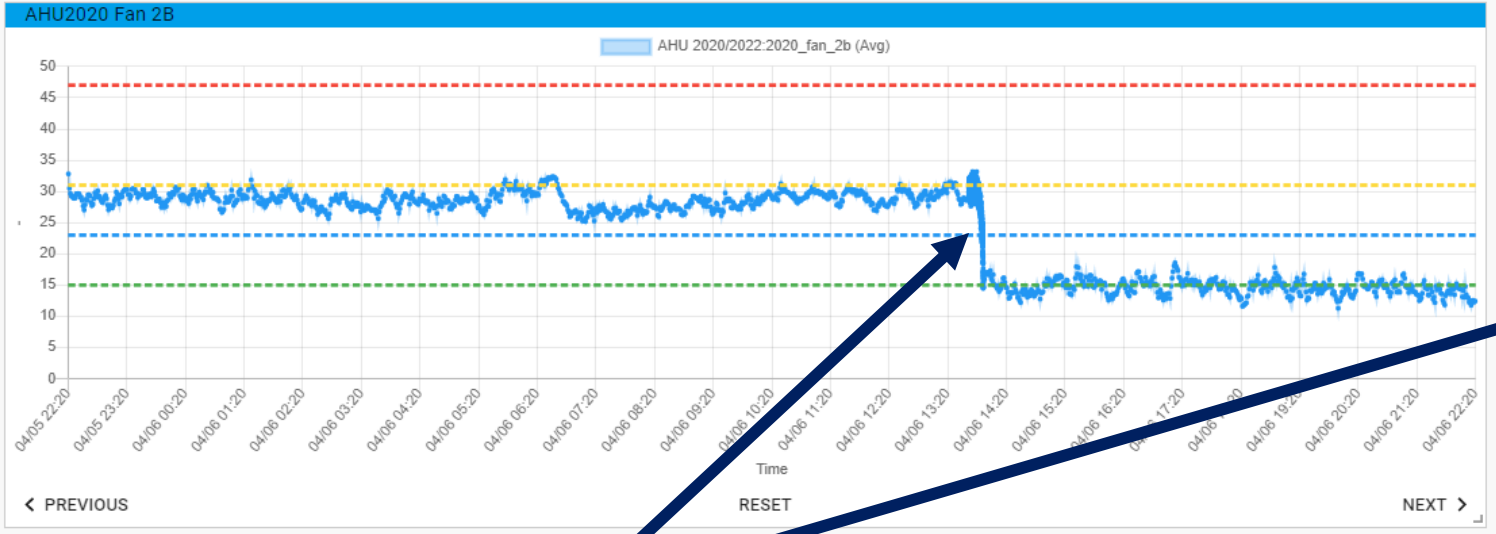


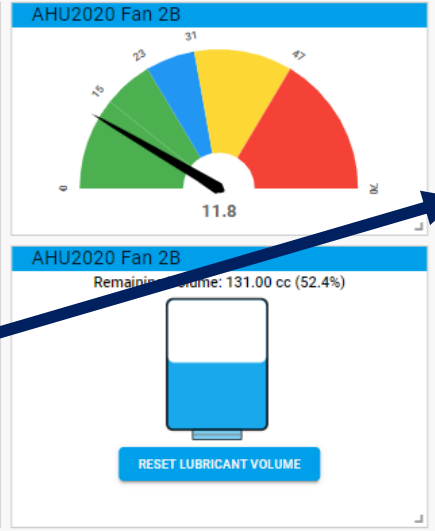
Metric	Value
Count	721.0
Minimum	7.830
Maximum	11.52
Mean	9.230
Median	9.232

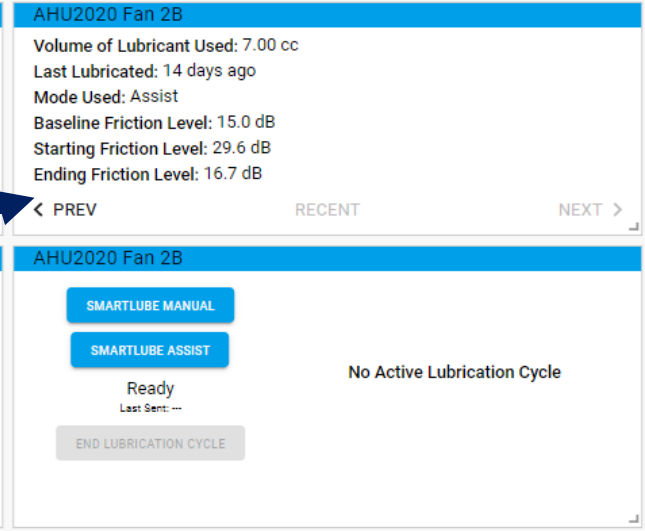
Peak Range	Count	%
9.000-9.500	250	34.67%

- **NOTICEABLE DECREASE IN FRICTION AFTER LUBRICATION**
- **NOTICEABLE DECREASE IN THE PEAK-TO-PEAK VALUES.**
- **NOTICEABLE CENTER POINT ON THE HISTOGRAM**

USE CASE
UNDER LUBRICATED BEARING

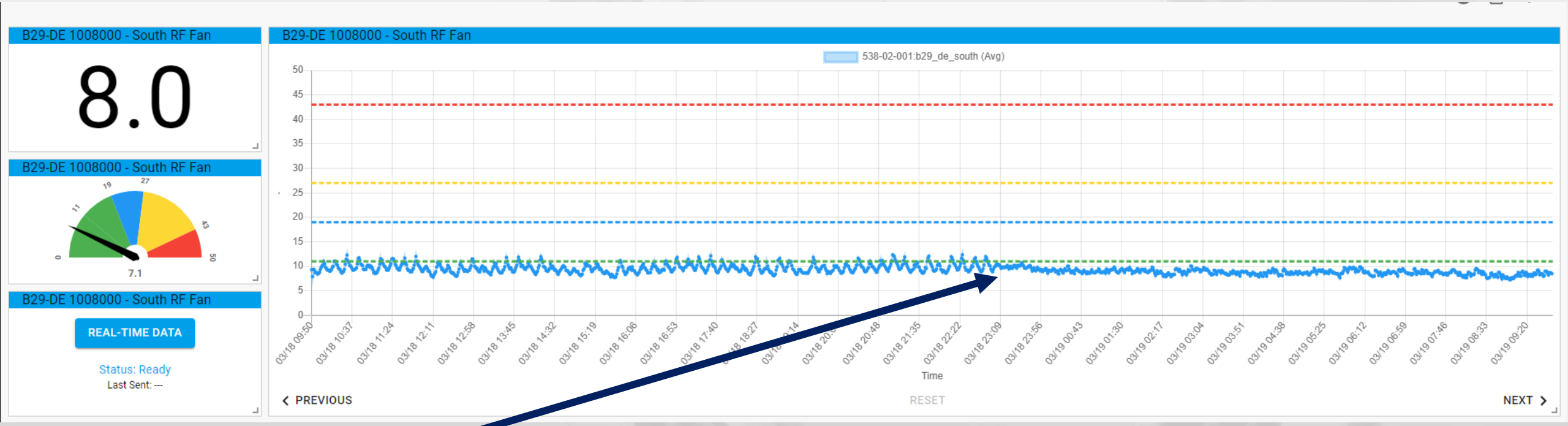






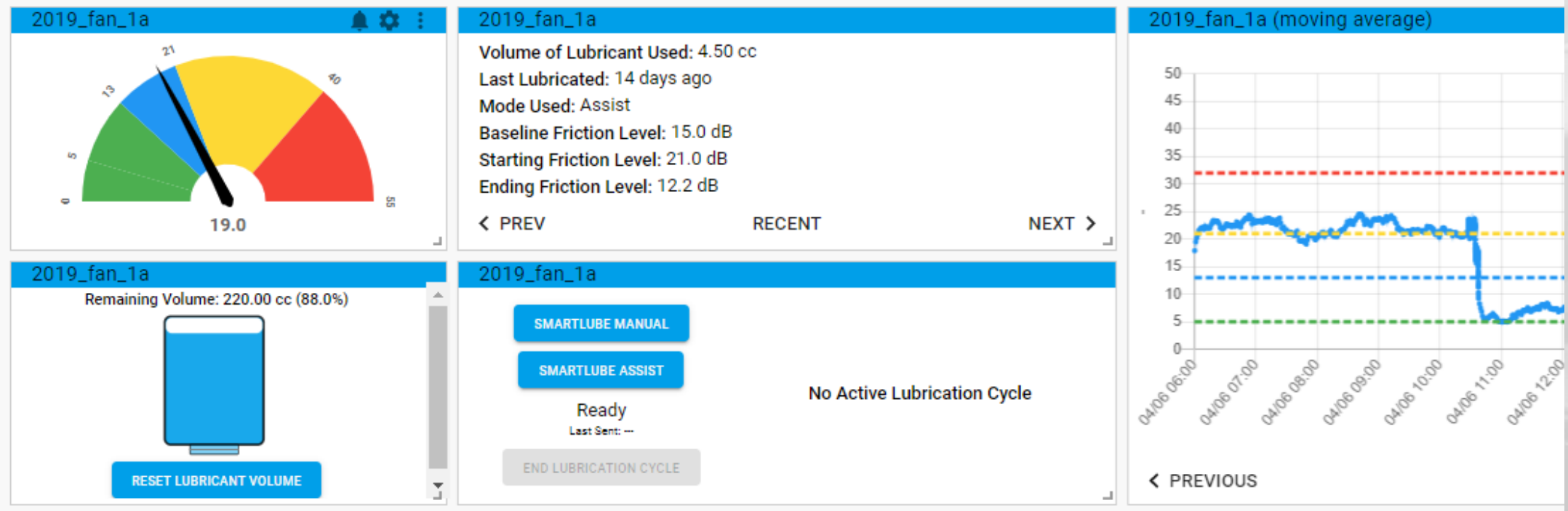
NOTICEABLE DECREASE IN FRICTION AFTER LUBRICATION

USE CASE
UNDER LUBRICATED BEARING



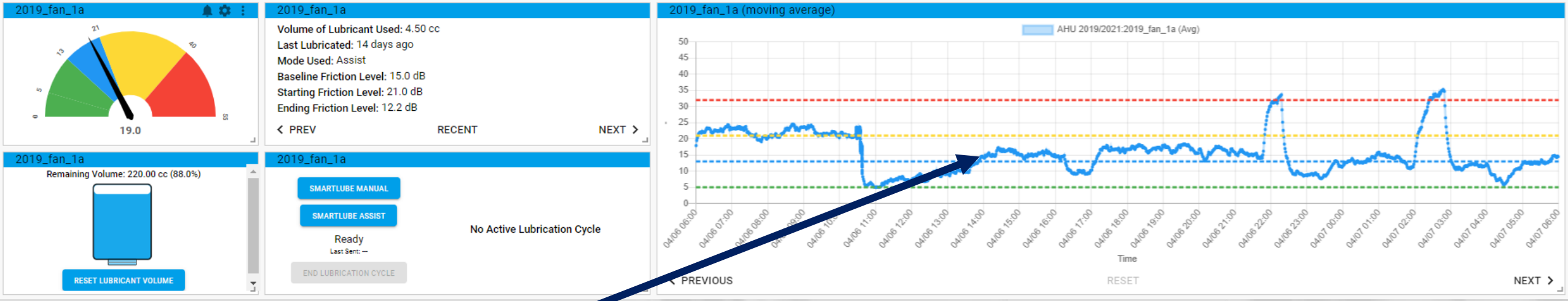
- **NOTICEABLE DECREASE IN IMPACTING AFTER LUBRICATION**
- **MICRO EXPLOSIONS ARE GENERALLY THE FIRST SIGN OF LACK OF LUBRICATION**

USE CASE
UNDER LUBRICATED WITH A BAD BEARING



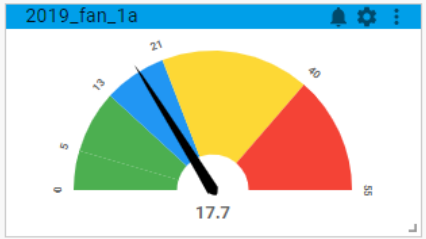
- LUBRICATION CAN **TEMPORARILY** LOWER FRICTION.

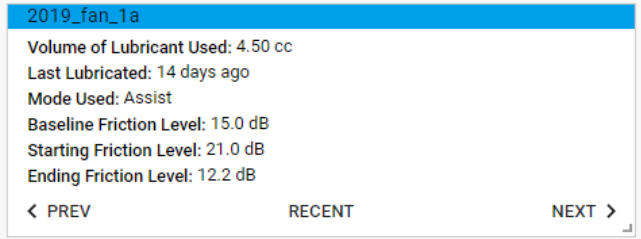
USE CASE
UNDER LUBRICATED WITH A BAD BEARING

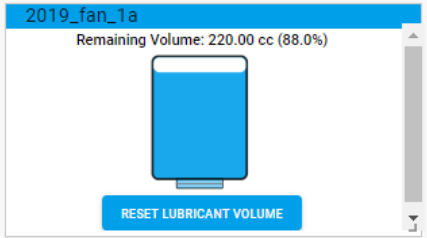


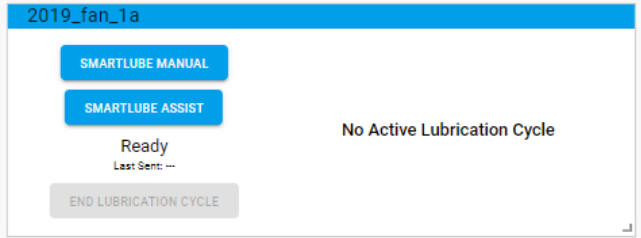
WITHIN A FEW HOURS OF LUBRICATION, THE FRICTION WAS BACK UP!

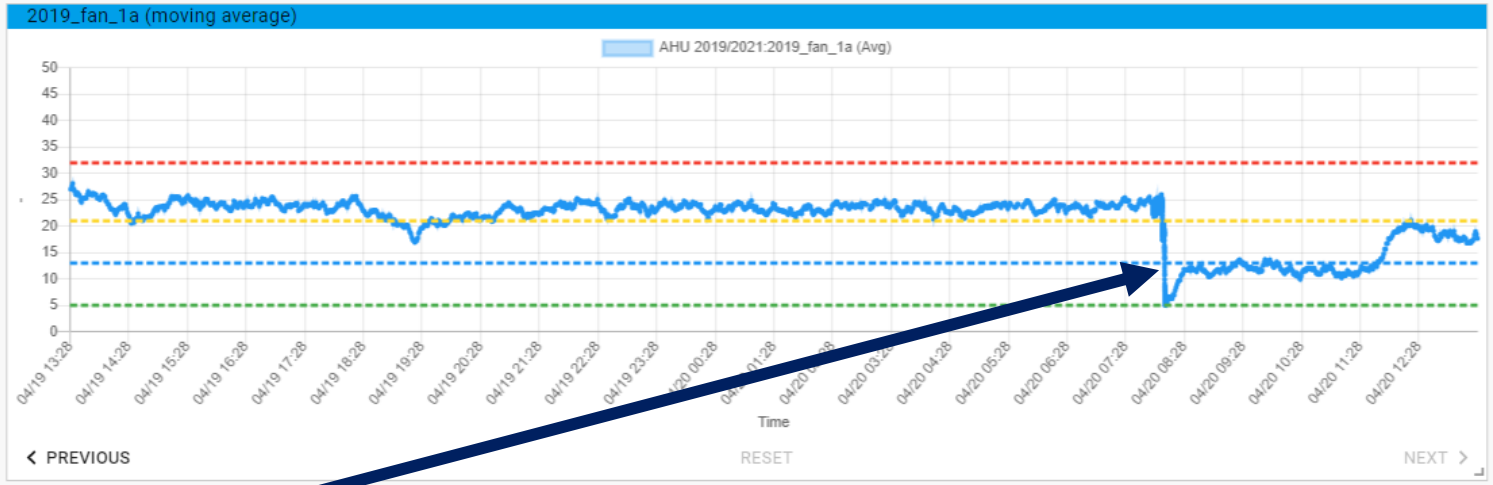
USE CASE
UNDER LUBRICATED WITH A BAD BEARING





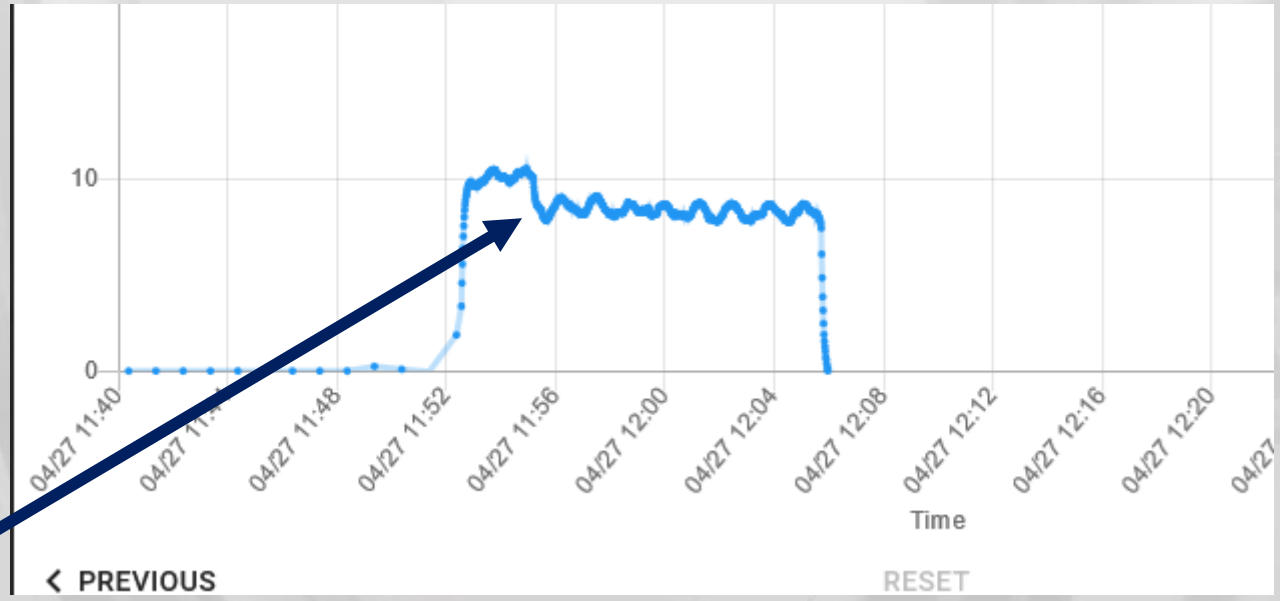






EVEN AFTER MULTIPLE LUBRICATION CYCLES DAYS APART

USE CASE
1.8 RPM BEARING

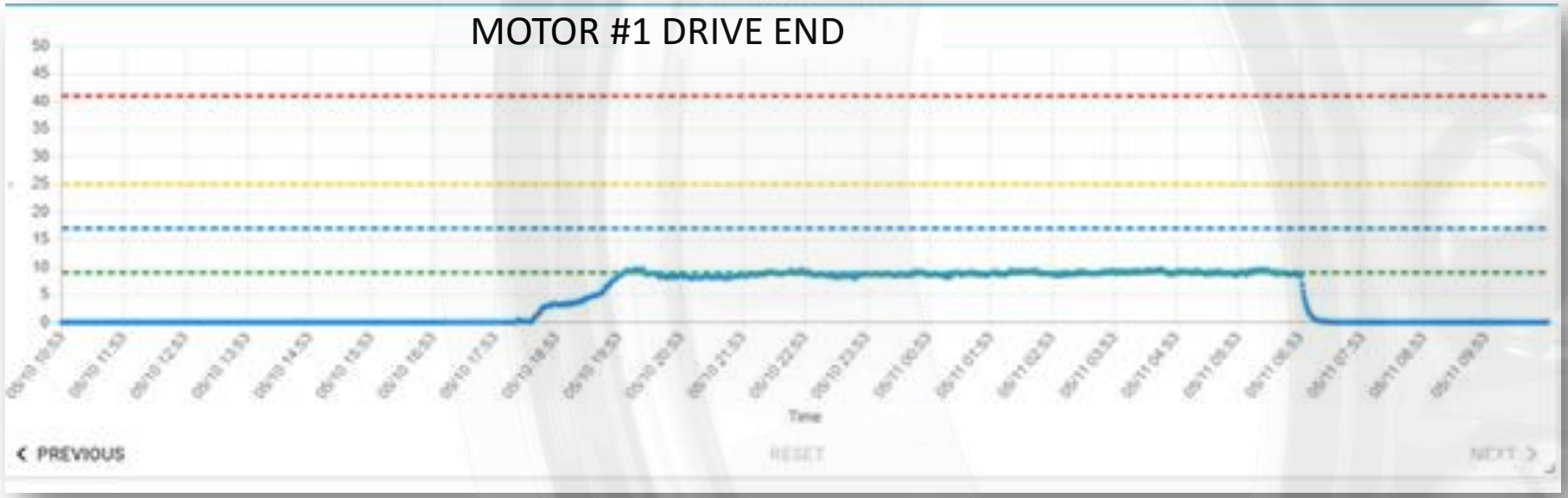


0.33 CC OF GREASE ADDED

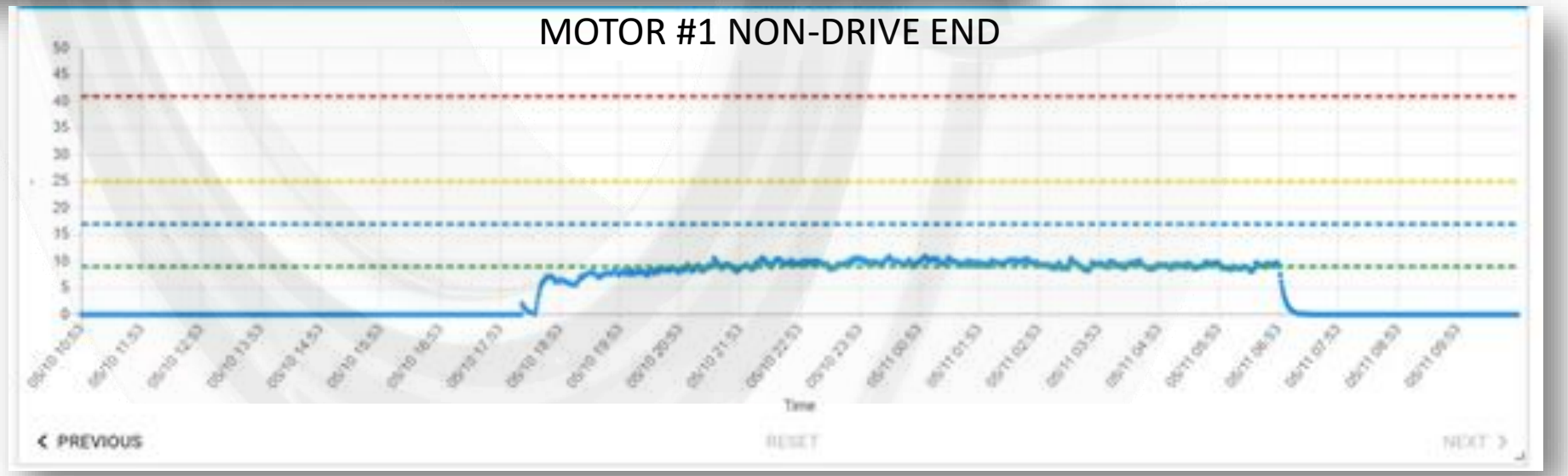
IDENTICAL MOTORS WITH

DIFFERENT FRICTION TRENDS

MOTOR #1 DRIVE END



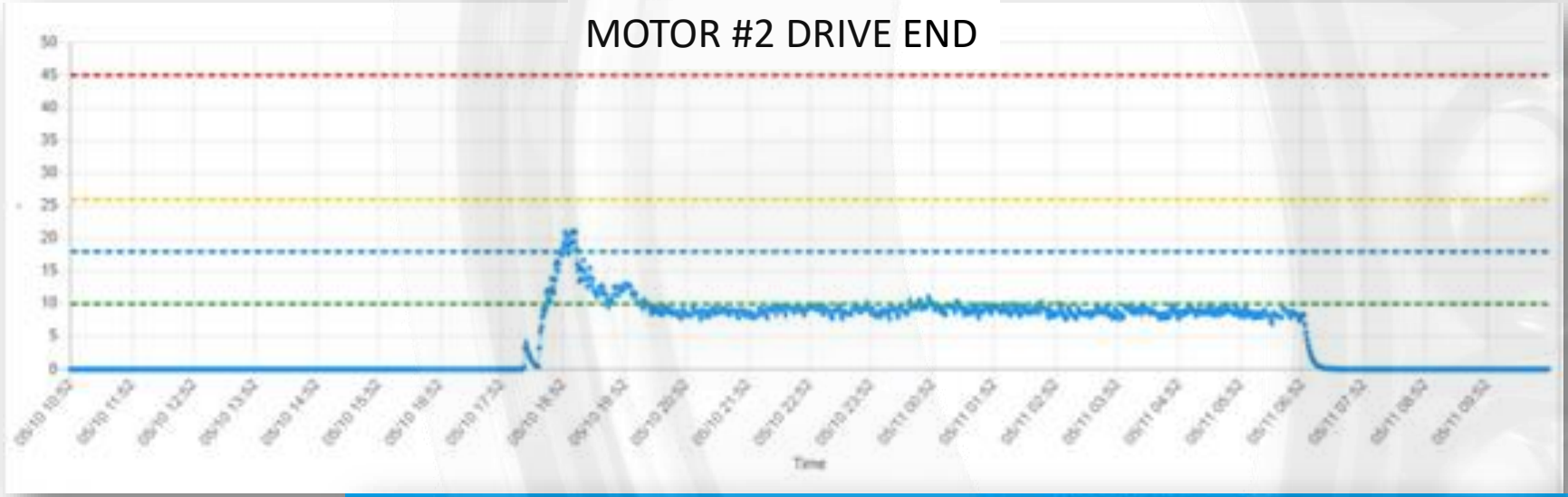
MOTOR #1 NON-DRIVE END



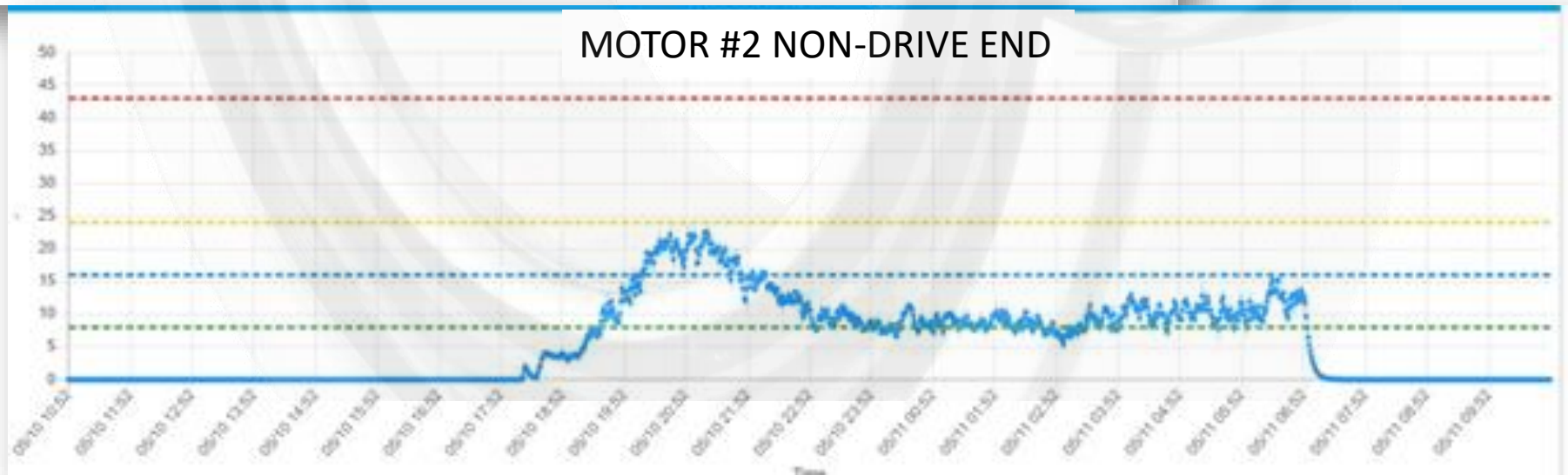
IDENTICAL MOTORS WITH

DIFFERENT FRICTION TRENDS

MOTOR #2 DRIVE END



MOTOR #2 NON-DRIVE END



CAUSE: THERMAL EXPANSION FROM IMBALANCE

Work Order #:	
Assessment Comment:	An imbalance condition continues to exist on the fan.
Analysis Comment:	The imbalance condition on the fan continues to be an issue. The overall amplitude in the Spectrum has increased going from 0.148 ips (inches per second) on May 2 to 0.259 ips inches per second) on May 6. This has been reported prior and is probably the cause of looseness observed in the envelope spectrum.
Repair Recommendation:	I recommend checking the runout of the motor shaft and fan hub where they mate. Inspect the blades for damages from impacts with the shroud. Inspect the shroud for impacts and clean any buildup that might be present. If the runout is less than 0.002", perform a precision balance, if greater, consider replacing the motor shaft. Consider looking at the bore of the fan hub and ensure it is centered.

MEASURING BEARING *FRICTION* IN REAL-TIME

WHAT 8.5 BILLION FRICTION DATA POINTS HAS TAUGHT US.

ChrisH@UESystems.com