# SUCCESS STORIES

HEAR SDT MORE Ultrasound Solutions

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# Paper Mill

## Implementation of an ultrasound-based preventive maintenance program on rotating machinery

**Author:** Patrice Dannepond

### Introduction

Today, we would like to share an experience feedback from a paper mill that has implemented a preventive maintenance program to monitor rotating machines using ultrasound technology. SDT International helped implement this monitoring program by training and coaching the teams in charge of mechanical maintenance reliability. The purpose of this program is to monitor a fleet of about 70 rotating machines during the year after its implementation and to extend it to 100 machines over the second year.

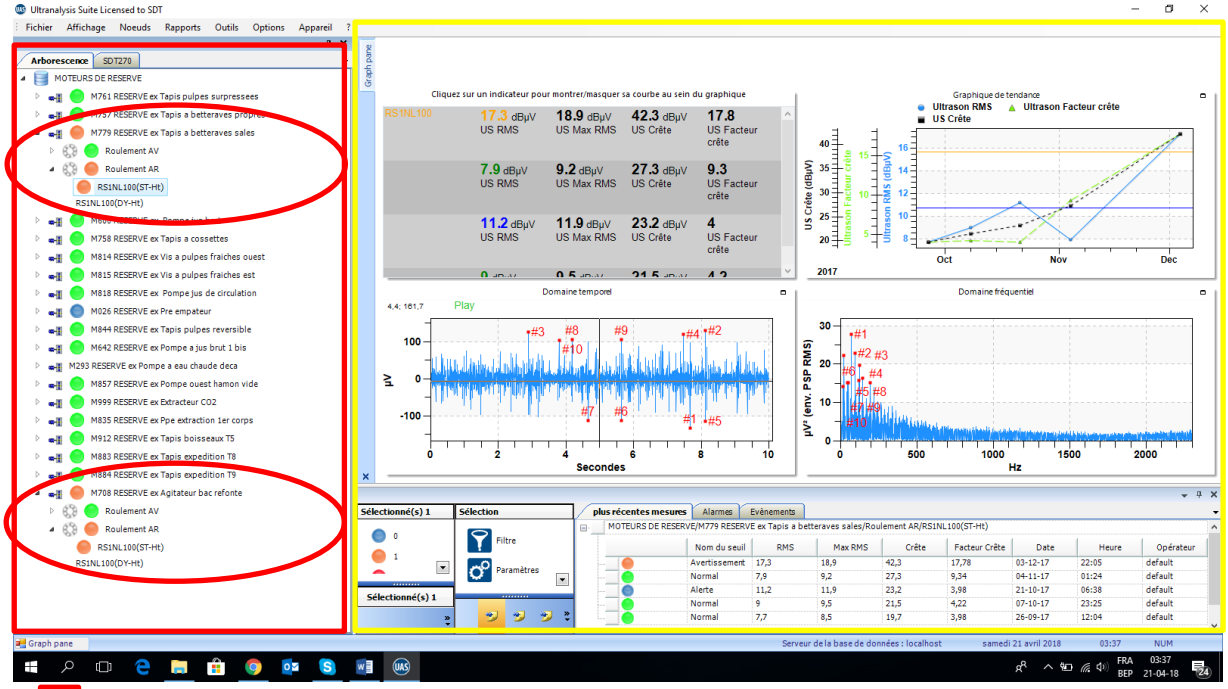
### Issue

This paper mill has relied on preventive maintenance for many years, using known and proven technologies for the monitoring of rotating machines. In 2018, they decided to extend this monitoring to equipment with rotation speeds up to 30 RPM, as well as to their speed-reducing gears.

They purchased an SDT270 type ultrasound detector, in DU version, along with its Ultranalysis® (UAS) software, and SDT International and the Reliability department of the paper mill developed a training program suited to the rotating machinery monitoring program. The first step consisted in creating the database including these 70 machines, and then in recording an initial measurement of the mechanical status of each bearing and each gear. After a simple onsite analysis (ultrasonic listening) and a more detailed analysis (overall or static measurements and spectral or dynamic measurements) using UAS, pre-alarm, alarm and danger thresholds were assigned to each measurement point.

This background work, which is required, allows technicians of the reliability department in charge of the measurements routes to get a quick overview of the asset hierarchy and immediately see the machines that have an alarm status.

## Display of the database in the UAS software




Display of the asset hierarchy including all rotating machines under monitoring and alarm statuses for each piece of equipment. In the present case, 19 rotating machines are monitored, 2 of which have exceeded the warning threshold for the bearings of the rear motor.

Display of the software graphic tools (matrix, trend curves, time signal, FFT spectrum, measurement time history).

## Issue

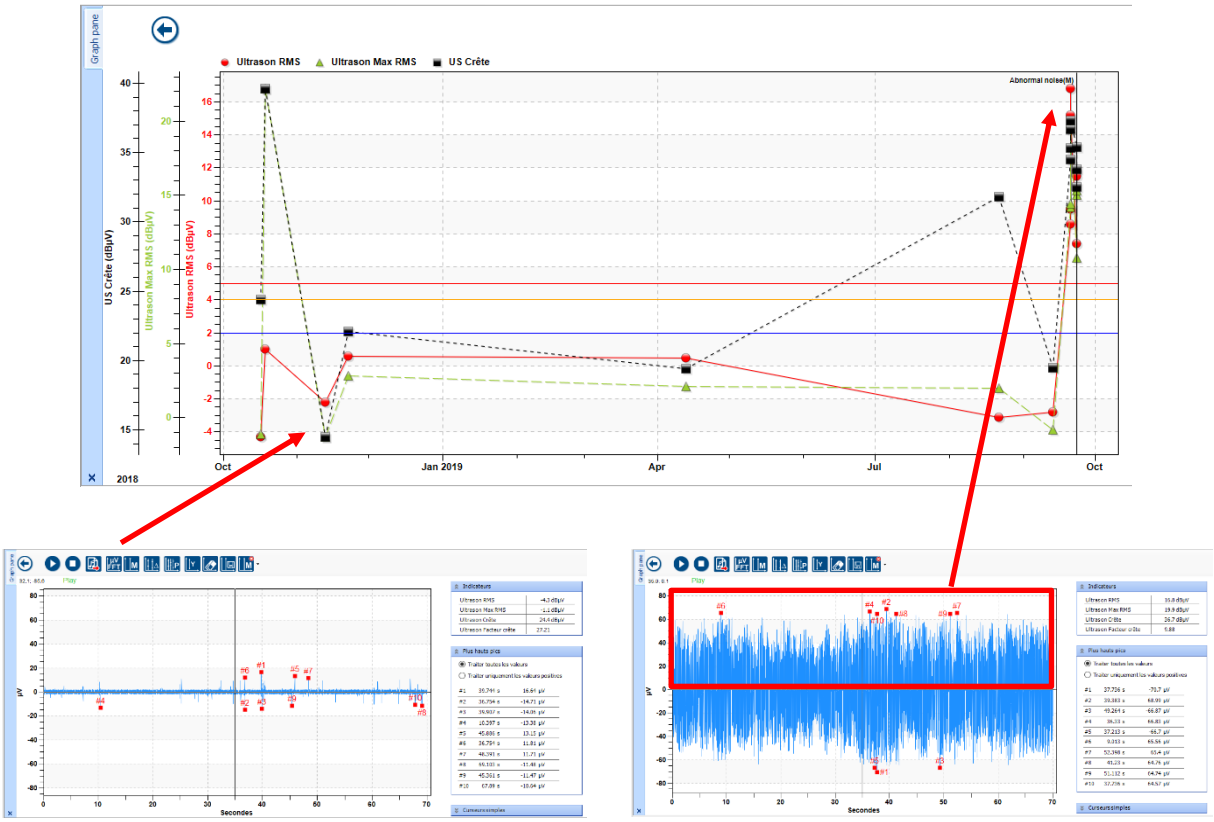
This preventive maintenance program has 3 objectives:

- Highlight the efficiency of ultrasound measurements on rotating machines.
- Issue a relevant diagnosis.
- Offer preventive maintenance with reliable indicators and alarms.

## Experience feedback after onsite measurement sessions from October 2018 to November 2019

Monitoring of a parallel reduction gear

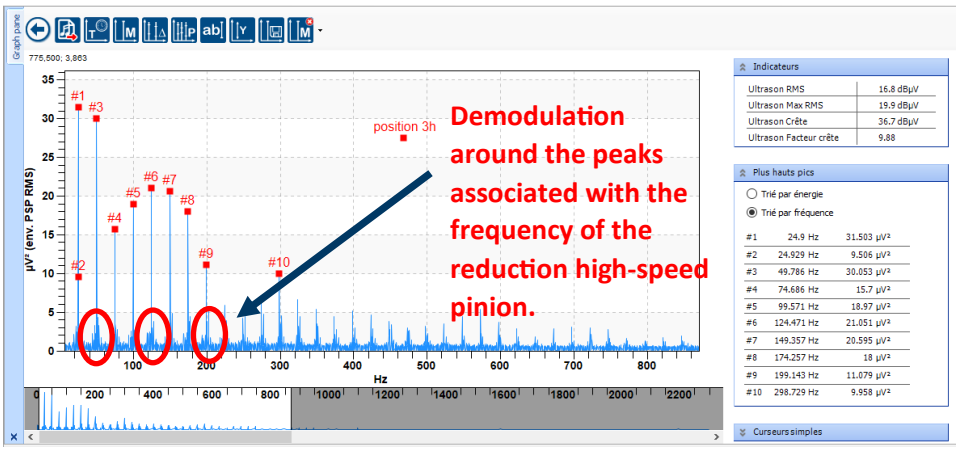
- Machine: **Decanter – High-speed input bearing of the reduction gear**




**Measurement carried out on October 16, 2018** **Measurement carried out on September 20, 2019**

On the time spectra (same scale), we can observe the occurrence of shocks compared to the first measurement carried out in 2018. The trend curves show the evolution of the RMS static value: from **-4.3 dBµV in 2018** to **+16.8 dBµV in 2019**.

Based on SDT criteria, this increase corresponds to the early failure of a mechanical part of the reduction gear (bearings and/or gears).



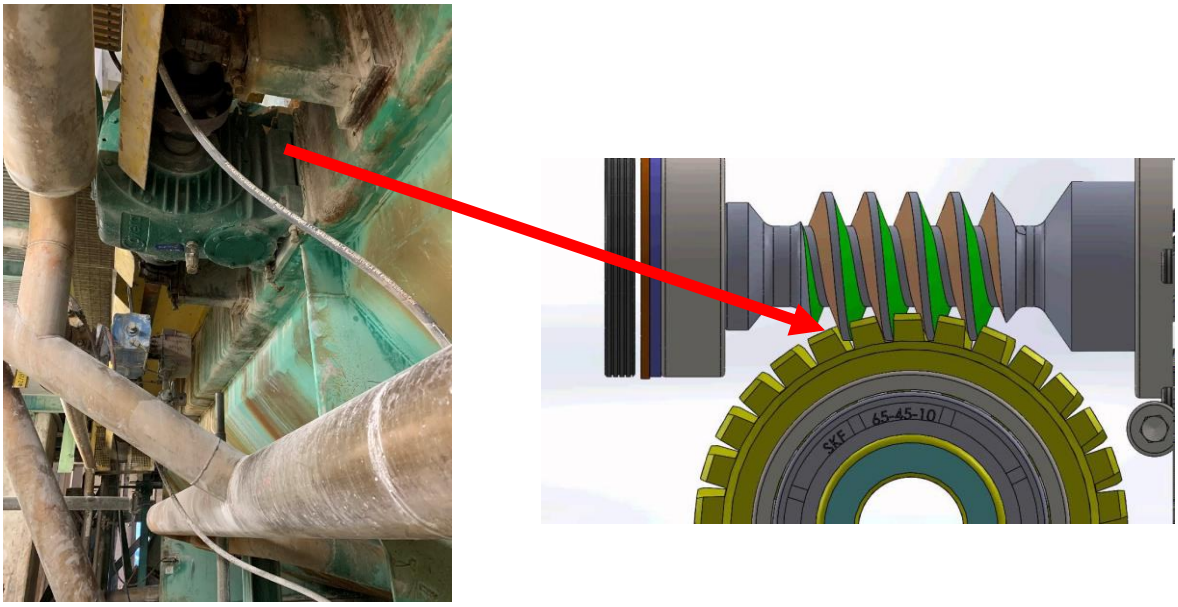

Listening to the bearing and analyzing the frequency spectra (see chart below) has allowed to confirm this diagnosis by observing the emergence of significant peaks associated with this gear damage.

We can observe repeated shocks associated with the frequency of the high-speed input drive pinion of the reduction gear (24.93 Hz and its harmonics) with demodulation at each peak. Broken tooth and teeth clearance. Replacement of the reduction gear during a scheduled production shutdown, which

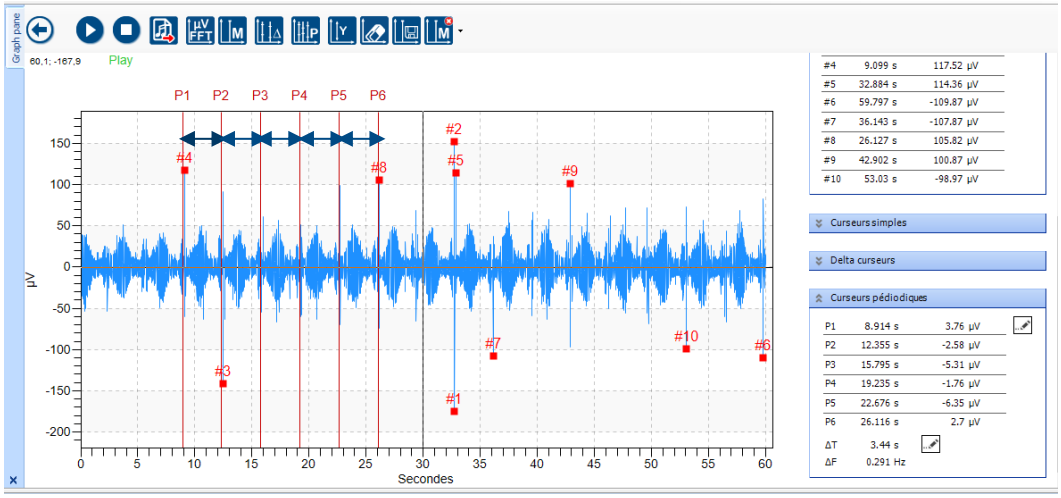
avoided an untimely breakdown which could have generated significant expenses due to production losses.

Wear detected on the tooth of the worm screw of a reduction gear, wheel, and screw:

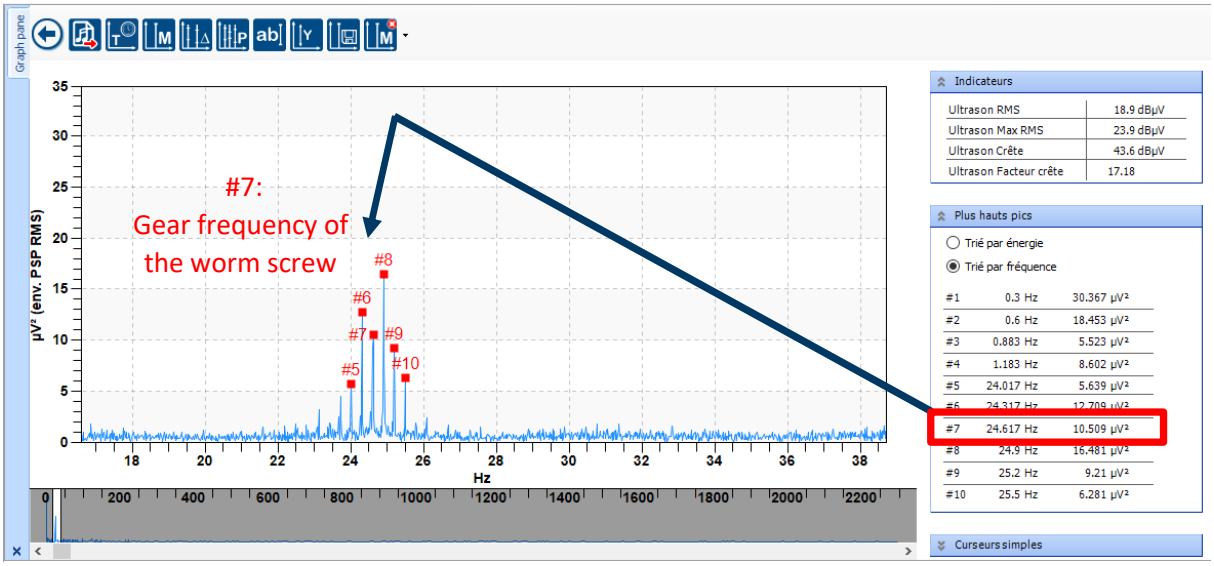
- Machine: **Lime mud filter agitator – High-speed input bearing of the reduction gear**



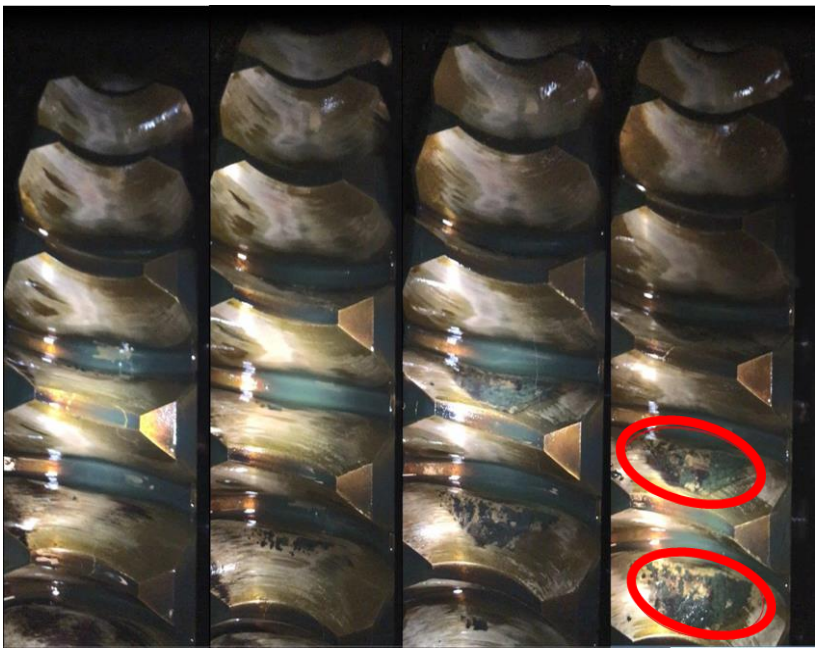

We can observe that between each revolution of the worm screw, there is a phenomenon occurring, which can be heard through the ultrasound detector as a sliding of the gear (worm screw/bronze wheel).




**Measurement carried out on December 11, 2016**

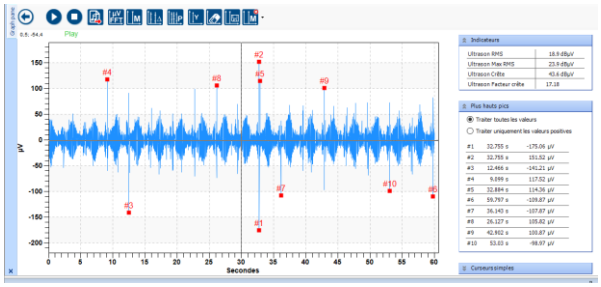



Zooming in on the envelope spectrum highlights the dissymmetry of the modulation around the meshing frequency, which is characteristic of a damaged gear mesh.

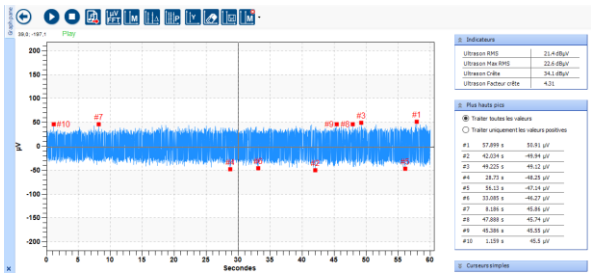


The endoscopic video inspection of the worm screw of the reduction gear confirmed the ultrasound diagnosis.

The customer took the reduction gear down during a production shutdown.



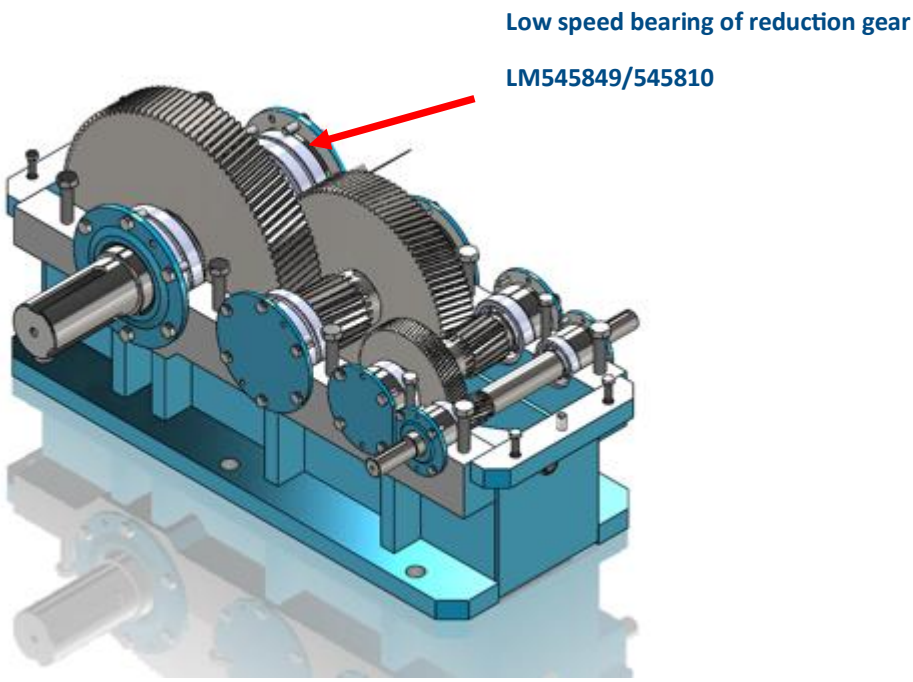
**Measurement carried out on July 10, 2018**



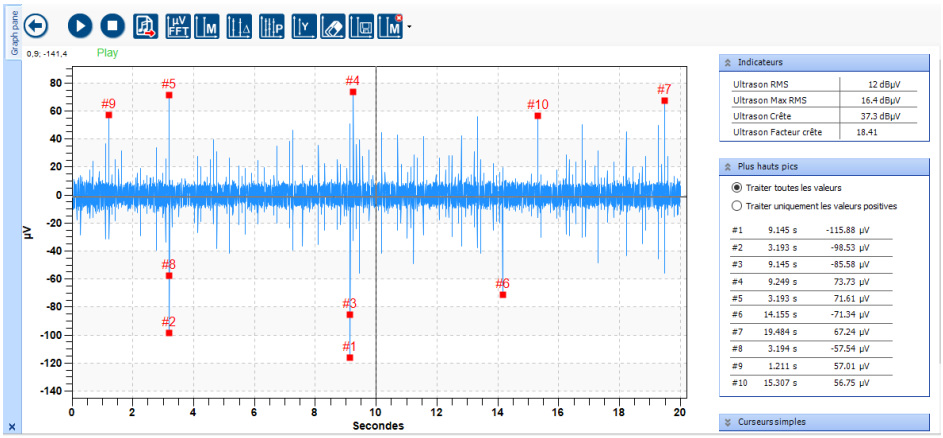
**Measurement carried out on October 29, 2019**
**After replacement of the reduction gear**

Monitoring of the degradation of the bearing of a low-speed reduction gear (opposite transmission):

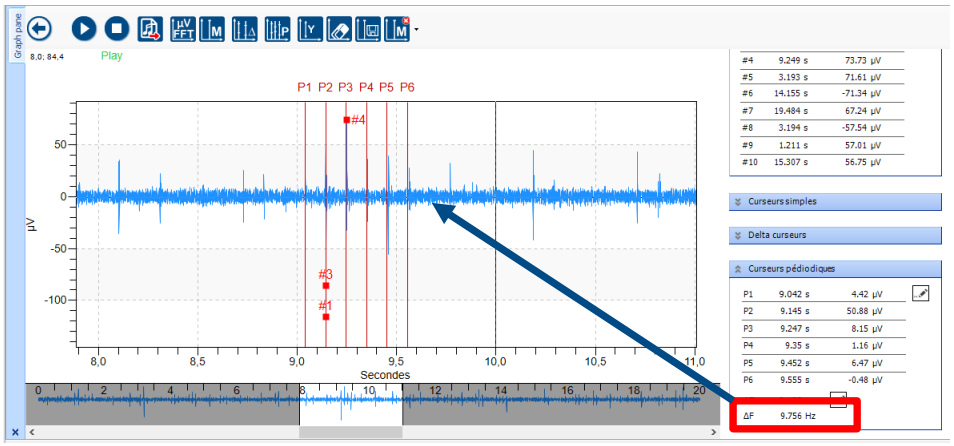
- Machine: **Vertex separator reduction gear – 4-train parallel reduction gear**



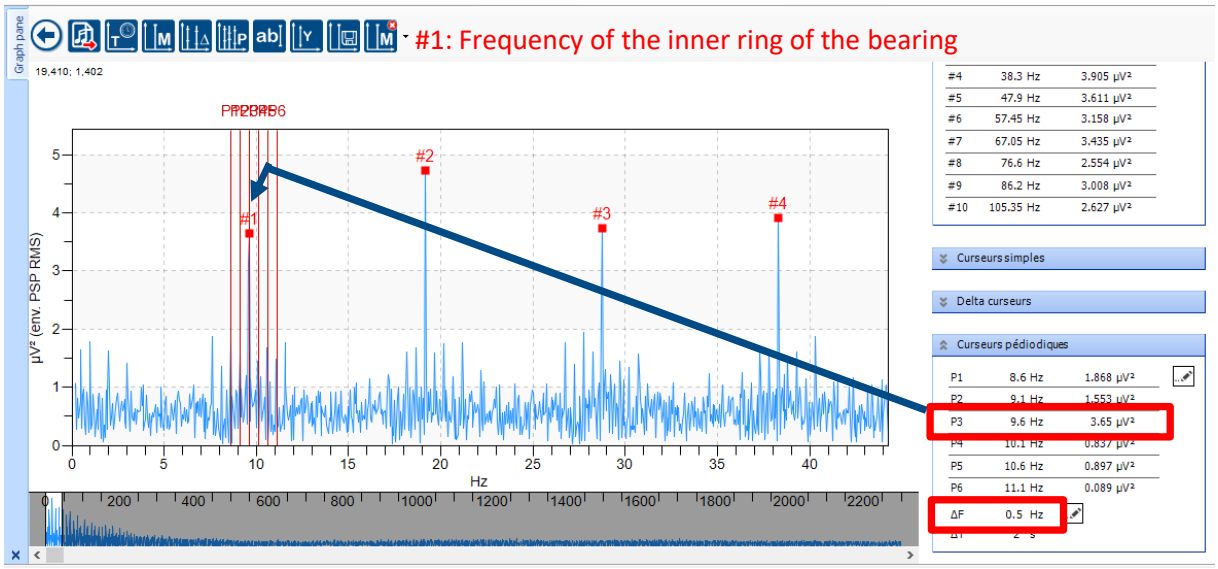

From the beginning of the monitoring of this reduction gear (August 2018) using ultrasound technology, the occurrence of shocks can be observed on the time waveform (TWF).




Below we focused on 3 seconds of the measurement, and we apply a periodic cursor to identify peak recurrences.



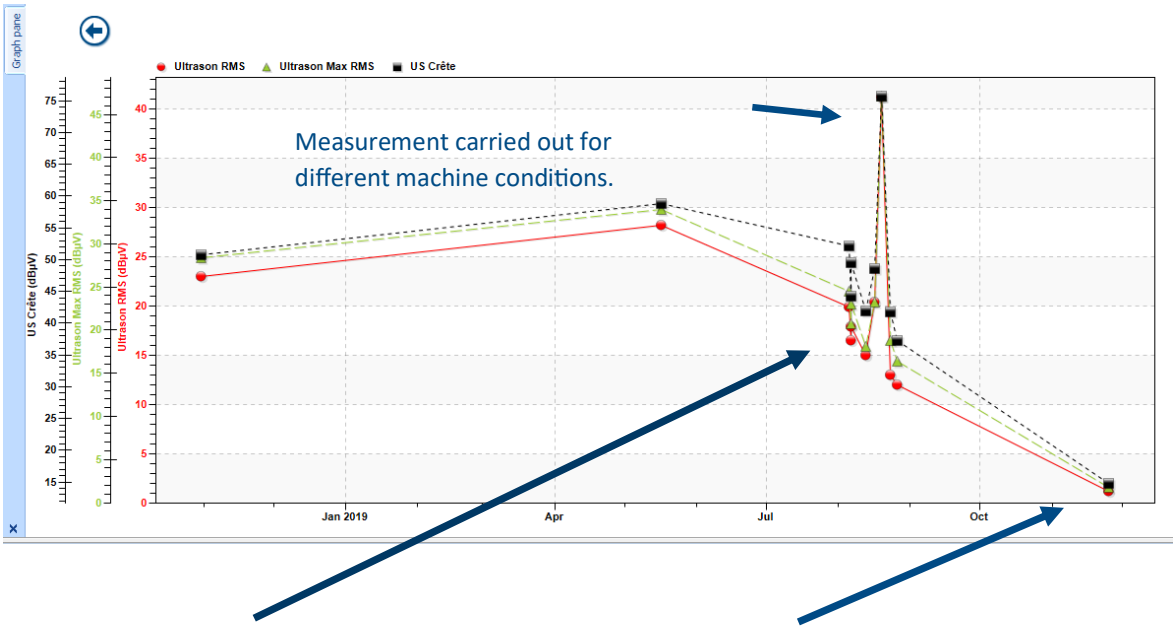
By looking at the envelope spectrum, one can observe repeated shocks at **9.756 Hz** (see the table of characteristic frequencies below) related to the frequency of the inner ring of the bearing of the low-speed reduction gear (opposite side of transmission).



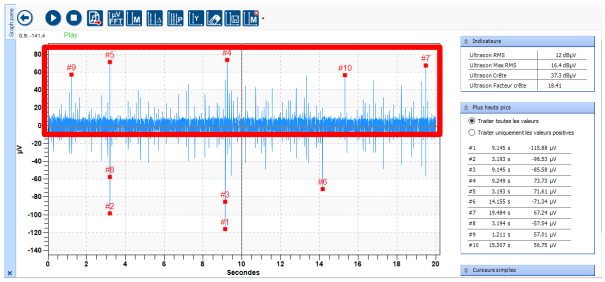

The amplitude of the scaling-type defect is modulated at the fundamental frequency of the rotation speed.

On the spectrum, this is evidenced by a peak at P3 (#1) corresponding to the bearing defect modulated at ΔF as confirmed on the harmonics: #2, #3, #4.

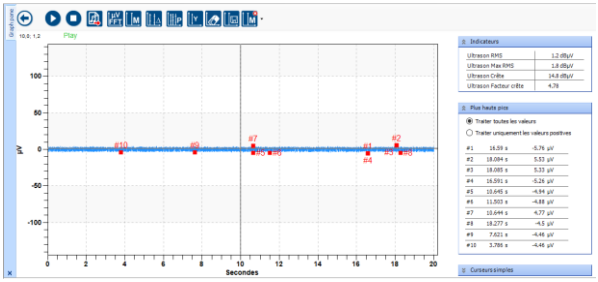
| CHARACTERISTIC FREQUENCIES | | | | | | |
|---|---|---|---|---|---|---|
| **BEARING** | **FBE** | **FBI** | **FER** | **FCAGE** | **F ROTATION** | |
| **LM545849/545810** | **8.31** | **9.59** | **3.39** | **0.23** | **0.50** | **LOW-SPEED RED.** |
| **Spectrum** | **x** | **#1** | **x** | **x** | **ΔF** | |




The trend curves show the decrease of the RMS value in red on the graph above, also confirmed by the other indicators, **from +12 dBµV in 08/2019 to +1.2 dBµV in 11/2019.**



**Measurement carried out on August 26, 2019**

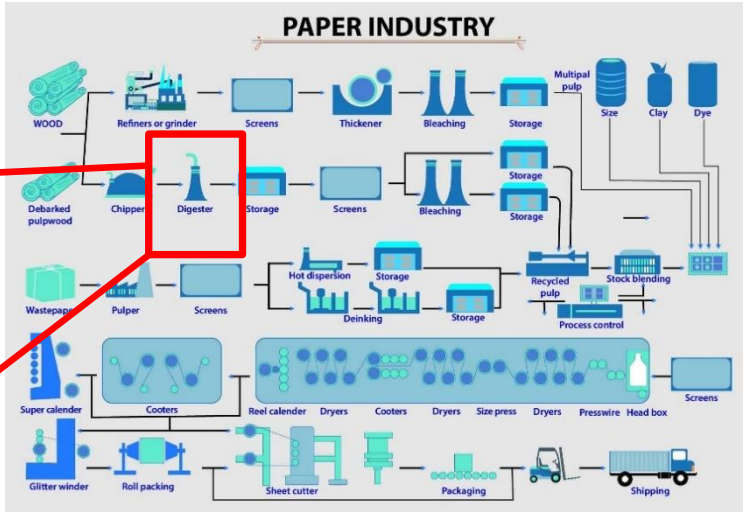


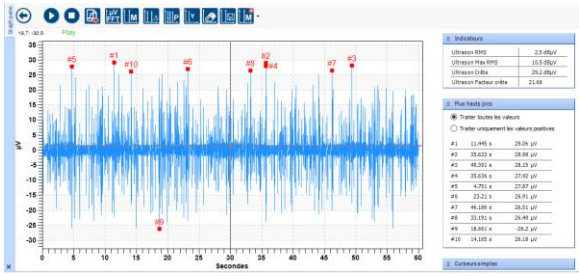
**Measurement carried out on November 25, 2019**
**After replacement of the reduction gear**

Replacement of the reduction gear during a scheduled production shutdown, which avoided an untimely breakdown which could have generated significant expenses due to production losses.

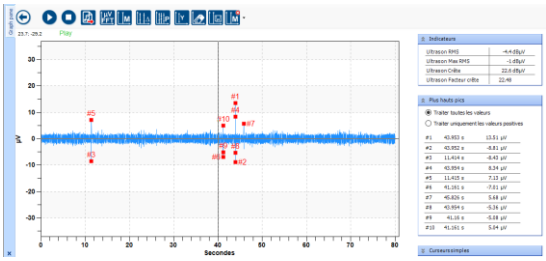
Monitoring of the degradation of the bearing of a low-speed reduction gear (opposite transmission):

- Machine: **Lime mud filter – Bearing opposite transmission 23140 CCK – 14.28 RPM**



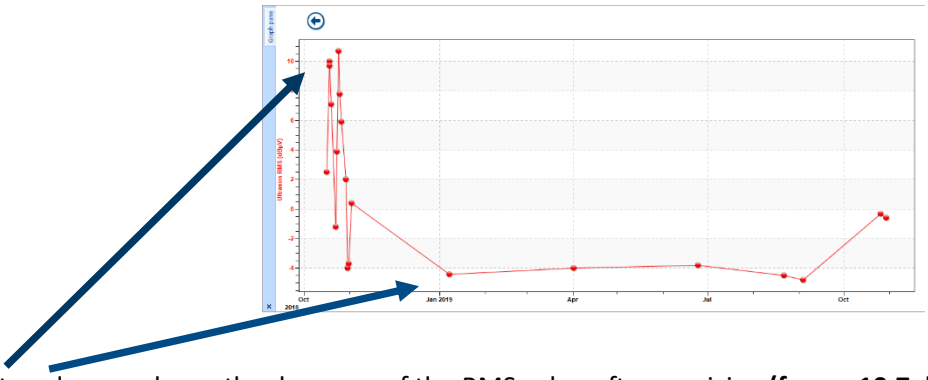



**Measurement carried out on October 16, 2018**



**Measurement carried out on January 07, 2019**

On the trend, one can observe the occurrence of high value in the RMS right from the beginning of the monitoring of this bearing. After replacement of the bearing, all shocks disappeared. The rolling elements were no longer held in their housings.




The trend curve shows the decrease of the RMS value after servicing **(from +10.7 dBµV in October 2018 to -4.4 dBµV in January 2019).**

## Conclusion

The challenge was taken up by the Reliability team of this paper mill. The implementation of a preventive maintenance program for 70 rotating machines has had a beneficial and decisive outcome. It will be extended to 100 other machines over the course of 2020.

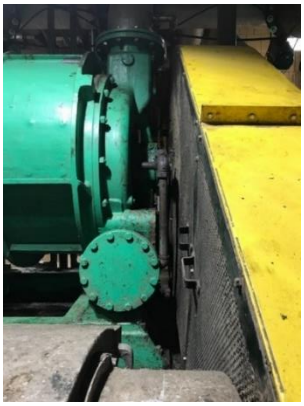
SDT International offered a simple solution and suitable measurement tools, along with a LEVEL 1 ASNT certified training program. Users have acquired a comprehensive mastery of this technology, which was new to them.

1. By using ultrasound technology to monitor low-speed rotating machines, this paper mill was able to avoid a number of unscheduled shutdowns (see examples below) and highlight the complementarity of ultrasound and vibration technologies.
2. Based on this experience, the Reliability department has decided to initiate ultrasound-aided greasing campaigns. Using suitable equipment (software and hardware), this acoustic lubrication program will ensure perfect greasing by indicating:
    - the right grease;
    - the right greasing location;
    - the right greasing interval;
    - the right quantity of grease to add;
    - the right indicators for the lubrication condition.

    Thus, full traceability of the lubrication program will be ensured.
3. The versatility of ultrasound detector SDT270 also allowed for the implementation of:
    - An energy-saving policy (detection of compressed air leaks, control of steam traps);
    - Control of tube blowers (detection of leaks on steam valves);
    - Preventive maintenance of high voltage electric systems (corona, tracking, arcing).

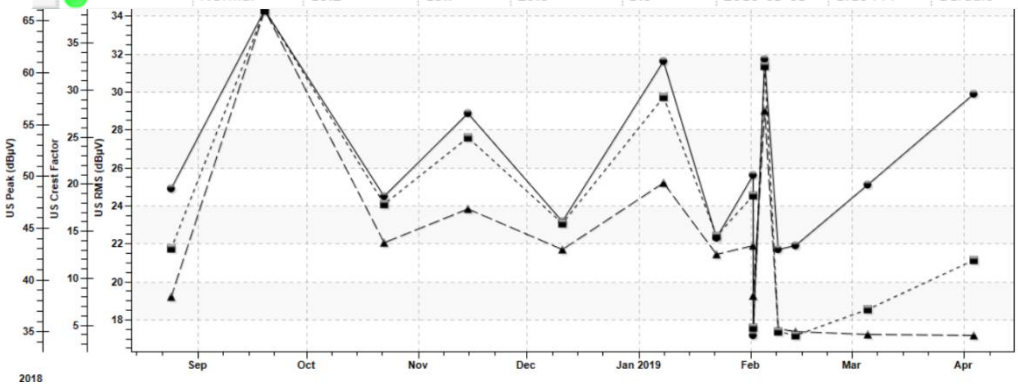
# Vacuum Pump at a Pulp & Paper Facility – Defect on Pump DE Bearing

**Author:** Patrice Dannepond

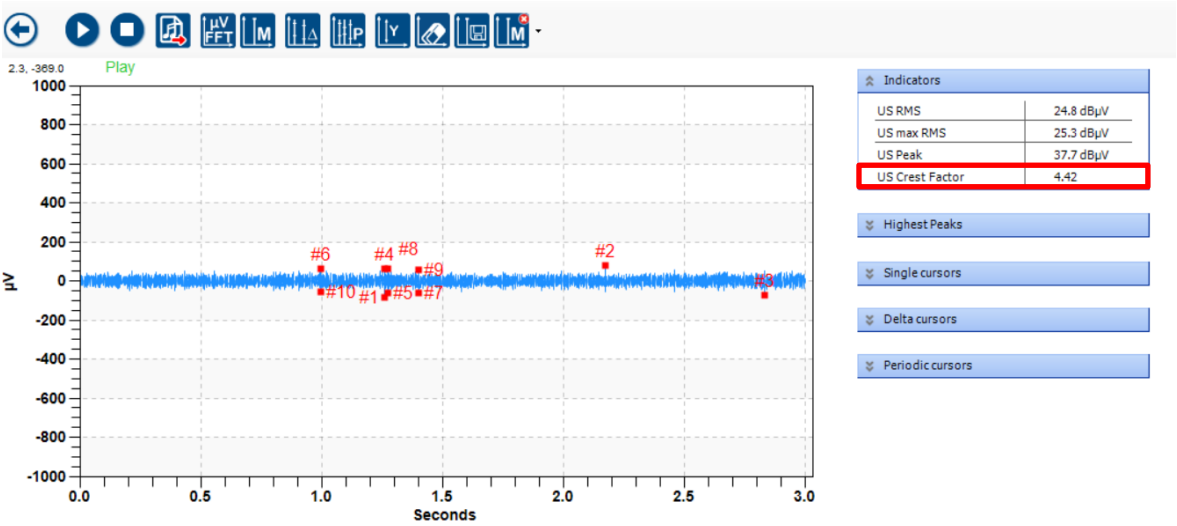



18-hour job to replace DE bearing on scheduled shutdown.
Crest Factor Alarm

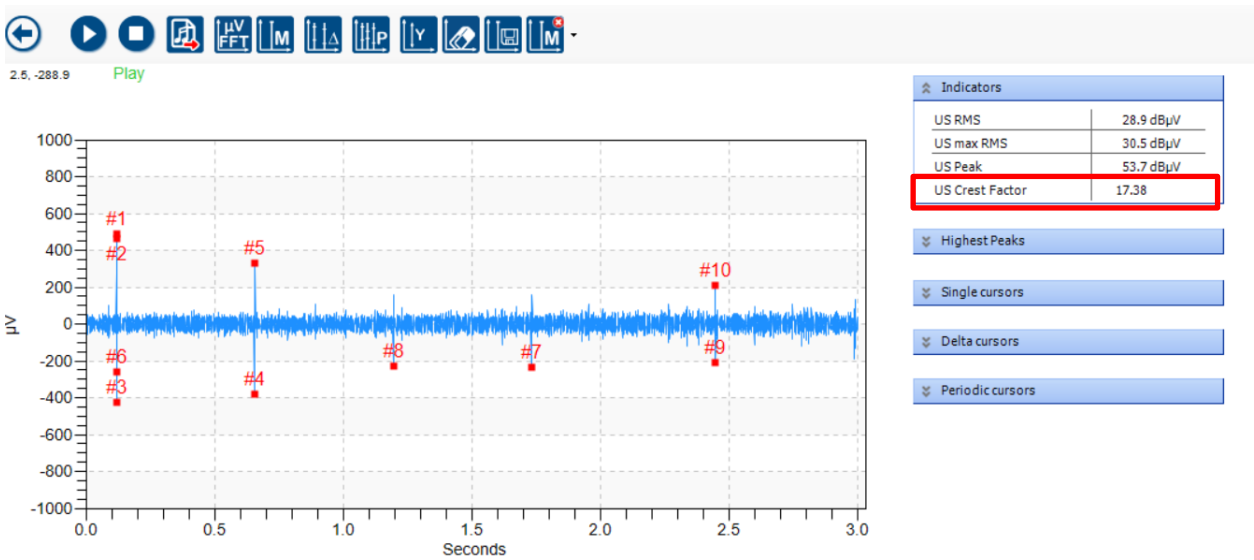
| | Level Name | RMS | Max RMS | Peak | Crest Fac | Date | Time | Operator |
|---|---|---|---|---|---|---|---|---|
| | Normal | 29.9 | 30.7 | 41.9 | 3.98 | 2019-04-03 | 12:58 PM | default |
| | Normal | 25.1 | 25.6 | 37.2 | 4.03 | 2019-03-05 | 9:03 AM | default |
| | Normal | 21.9 | 22.9 | 34.7 | 4.36 | 2019-02-13 | 9:23 AM | default |
| | Normal | 21.7 | 22.4 | 35 | 4.62 | 2019-02-08 | 9:57 AM | default |
| | Danger | 31.7 | 38.9 | 60.6 | 27.86 | 2019-02-04 | 3:30 PM | default |
| | Alert | 17.2 | 18 | 35.4 | 8.13 | 2019-02-01 | 1:52 PM | default |
| | Alert | 25.6 | 27.5 | 48.2 | 13.49 | 2019-02-01 | 9:37 AM | default |
| | Alert | 22.3 | 23.5 | 44.3 | 12.59 | 2019-01-22 | 12:50 PM | default |
| | Warning | 31.6 | 34.9 | 57.7 | 20.18 | 2019-01-07 | 3:30 PM | default |
| | Alert | 23.2 | 27.3 | 45.5 | 13.04 | 2018-12-10 | 3:05 PM | default |
| | Warning | 28.9 | 30.5 | 53.7 | 17.38 | 2018-11-14 | 1:25 PM | default |
| | Alert | 24.5 | 26 | 47.3 | 13.8 | 2018-10-22 | 11:07 AM | default |
| | Danger | 34.3 | 37.9 | 66 | 38.46 | 2018-09-19 | 10:04 AM | default |
| | Alert | 24.9 | 25.2 | 43 | 8.03 | 2018-08-24 | 1:28 PM | default |
| | Normal | 24.8 | 25.3 | 37.7 | 4.42 | 2018-07-23 | 1:19 PM | default |
| | Normal | 26.1 | 26.8 | 38.6 | 4.22 | 2018-06-25 | 11:20 AM | default |
| | Normal | 25 | 25.3 | 42.9 | 7.85 | 2018-05-29 | 1:16 PM | default |
| | Normal | 19.1 | 19.6 | 30.6 | 3.76 | 2018-04-30 | 8:40 AM | default |
| | Normal | 23.1 | 23.5 | 37.5 | 5.25 | 2018-04-02 | 10:55 AM | default |
| | Normal | 18.2 | 18.7 | 29.8 | 3.8 | 2018-03-05 | 1:18 PM | default |



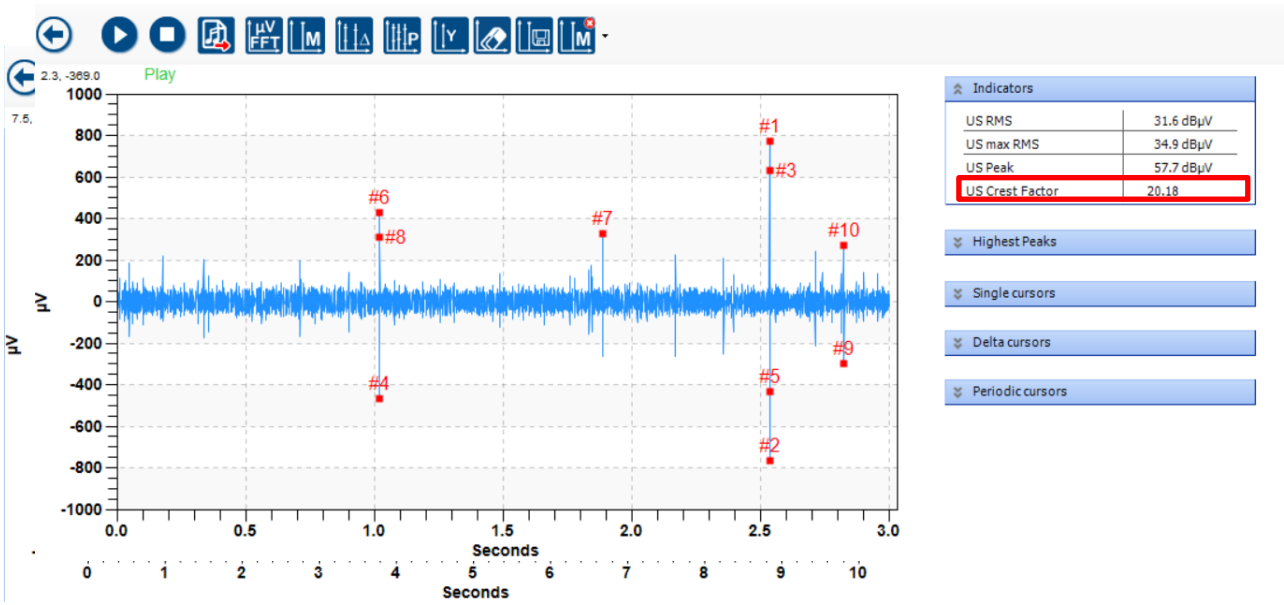
**July 23, 2018**




**November 14, 2018 – Repetitive Impacting**

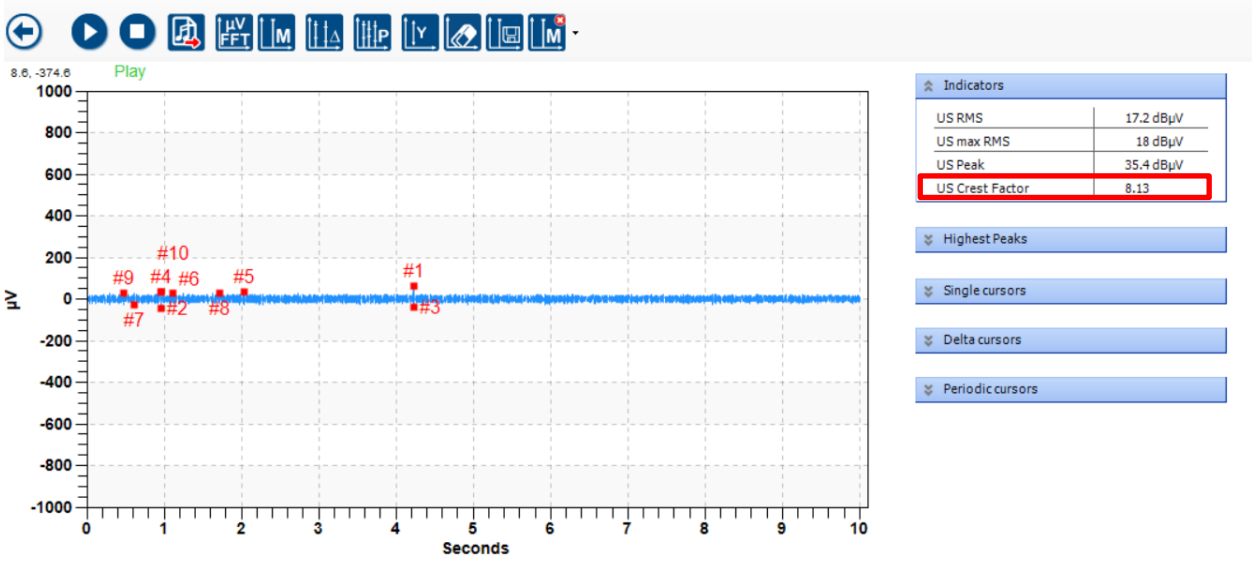



**January 7, 2019**

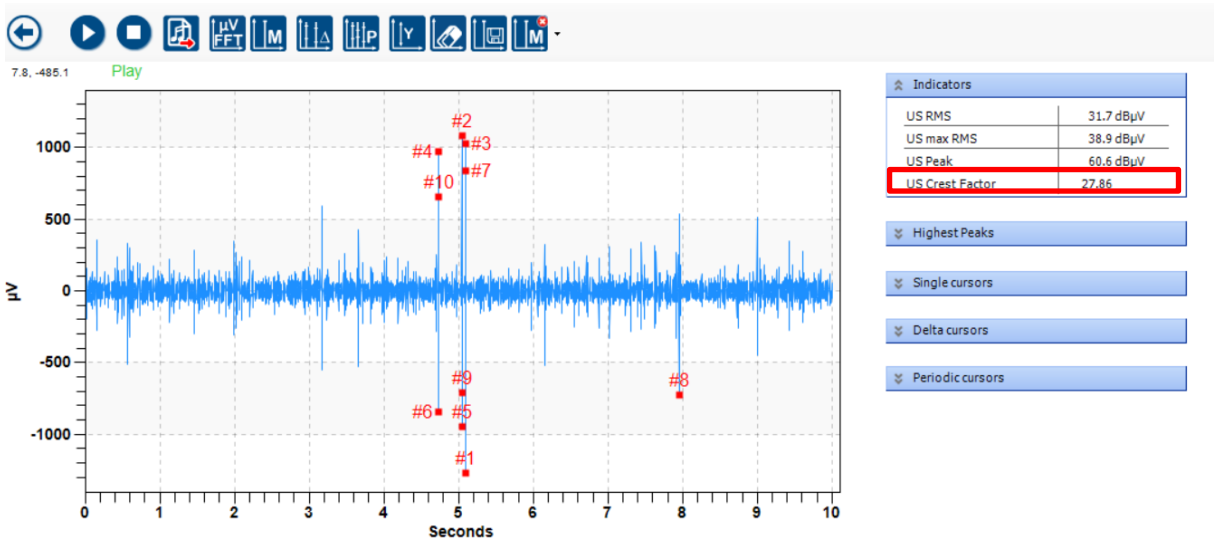



**February 1, 2019**

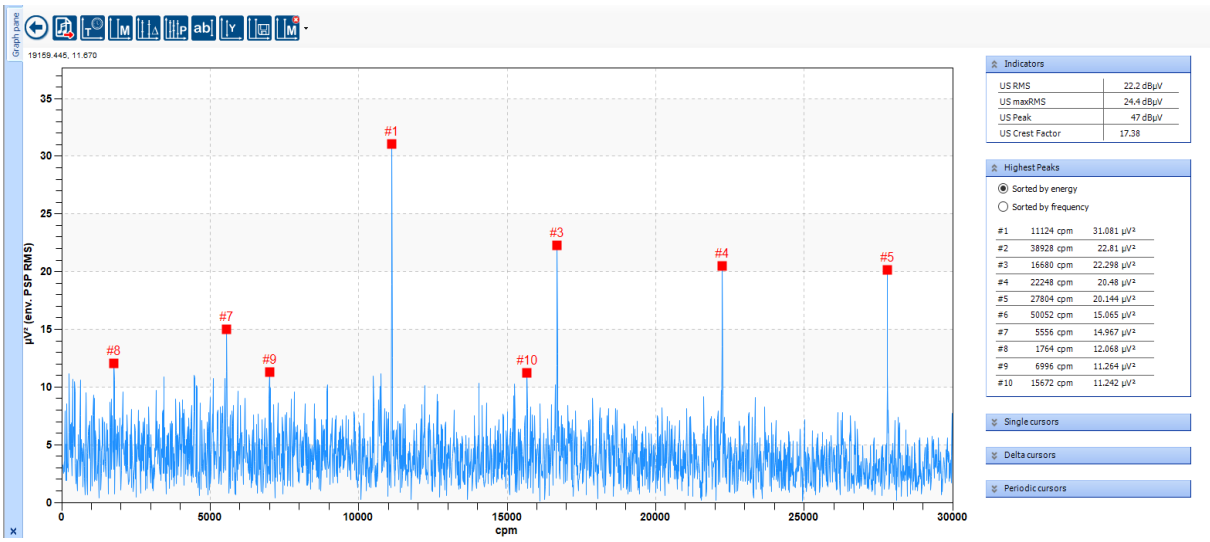
**February 1, 2019 – After Greasing**




**February 4, 2019 – 3 days later**




Recommended bearing replacement as soon as possible due to a signal containing high peaks indicating the lifetime span of the bearing.
Next available extended shutdown – April 15 – April 17. Bearing greased repeatedly until shutdown.



Images of bad bearing – no secondary damage occurred:

**Rolling elements**

**Inner Race**

**Outer Race**

# Low rotation speed machine control using ultrasound

**Author:** Patrice Dannepond

The founding principle of predictive maintenance could be “better safe than sorry”. It requires sound knowledge of the machines, taking into account of early signs and economic realism.

Today, predictive maintenance is based on different technologies that maintenance departments can use to assess failure risks, frequency ratio and severity level.

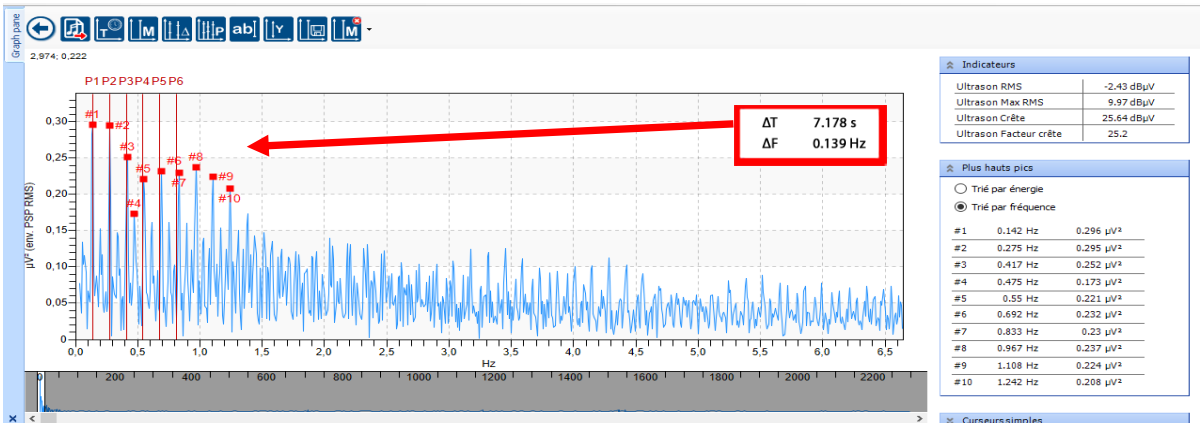
But it’s another matter when it comes to selecting the right analysis tools, the right technology, and the right indicators for the early detection of a failure on a rotating machine, in particular low-speed machines. Ultrasonic technology is used to issue this diagnosis, as it can be easily and efficiently implemented.

Recently, SDT International took up this challenge on a rotating machine with a rotation speed of 8 RPM= 0.13 Hz.

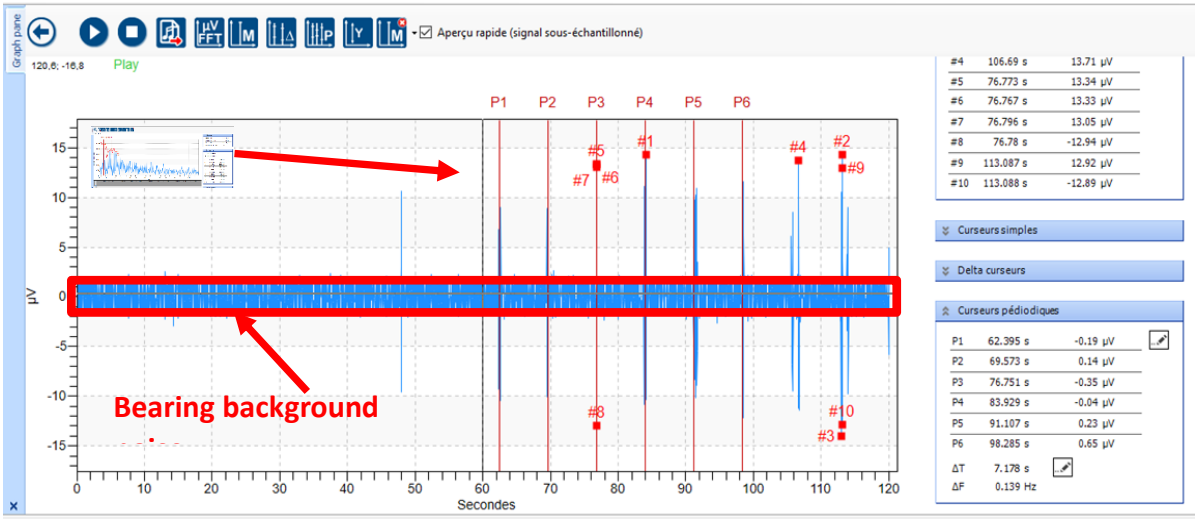
More than a week earlier, the maintenance department of a world-renowned company had detected unusual noise on a strategic production asset. The sudden stop of this machine would have led to the complete shutdown of the production site. Not to mention the financial cost of replacing these 4 bearings, the time required for the procurement of these specific bearings and the cost of the maintenance labor.

There was a dual stake here: control the condition of these bearings and attempt to detect the origin of this noise.

A diagnosis could be issued using the new ultrasonic measuring instrument, SDT340, and its FOCUS mode that can generate sampling frequencies up to 256 K samples per second.




The spectrum shows an impact at the rotation speed (0.13 Hz) of the shafts of the rotating machine, along with its harmonics. Sub-harmonic frequencies can also be observed at 0.5 x the rotation speed, which is a characteristic spectrum for a rotational clearance due to friction or significant impacts. No impact due to bearing frequencies are observed. Our diagnosis is confirmed by the time waveform.




The graph shows that the observed impacts are indeed associated with the rotation speed of the shafts of the machine at 0.13 Hz, i.e., a rotation speed of 8 RPM.

In terms of energy, these impacts are not necessarily constant for each shaft revolution (time signal recorded over a period of 2 minutes) and can be clipped if the gain is not suitable.

The encountered problem is due to the wear of the shafts and of the disks that are mounted onto these shafts and generate abnormal friction.

Now, the maintenance department knows the origin of the noise and the condition of the bearings, which just need to be monitored on a periodic basis.

# Precision Lubrication with LUBExpert

**Author:** Ken Mitchell

## Implementation of an ultrasonic lubrication program in a paper mill to acoustically grease bearings right

The LUBExpert system has allowed the maintenance team to shift away from unreliable calendar-based lubrication to on-condition lubrication with instant feedback to the technician as each bearing is greased.

Dryer section felt rolls – previously greased on a time-based schedule delivering 40 grams of grease every 4 weeks before the ultrasound program was implemented.

Ultrasonic greasing program started; first dryer felt roll greased from an RMS of 14.1 dBµV down to 12.2 dBµV after delivering only 20 grams of grease.

One month later, approx. 4 weeks to respect the established lubrication program, ultrasound shows the RMS has increased to 17.2 dBµV, again the bearing is greased, this time delivering 25 grams total quantity to reduce to 11.7 dBµV.

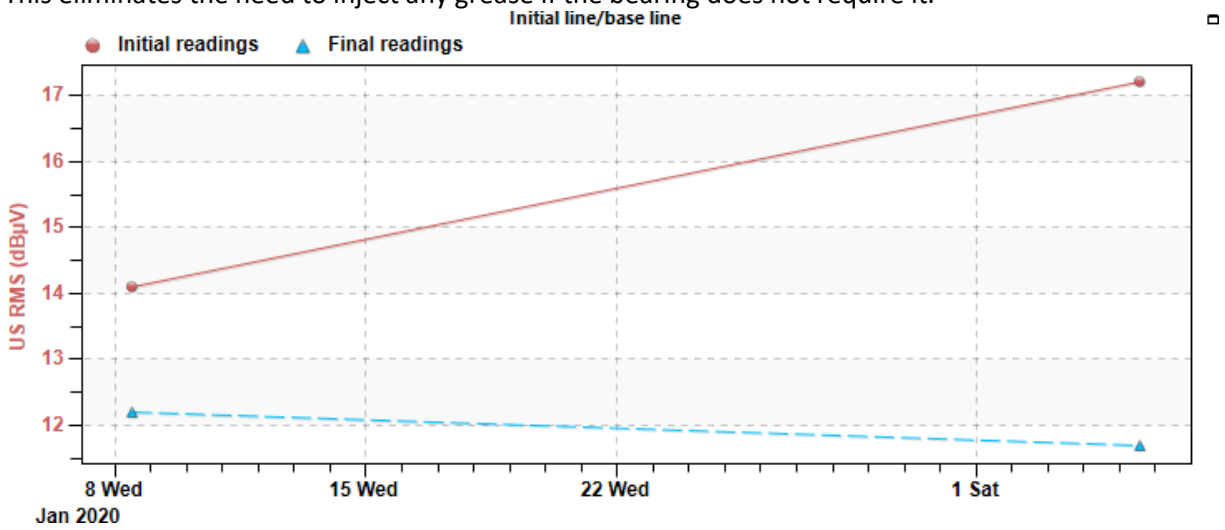
| | Level Name | RMS | Max RMS | Peak | Crest Factor | Lube Alarm | Lube Alarm | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | 11.7 | 12.6 | 28 | 6.52 | | lubrication success F | SHP 460 | 15 |
| | Normal | 11 | 14.6 | 36.2 | 18.19 | | free mode | SHP 460 | 10 |
| | Alert | 17.2 | 20.5 | 35.7 | 8.42 | | initial reading | SHP 460 | 0 |
| | Normal | 12.2 | 14.1 | 36.6 | 16.61 | | Lubrication success | SHP 460 | 20 |
| | Normal | 14.1 | 16 | 32.4 | 8.22 | | initial reading | SHP 460 | 0 |

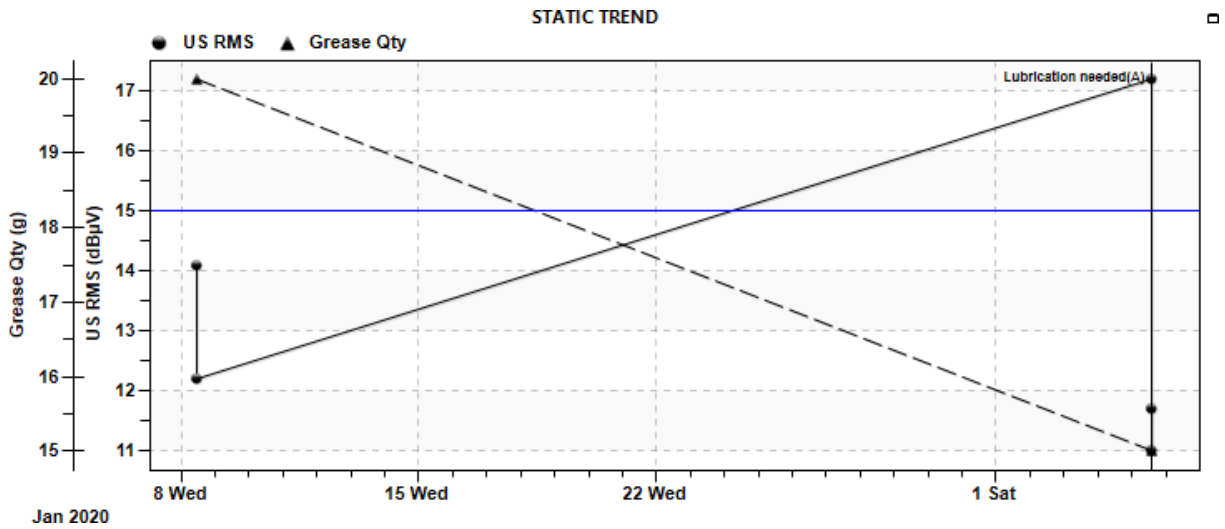
Initial greasing saved over lubrication of 20 grams (50%) and a further 15 grams (37.5%) to the first roll.

The Ultranalysis® Suite 3 software provides trending and initial/base line readings each time the

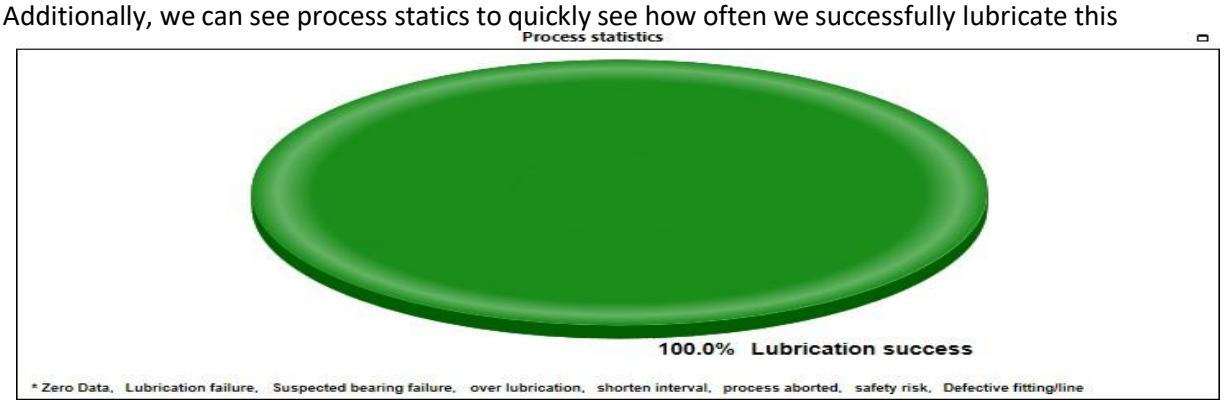
bearing is greased.
An absolute alarm at 15 dBµV was added to indicate whether the bearing needs lubrication (over and the LUBExpert will prompt for greasing, under it will return a message of “lubrication not needed”).

This eliminates the need to inject any grease if the bearing does not require it.




Additionally, we can see process statics to quickly see how often we successfully lubricate this




bearing.

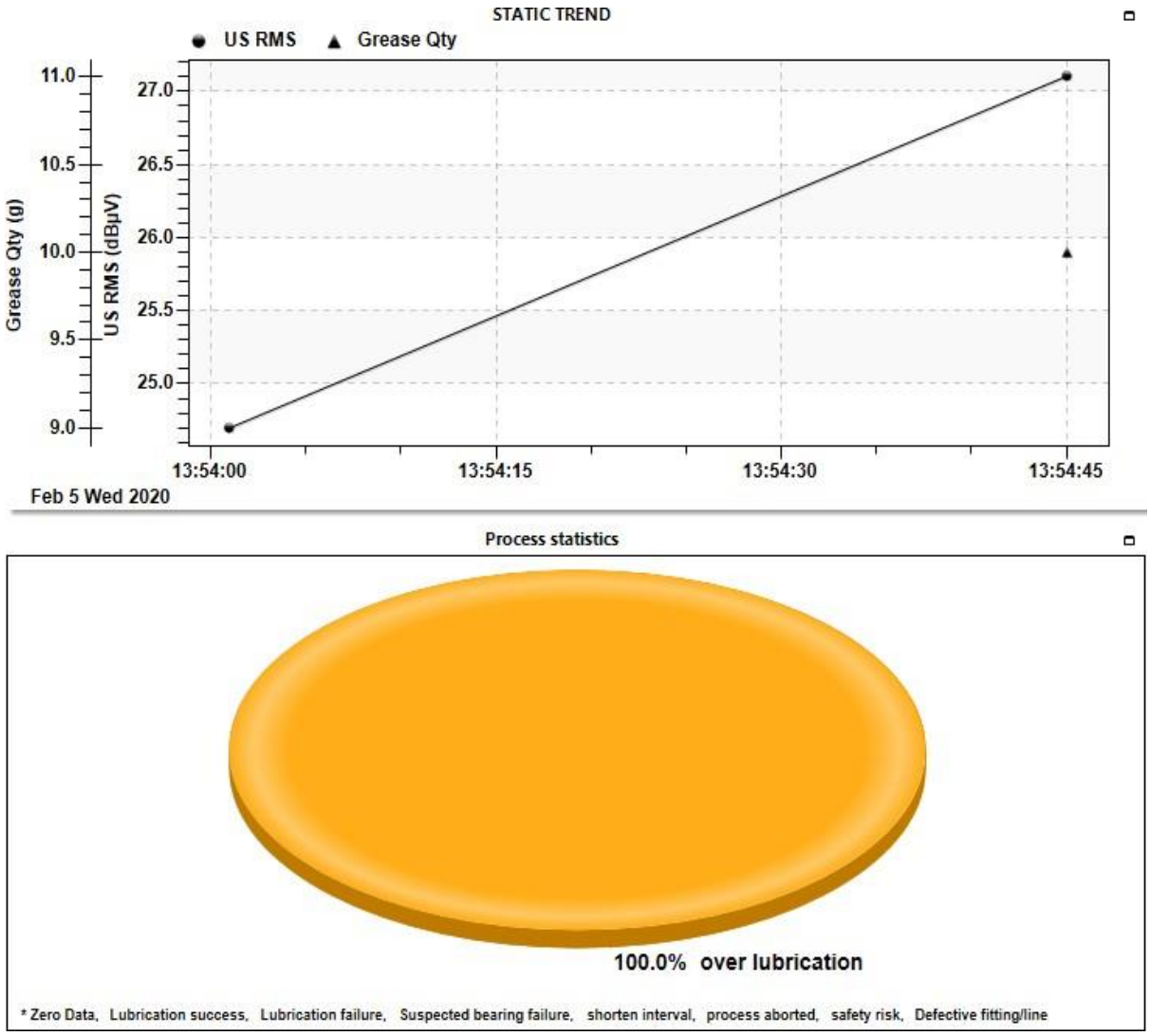
In a different dryer section of the machine, a felt roll was visited for the first time with the LUBExpert, one month had passed since the last greasing.

Not knowing the lubrication status of this bearing, an initial injection of 10 grams was delivered and the RMS immediately increased to 27.1 dBµV.

On the onset, it would appear that we have done something bad to this bearing by entering an over

| | Level Name | RMS | Max RMS | Peak | Crest Factor | Lube Alarm | Lube Alarm Level | Grease Name | Nb. Grease Shot |
|---|---|---|---|---|---|---|---|---|---|
| | | 27.1 | 30.4 | 47.4 | 10.35 | | over lubrication F | SHP 460 | 10 |
| | | 24.7 | 31.5 | 52.5 | 24.55 | | initial reading | SHP 460 | 0 |

lubrication status on the LUBExpert.




However, keeping in mind that we were previously delivering 40 grams to this bearing, we have effectively prevented an additional 30 grams of unnecessary grease being injected into this bearing which would have increased friction levels, heat, and wear even further.

As more data is taken on this bearing and how it reacts to greasing, alarms can be set up to inform the operator that lubrication is not needed before injecting any grease. That will be the final setup of the program.

Suction pick-up roll bearings failed one month prior due to improper lubrication resulting in a bearing change at a cost of CAD $16 000 (10 865€), 8 hours of labor and loss production time to change the bearing out.
The bearing was checked upon startup using the LUBExpert and it was discovered that it was not greased properly, resulting in an under greased status which could have led to another premature

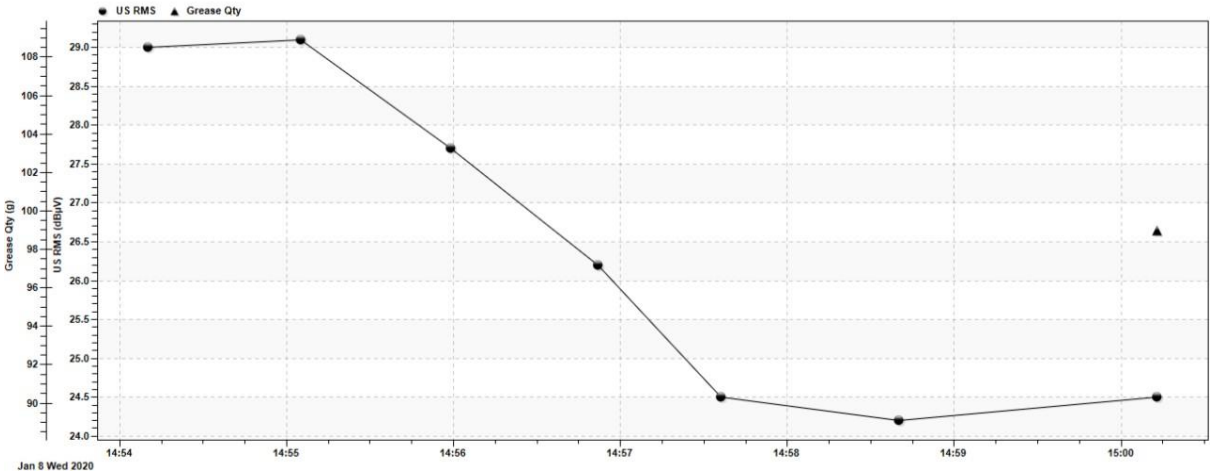
bearing failure.

A total of 99 grams was effectively delivered to the bearing (total capacity is 271 grams) upon startup, indicating that the bearing was initially filled to only 63% of the required capacity.

The bearing initially showed an **RMS of 29 dBµV** and was reduced to an **RMS of 24.5 dBµV** through ultrasonic greasing with the LUBExpert.

| Level Name | RMS | Max | Peak | Crest | Lube Alarm | Lube Alarm Level | Grease Name | Nb. Grease Shot |
|---|---|---|---|---|---|---|---|---|
| | 24.5 | 24.9 | 36.5 | 3.98 | | lubrication success F | SHP 460 | 99 |
| | 24.2 | 24.8 | 36.3 | 4.03 | | free mode | SHP 460 | 19 |
| | 24.5 | 25 | 37.8 | 4.62 | | free mode | SHP 460 | 20 |
| | 26.2 | 26.8 | 37.8 | 3.8 | | free mode | SHP 460 | 20 |
| | 27.7 | 28.3 | 39.5 | 3.89 | | free mode | SHP 460 | 20 |
| | 29.1 | 29.5 | 40.2 | 3.59 | | free mode | SHP 460 | 20 |
| | 29 | 29.4 | 40.1 | 3.59 | | initial reading | SHP 460 | 0 |

The Ultranalysis® Suite 3 trend shows us that we have successfully greased the bearing to the optimum level as expected.




This initial check prevented what could have been another catastrophic failure during production, increasing reliability on this roll and ensuring proper lubrication, reduced friction, and wear on this bearing.

# Defective Bearing on DC Motor

**Authors:** Gilles Lanthier and Tristan Rienstra
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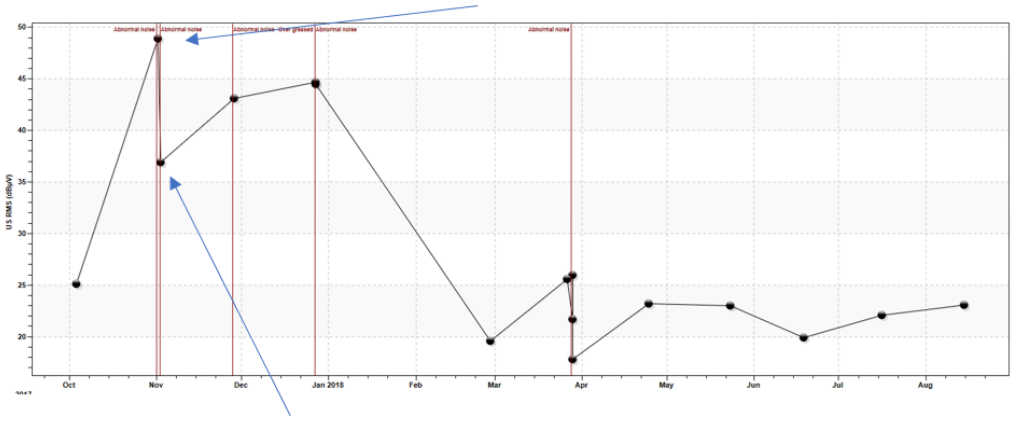
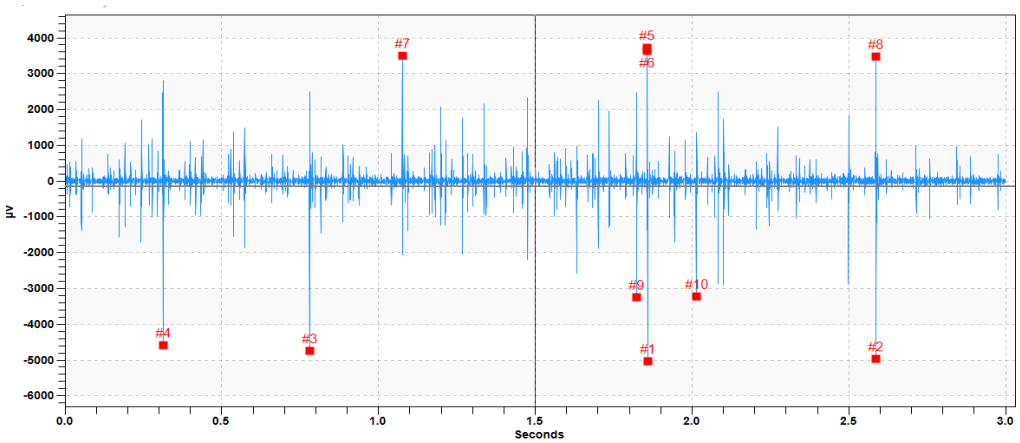
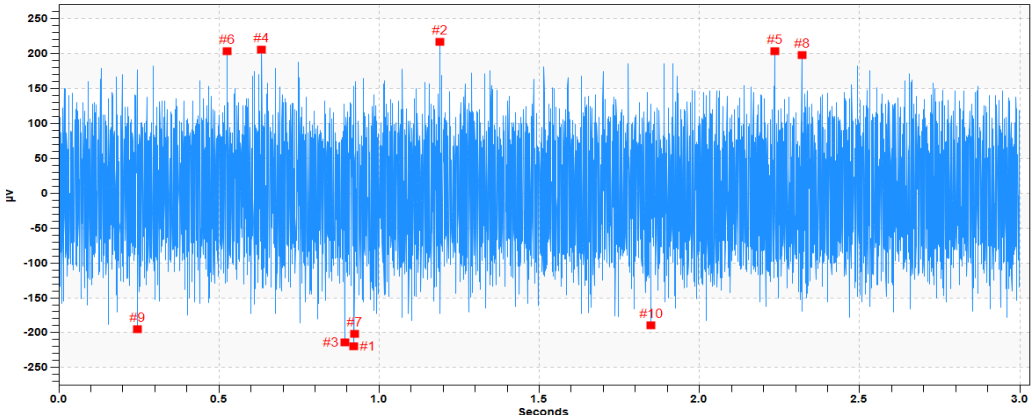
Problem identified by ultrasound on November 1st.
Ultrasound Trend - high RMS ultrasound values in early November




Bearing greased on November 2nd.
Whenever we suspect a bearing problem, our first step is lubrication.
November 1st ultrasound reading:

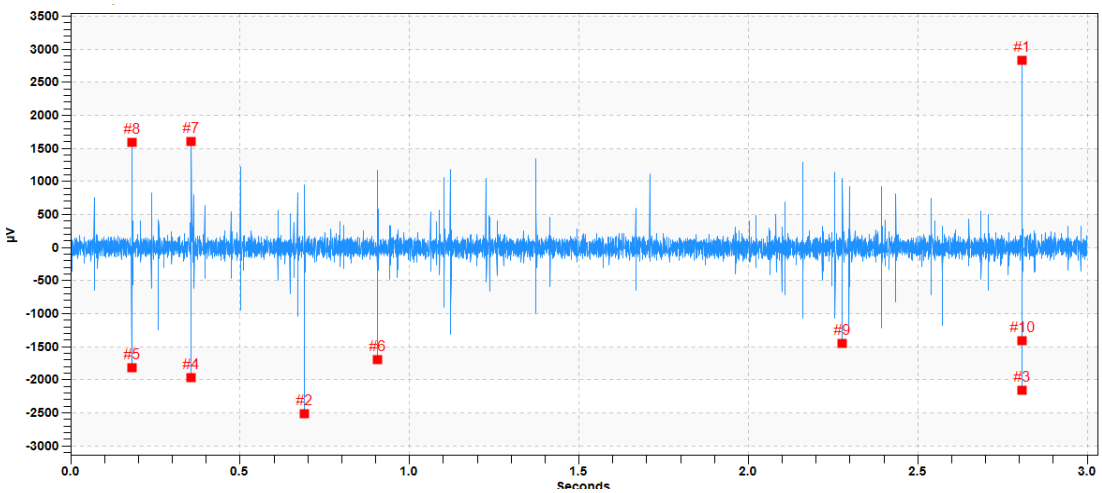



Ultrasound reading after greasing on November 2nd:

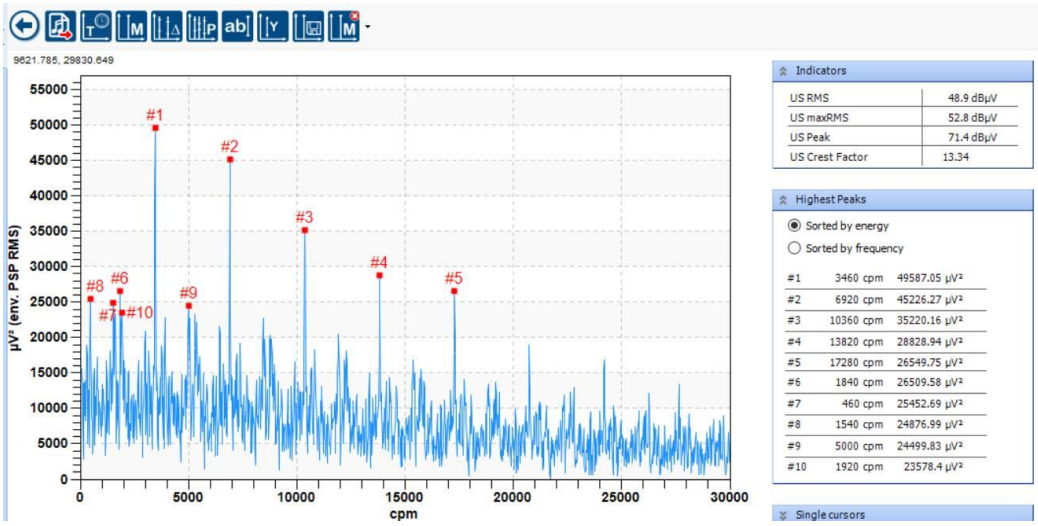



Ultrasound levels decrease as predicted.

Ultrasound reading on November 28th (still containing high peaks as November 2nd):




Levels rise back up. Bearing defect is very clear:




Defect clearly visible. The bearing is finished.

## Outer race damage:

**Figure 3 Outer race damage (BPFO)**

# Finding Vacuum Leaks in a Multi Effect Evaporator

**Authors:** Allan Rienstra and Karl Hoffower
**Email address:** allan.rienstra@sdtultrasound.com

## Black Liquor Evaporator Vacuum Leak Survey

In November 2009, SDT Ultrasound Solutions received a phone call from Clearwater Paper Corporation, Lewiston, Idaho Plant asking if our ultrasound technology could find vacuum leaks on evaporator stacks.

Several leak detection service companies had been approached already but none seemed willing to risk the expense of visiting the plant with an uncertain outcome. SDT is lucky enough to have a sound technical representative situated near the Pacific Northwest willing to embrace the risk in exchange for providing customer solutions and satisfaction. Karl Hoffower, of Failure Prevention and Condition Monitoring Solutions, Inc took the call and scheduled a visit to the mill. He filed this report.

Vacuum Leak Inspection on Multiple Effect Evaporator at major Pacific Northwest pulp & paper mill.

On December 14$^{th}$ and 15$^{th}$, a vacuum leak survey was completed on the black liquor evaporator at a major pulp and paper producer in Idaho. Evaluation of the black liquor process numbers indicated the most likely area of the vacuum leak was somewhere in the 4$^{th}$ effect piping.

Using the SDT170 ultrasound listening device coupled with the SDT RS-1 (resonant sensor 1) contact needle probe, contact measurements were obtained at various locations along the 4$^{th}$ effect stack.

These readings were taken through the insulation and outer steel wrapping. The highest reading noted was 51 dB. This location also correlated with the thinnest section of the stack recorded by ultrasonic thickness testing already done by their NDT crew.

Switching to airborne ultrasound detection mode revealed a jump from the ambient levels of 18 dB to a strong 32 dB -33 dB with the tell-tale whooshing sound of a vacuum leak.

When the insulation near the bottom of the access door was moved the airborne ultrasound levels rose to 38 dB cutting away a large section of the sheet steel and insulation revealed numerous points where the metal had been breached by the corrosive black liquor. The breaches had created a loss of vacuum in the 4th effect stack. Rubber sheets had been pre-cut in preparation for discovering the locations of the leaks. These sheets were placed over the areas of the holes as a temporary repair and to avoid a complete loss of vacuum on the evaporator system when the insulation was removed. A repair was carried out to help allow the system to function properly and continue until a planned outage in March 2010 can have the stacks replaced. Gor-tex™ sheets were Clearwater Pulp, Lewiston, ID wrapped around the stack and sealed with silicone caulking.

The OSI PI process monitoring software showed an immediate change in the correct direction by the application of the rubber sheets and an even better improvement with the Gore-Tex™ sheets and silicone caulking.

The “morning report” at IPPD on December 17, 2009, stated the following: “Vacuum improvements on the evaporators resulted in the best solids throughput tons per day we have achieved on the set in the recent past.”

### Testing procedure:

Mr. Frei revealed the evaporator stacks had several access ports covered by rubber stoppers. These pre-made ports had been constructed to allow easy access for periodic thickness testing. The procedure discussed was to access these ports on the evaporator and contact or “touch” the point with the RS-1 needle probe. The decibel level would be recorded and mapped out. Mr. Frei also told us of additional access doors created on the stacks for thickness testing. These access doors were sealed with silicone and screws with 4”-6” of insulation in-between. These additional doors helped make our survey successful. By mapping the decibel levels at various points around and along the stacks, an area or areas of potential leak could be determined for further investigation.

### Challenges:

There were several challenges to completing this survey, access being the primary hurdle. 4 rubber access points were easy to get to while standing on the roof of the evaporator building. A man-lift was then employed to gain access to more points. But if the leak was occurring in a location inaccessible by the man-lift, then staging would have to be employed to gain access to the other stacks. Flow is made more turbulent at twists, angles, and bends, like 90-degree elbows. The evaporator stacks had numerous 90-degree elbows.

Differentiating between excessive turbulent flow caused by a 90-degree elbow and a vacuum leak was another potential hurdle that was overcome by my inspector training. This training prepared me with the necessary skills to differentiate between internal turbulent flow and turbulent flow that is the result of a leak.

### Survey:

The black liquor evaporator uses a 7-effect counter flow method to concentrate the mixture. Using the OSI PI monitoring software, Mr. Frei stated their evaluation set the most likely location to be in the 4th effect stack. The pictures here show the map of decibel levels after we conducted the survey. The decibel levels taken on the inside area of the stack dropped as we moved away from the high of 51 dB, down to 38 dB.

The survey required the use of a man-lift to access all of the doors. While the contact ultrasound measurements were made, RCM Tech Jim Storey also conducted contact ultrasound thickness testing. Mr. Storey said that the last thickness survey conducted on this stack was about 5 years ago.

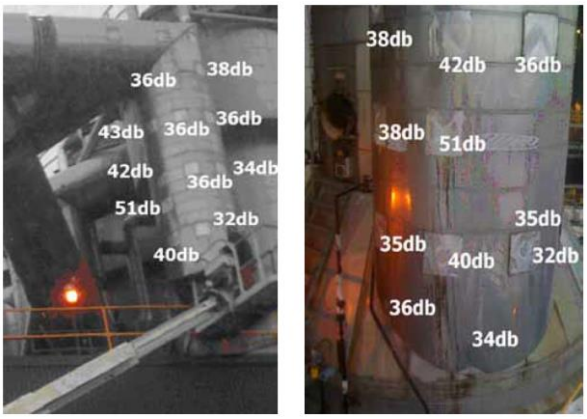



**Diagram shows dB levels mapped out using SDT RS1 Contact Probe. Vacuum leaks detected through 4" insulation and outer sheet steel. Loudest areas were cut away and patched with Gor-Tex™ patches.**

With airborne ultrasound leaks, a large leak usually registers at 65-75 dB or around 15' away from the source. Since no other points had anything higher than 51 dB, we decided to return to that location and investigate further.

As the additional pictures below will show, there was a strong correlation between the locations of the leaks and the thinning of the wall of the stack. At the location of the highest ultrasound, 51 dB, the wall was found to be 0.091" thin. The thinnest area found on our initial survey.


**Wall thinning correlated to high dB values.**

With the ultrasound level increasing as we recorded contacts close to the bottom, I changed from the contact probe to the airborne sensor. Ambient ultrasonic dB levels were 18 dB around the stack. When I brought the airborne sensor near the 51 dB access door, the airborne sensor jumped to 32 dB – 33 dB and gave the telltale whooshing sound of rapidly moving air. When I used my hand to separate some of the insulation away from the metal flange, the airborne sensor levels rose to 38 dB.

It was decided that we would need to have a larger area open for inspection.
Mr. Storey and I went back to confer with Mr. Frei and Mr. Fleischman about how we could gain access to the stack below the retaining ring. Mr. Storey marked out the approximate dimensions we wanted to have cut away in chalk.


We went back to the Maintenance shop and were introduced to Mr. Jim Rose. He discussed how he would cut the sheet steel away and remove the insulation to give us better access. Mr. Frei reminded us that we would need to have some type of blocking material to immediately cover the holes we expected to find. If we did not, the probability of losing the vacuum was great, thus potentially causing the entire process to shutdown.

## Corrosion Damage Found:

As soon as Mr. Rose removed the sheet steel we could see where the insulation had collapsed around the vacuum pull of the stack. As the insulation peeled away, the holes were immediately visible. We placed two rubber sheets over the large holes to prevent the loss of vacuum. The sheet on the left covered the largest area of corrosion, about 8” wide. The 2nd major area of damage was about 1½“ wide.

Opening the access door allowed further pinpointing with RS1 ultrasound probe along the underside of the metal flange area.


The exact number of holes was too numerous to count. Also, many of the holes had blended together from the corrosion.

Mr. Rose recommended applying Gor-Tex™ sheets sealed with silicone to affect a strong, yet temporary repair. The decision was to strengthen and seal the holes so that the process could continue until a planned outage in March 2010. At that time a complete repair/replacement could be implemented.

As they removed more of the sheet metal and insulation for the final repair, additional thickness testing was performed.

The areas below where the holes were discovered clearly show how the stack is wearing out. 0.077" was the thinnest area found without actually being a hole.

## Conclusion:

After the Gore-Tex™ sheets were wrapped and sealed, the process monitoring software validated the repair. The amount of vacuum began returning to levels not seen for quite a while. The control valve also moved dramatically in the correct direction right as the repair was being finished.

By 4 pm on December 15th it was apparent the system had returned to normal. The survey is considered ended and a success.

I was sent an email that noted, the "morning report" at IPPD on December 17, 2009, stated the following: "Vacuum improvements on the evaporators resulted in the best solids throughput tons per day we have achieved on the set in the recent past."

The report filed by Mr. Hoffower illustrates just how complex the job of locating vacuum leaks can be. The complexity in this case was magnified by several conditions including insulation material wrapping the stack, sheet metal covering the insulation, primary and secondary air gaps between stack, insulation, and sheet metal, high elevations requiring a lift and platform, ambient noise in the ultrasound frequencies related to nonleaking turbulent flow, and of course the discomfort of high temperatures which also pose a safety risk.

The report also illustrates how rewarding the job can be. The win for this paper company is a reduction in energy costs through more efficient vacuum level maintenance and better thermal transfer from effect to effect. Additionally, they have the best throughput of black liquor in years. Make no mistake here; it is trying times for paper makers.

The difference between a profitable quarter and a losing quarter may well be decided by the efficiency of a single process such as black liquor production.

Many leak surveys are abandoned due to frustration which is the product of poor-quality equipment ill-suited to the task. It is also the product of training.

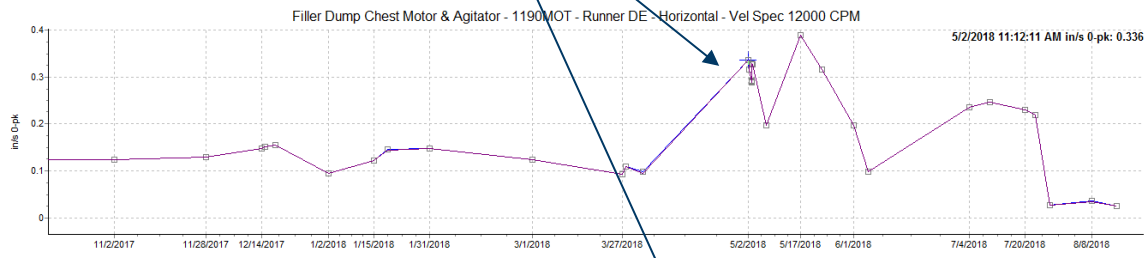
Without ultrasound training, an inspector will be overcome by the hurdles of the task. Your investment in an ultrasound program must be threefold. Invest in quality ultrasound equipment, quality personnel to carry out the inspection, and most important, inspector training. Training must address the unique place ultrasound holds for reliability and plant maintenance, ensure good transfer of knowledge between inspector and student, and return the inspector to the field with the confidence to succeed in the most trying inspections.

# Filler Dump Chest Agitator

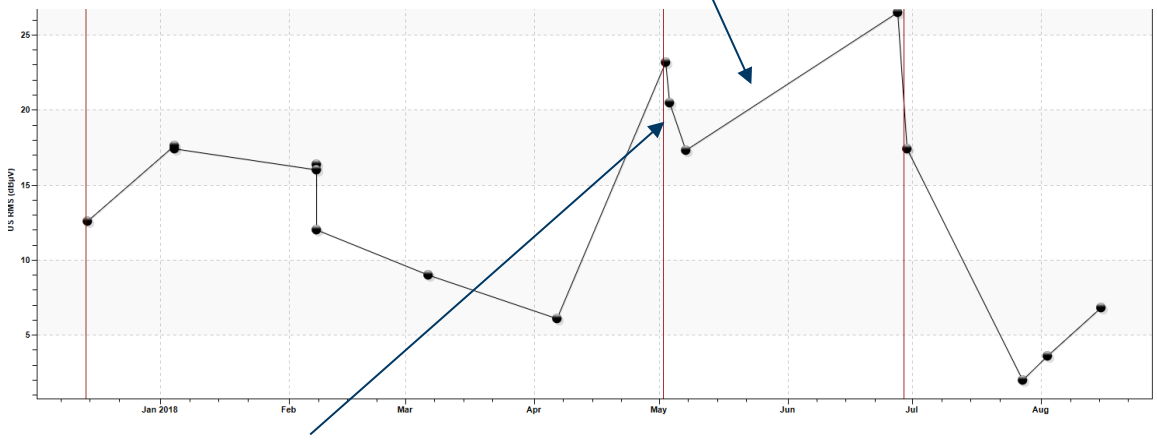
**Author:** SDT Ultrasound Solutions

During Ultrasound & Vibration data collection at the beginning of May increased Vibration levels could be seen as well as increased RMS (friction levels) in Ultrasound. The Ultrasound could also hear impacting coming from the bearing.

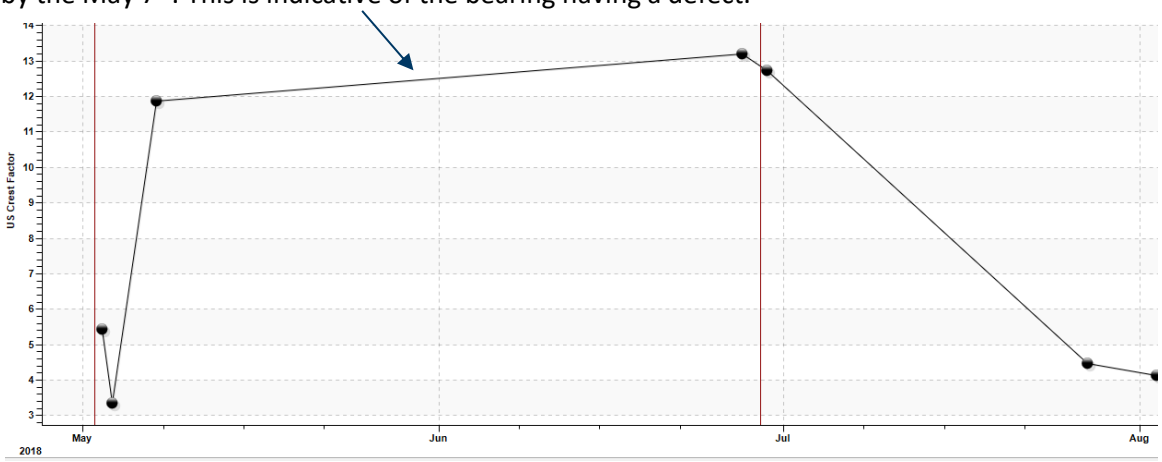
**Vibration**



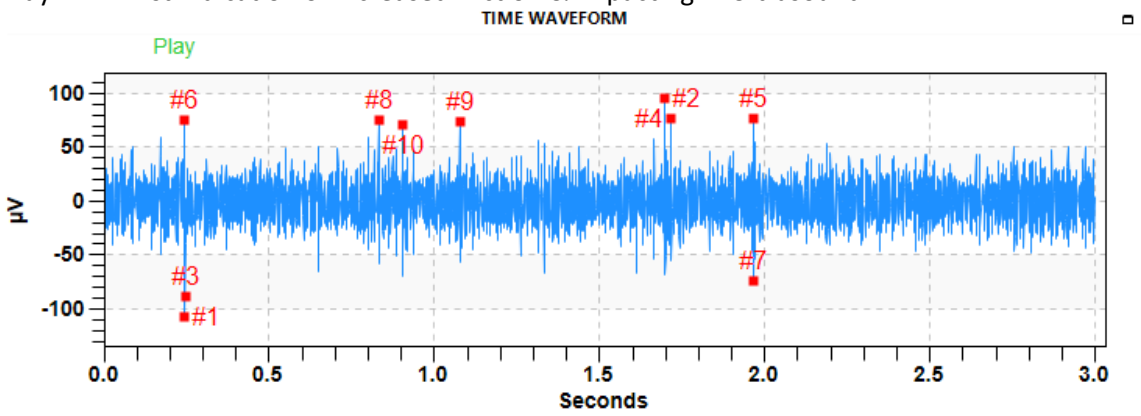

**Ultrasound**



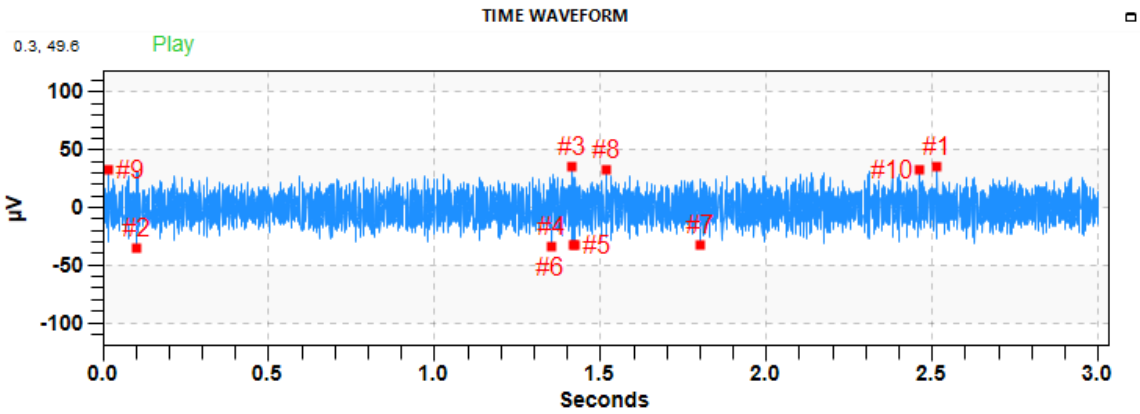

Greasing the bearing on May 3rd reduced the friction as seen by the drop in RMS over a few days and masked the impacting, but the impacting returned as seen by the Crest factor going back up to 11.88 by the May 7th. This is indicative of the bearing having a defect.



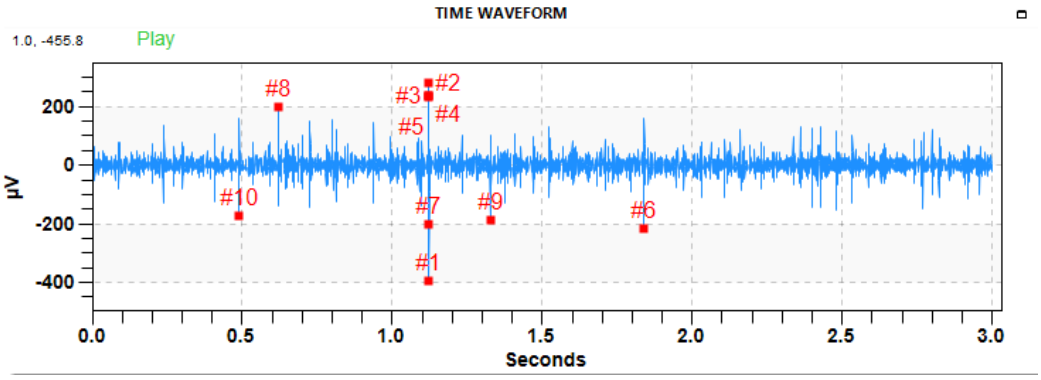
May 2nd – First Indication of increased friction & Impacting in Ultrasound.



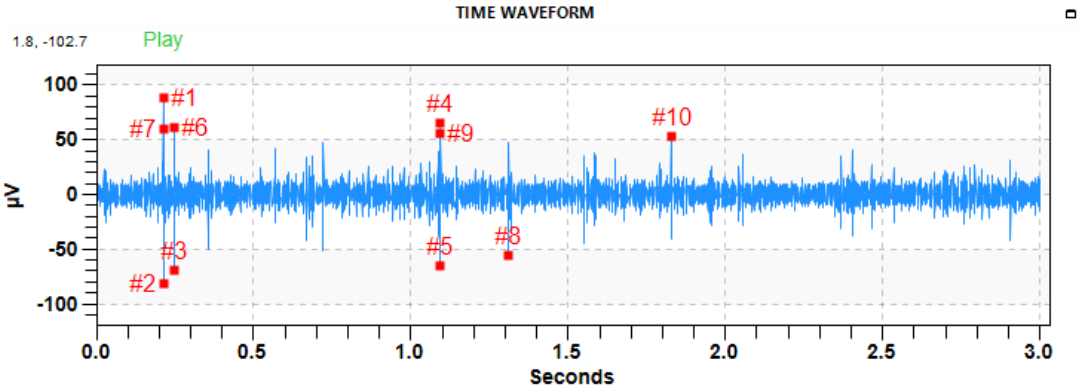

May 3rd – Greased Bearing. Reduced Friction.



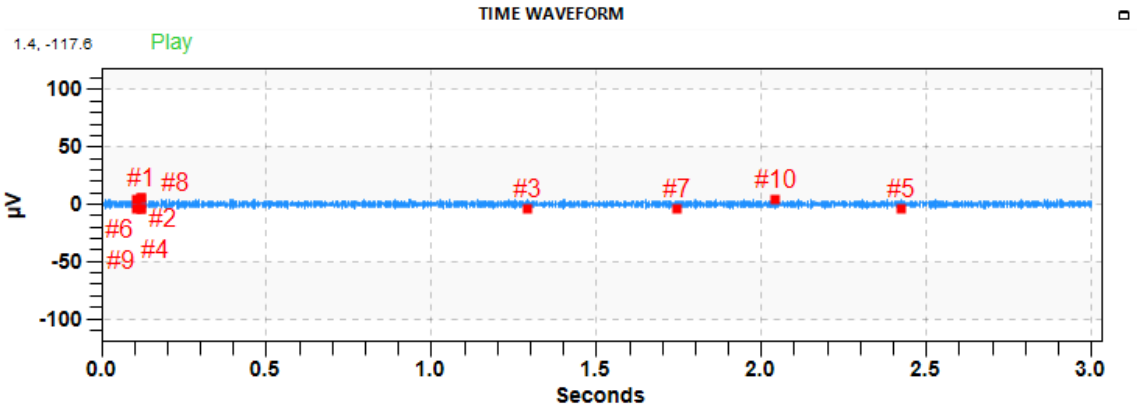

May 7th – Impacting back four days after greasing. Bearing has a defect.



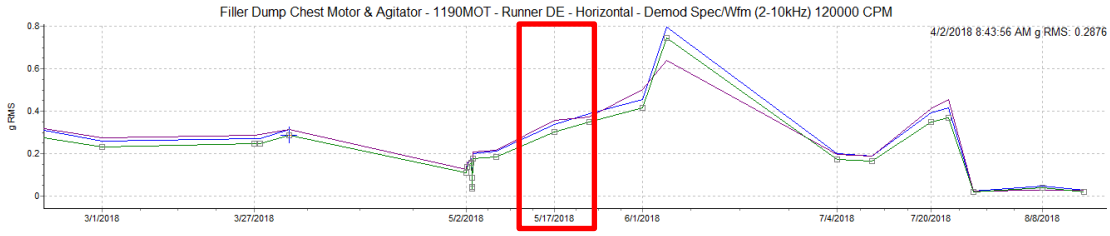

June 27th – Bearing being monitored and greased regularly but by end of June Impacting significantly worse. Scheduled for swap at next shutdown on July 24th.



July 27th – New Ultrasound reading after bearing replaced.




The g RMS trend from vibration shows increasing levels around middle of May confirming Ultrasound findings of a defective bearing.

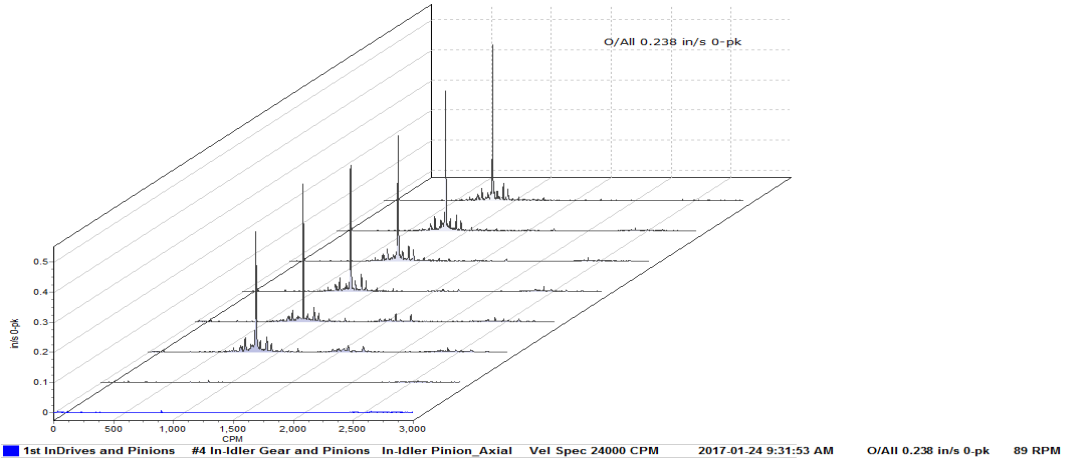



**Pictures of the DE Agitator Bearing after it was removed on July 24th shutdown:**

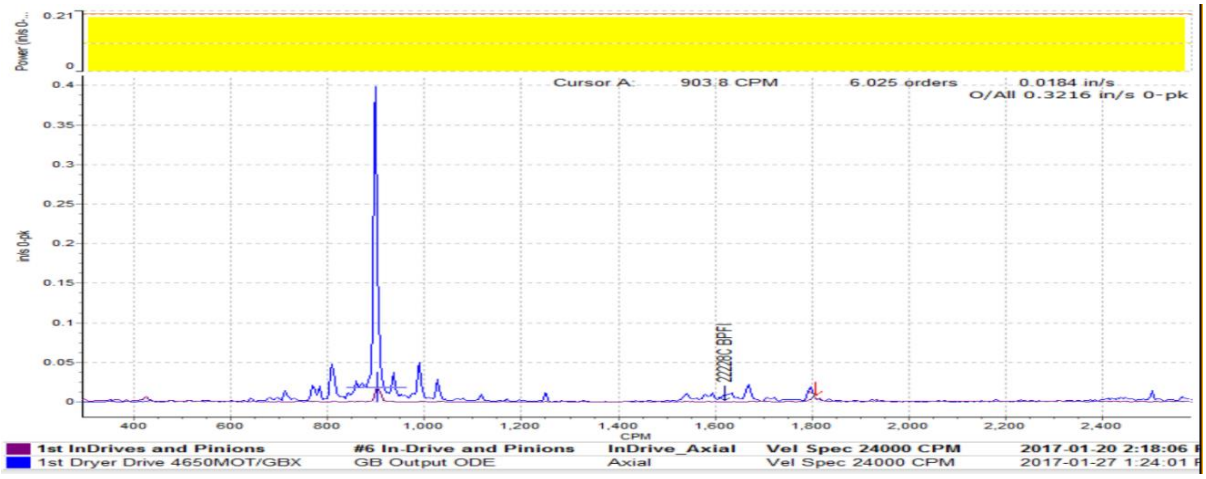
## Motor & Gearbox - Pulp & Paper Facility

**Author:** SDT Ultrasound Solutions

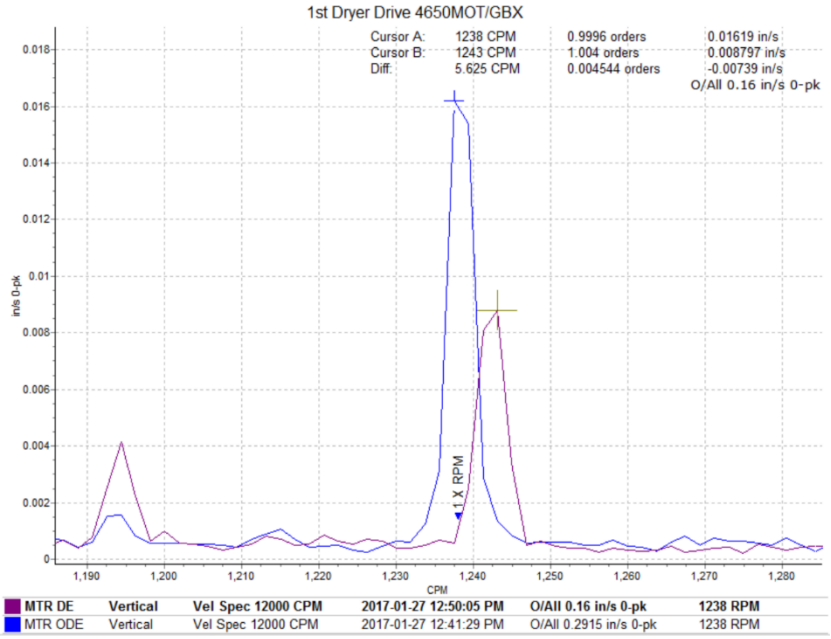
This report will cover the findings on Motor & Gearbox. This vibration was not present until this motor was changed. The motor gearbox is now vibrating excessively in the axial direction across the whole machine train when it is under a load. Usually in vibration analysis, most frequencies can be the in-drive position 4 and 6 where the 900 CPM frequency is not significant in amplitude. Related to the rotating speed of the malfunctioning component unless it is a natural frequency problem. The frequency of interest is 900 CPM, which is not related to the rotational speed of the machine. The waterfall below illustrates the high vibration in the axial direction across the machine. The First two readings belong to the In-Drive. This eliminates the In-Drive as the source of the vibration.




During the investigation, we used a strobe light to verify the speed of the DC motor. Usually under normal operating conditions the strobe light would make a reference mark (key or keyway) appear frozen. In our observation, the refence mark would vary its position 30 degrees continuously. This could be caused by either a continuous change in load or DC motor control problem. This variation could be causing a hammering on the gear train which could be causing the appearance of the 900 CPM peak as a natural frequency of one of the gears.

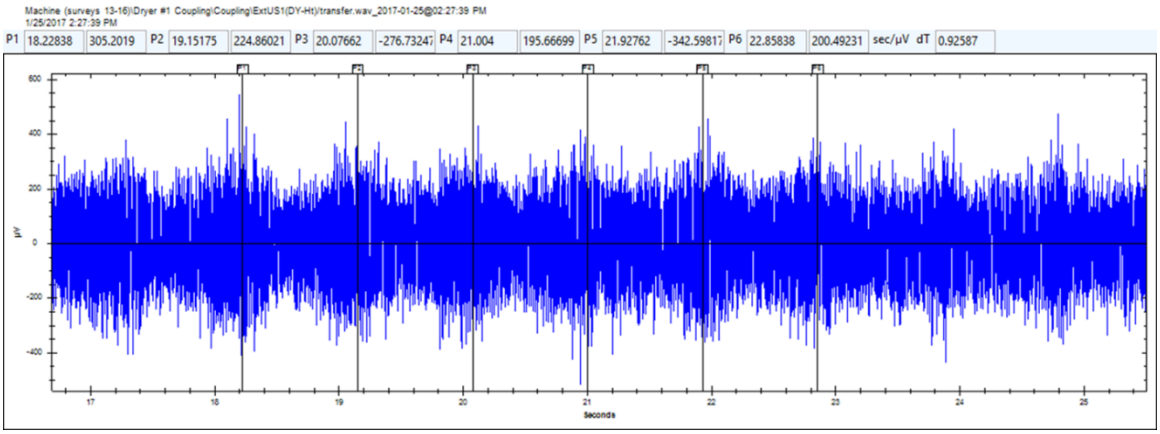



The two spectrums below illustrate the variation in speed on the motor. The first is on the DE and the second is on the ODE vertical.



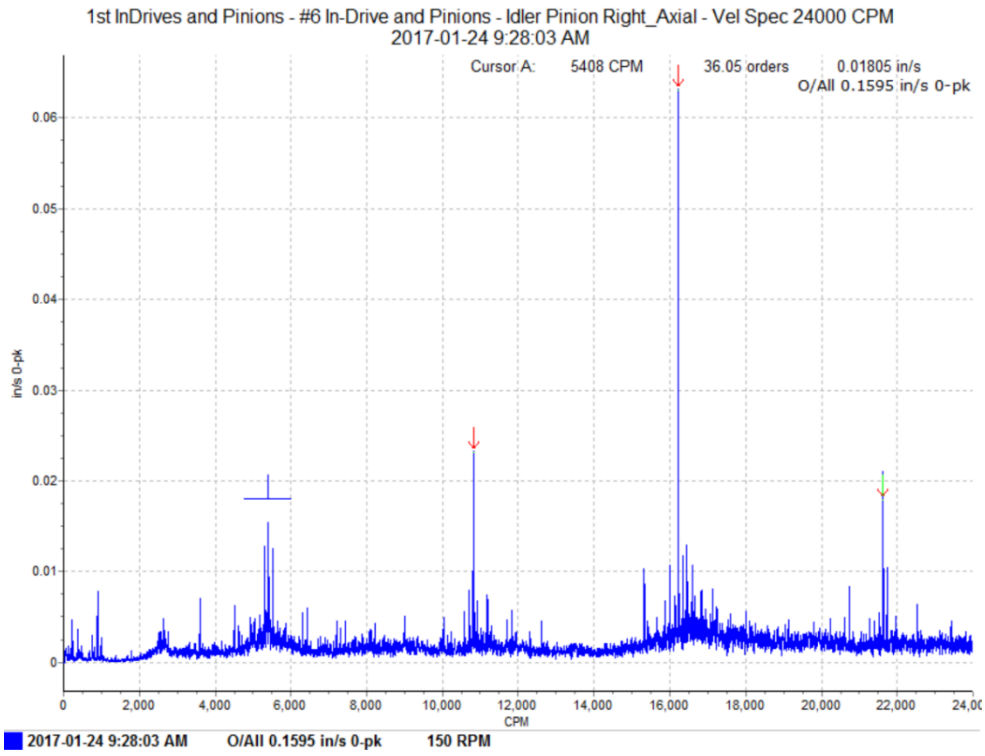

It should also be noted that on this motor the encoder shaft coupling had been replaced due to a failure.

Ultrasound readings were also taken on the output coupling. It was generating a pulsating noise which was repeating every 90 CPM or at the output speed of the gearbox possibly due to the variation of the load on the coupling due to the variation in speed.

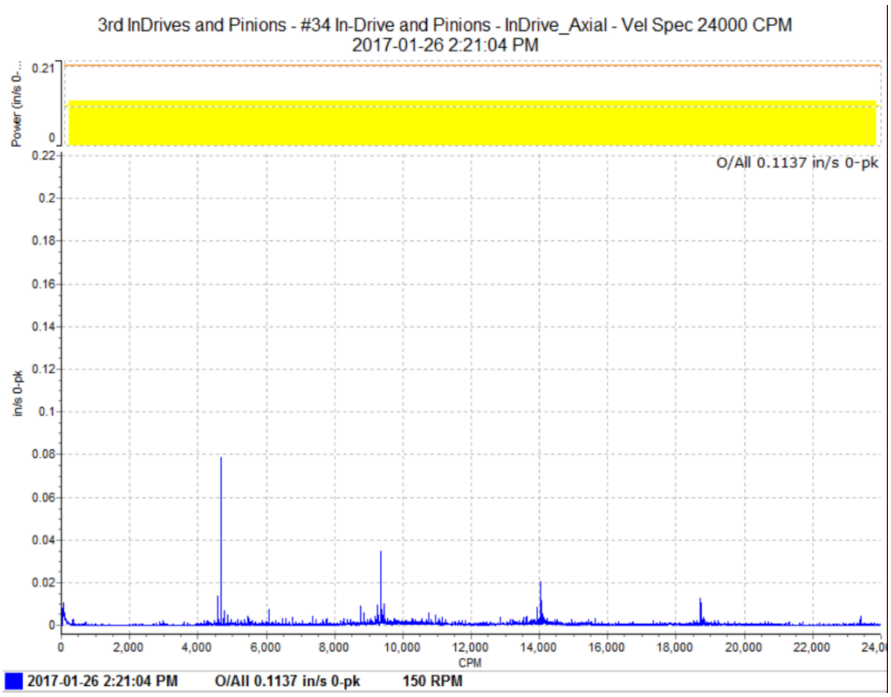



## In-drive Misalignment

There is also evidence that there is a misalignment condition between the output of the gearbox and the In-Drive.




Gear Misalignment is the probably the most prevalent cause of gear failure. Typically, this results from coupling misalignment between the input and/or output drive systems and the mating components. This produces Gear Mesh Frequencies (GMF) and sideband frequencies, spaced out at the rotating speed of the faulty gear. Gear misalignment can also occur internally if the gear shaft support bearings are not properly aligned with respect to one another. While not common, this problem will usually lead to premature bearing failure before gear problems are considered severe.



# Ultrasound & Vibration on DC Motor connected to Fan Pump

**Authors:** Gilles Lanthier and Tristan Rienstra
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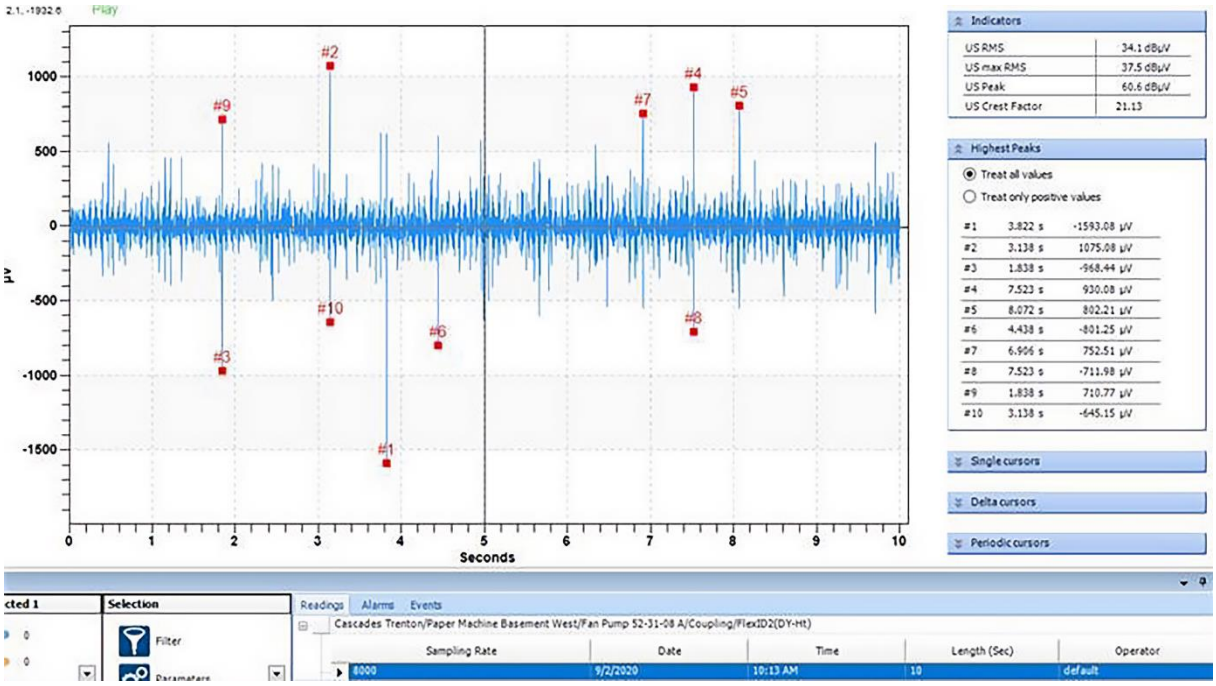
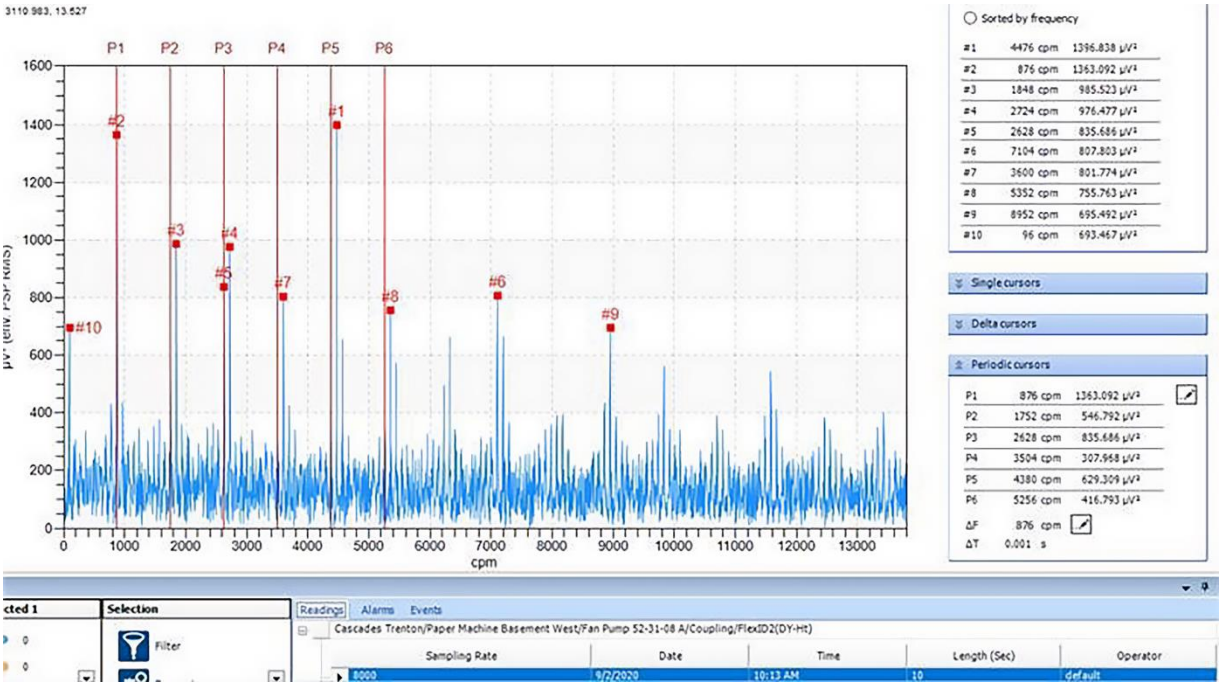
The following are the time-wave and spectra ultrasound measurements, and the vibration measurements taken on the coupling of a DC motor connected to a fan pump. By using two technologies we were able to fully diagnose everything wrong with this asset.

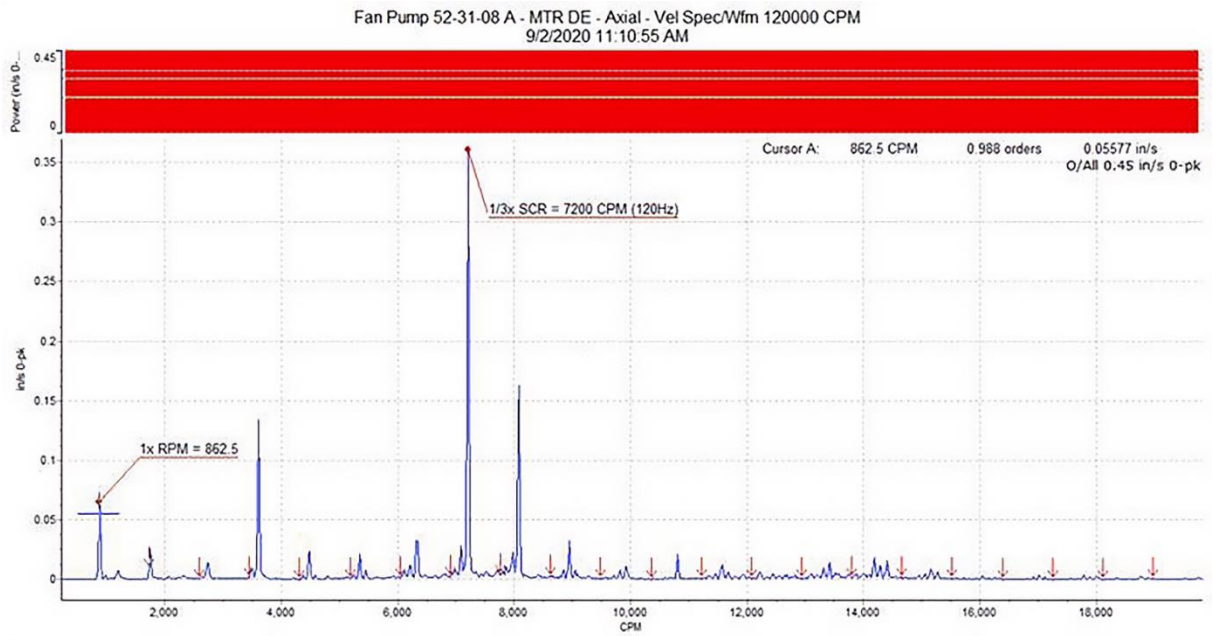



First, let's start with the ultrasound readings. As you can see in the time-wave measurement, this coupling appears to be in bad shape with lots of impacting at its regular run speed. When you look at the spectra you can note something strange, because of recurrences clearly identified with the periodic cursors. After making this discovery our data collectors from the Partnered Ultrasound team decided to utilize vibration analysis where we discovered the motor run speed was fluctuating.

When a firing card fails, then 1/3 of the power is lost, resulting in momentary speed changes in the motor's rotation. This can lead to high amplitudes at 1/3X and 2/3X SCR frequencies. As you can see on the vibration measurement this motor was firing at 1/3X SCR which is 7200 CPM meaning 2/3rds of the firing cards were faulty.

Using two condition monitoring technologies our Partnered Ultrasound Team was able to fully diagnose the problem on this asset. Ultrasound to find the broken coupling and vibration to find 4 blown fuses out of the 6 on the DC motor.


P1
P2
P3
P4
P5
P6
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
cpm
Sorted by frequency
#1 4476 cpm 1396.838 µV²
#2 876 cpm 1363.092 µV²
#3 1848 cpm 985.523 µV²
#4 2724 cpm 976.477 µV²
#5 2628 cpm 835.686 µV²
#6 7104 cpm 807.803 µV²
#7 3600 cpm 801.774 µV²
#8 5352 cpm 755.763 µV²
#9 8952 cpm 695.492 µV²
#10 96 cpm 693.467 µV²
Single cursors
Delta cursors
Periodic cursors
P1 876 cpm 1363.092 µV²
P2 1752 cpm 546.792 µV²
P3 2628 cpm 835.686 µV²
P4 3504 cpm 307.968 µV²
P5 4380 cpm 629.309 µV²
P6 5256 cpm 416.793 µV²
ΔF 876 cpm
ΔT 0.001 s
Selection
Filter
Readings
Alarms
Events
Cascades Trenton/Paper Machine Basement West/Fan Pump 52-31-08 A/Coupling/FlexID2(DY-Ht)
Sampling Rate
Date
Time
Length (Sec)
Operator
8000
9/2/2020
10:13 AM
10
default


Fan Pump 52-31-08 A - MTR DE - Axial - Vel Spec/Wfm 120000 CPM
9/2/2020 11:10:55 AM
Cursor A: 862.5 CPM 0.988 orders 0.05577 in/s
O/All 0.45 in/s 0-pk
1/3x SCR = 7200 CPM (120Hz)
1x RPM = 862.5
in/s 0-pk
CPM

## Steam Up Thermal Expansion

**Authors:** Gilles Lanthier and Tristan Rienstra
**Email addresses:** gilles.lanthier@sdtultrasound.com and tristan.rienstra@sdtultrasound.com

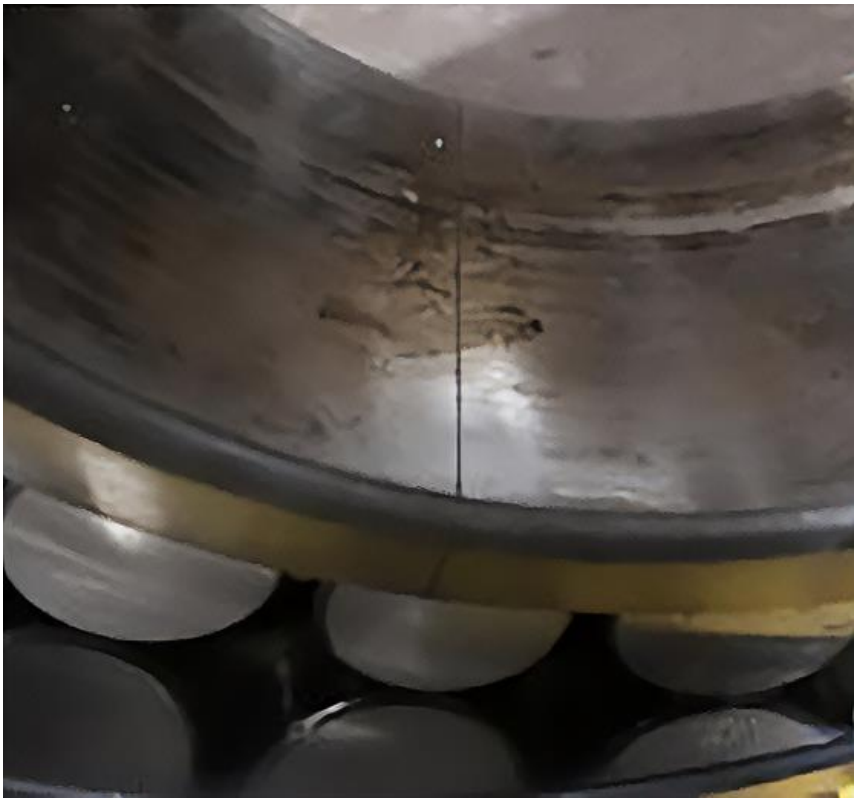
This inner race bearing on a dryer roll is the victim of thermal expansion that happened too quickly.

Factories enter shutdowns so that their assets and machinery can receive maintenance and repairs. Steam is used heavily in papermills for the process of making paper. When a paper machine is shut down for its regular scheduled maintenance the steam is shut off so that the millwrights can safely make the necessary repairs.

After the maintenance has been performed the steam is then turned back on. If the steam is reintroduced to the bearing too fast, it creates thermal shock; where the journal will rapidly undergo thermal expansion causing the split you see on the bearing in the image.

To prevent this, ensure that steam is reintroduced to the paper machine slowly, allowing for the temperature of the bearing to rise less rapidly, and therefore allowing its thermal expansion to not be so abrupt.

This defect and its cause were found by Gilles Lanthier, one of the members of our Partnered Ultrasound Team.



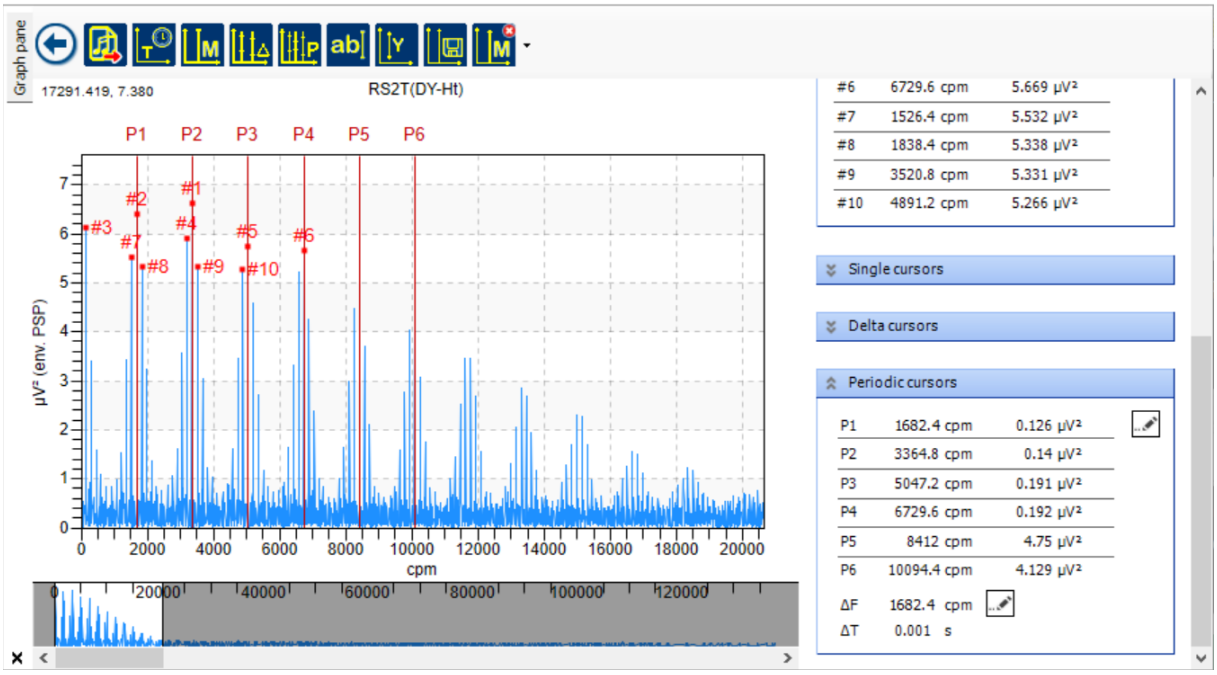
## Paper Roll Defective Inner Race

**Authors:** Gilles Lanthier and Tristan Rienstra
**Email addresses:** gilles.lanthier@sdtultrasound.com and tristan.rienstra@sdtultrasound.com

Paper roll with a defective inner race detected with ultrasound (UAS3 and SDT340).

The following is the spectrum of a slow-speed bearing (150 RPM), on a large roll (4-foot diameter), in a paper machine. Gilles Lanthier, our Partnered Ultrasound Senior Analyst found this defect using his SDT340 and performed analysis using UAS3 software. This find was then confirmed using vibration analysis.

You can use the SDT340 and UAS3 to monitor the condition of all of your slow speed rotating assets.



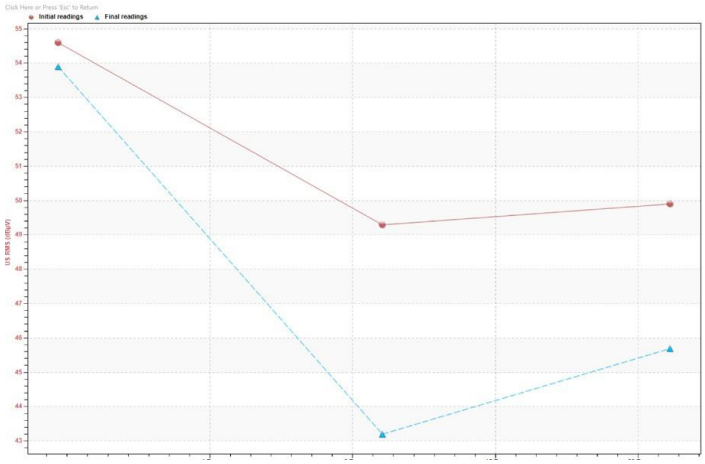

# Bearing Grease Management using Ultrasound

**Author:** GVS Reliability Products

## Inspection Technique

Greasing of bearings using ultrasound, often described as best practice, helps us understand how much grease needs to be applied. Ultrasound is a good measure of friction - too little or too much grease in a bearing produces elevated friction levels. Using ultrasound, the right quantity of grease is determined by assessing the levels.

SDT LUBExpert ensures that the right quantity of grease is applied to each bearing using ultrasound, condition-based lubrication.




The Ultranalysis ® Suite 3 software also provides a means of storing valuable lubrication data, trending, and traceability where grease replenishment quantity, intervals and ultrasound levels are recorded. Information stored in this database may also be used to optimize lubrication schedules / intervals and for root cause failure analysis.

The LUBExpert also facilitates basic screening of bearing condition using the ultrasound crest factor algorithm.

| Level N | RMS | Max | Peak | Crest Fa | Lu | Lube Alarm Level | Grease Nam | Nb. Gr | Grease | Sa | Sof | Se | Date | Time | Manual inp | Se | In | Se | Sens | Instr | Res.F | Mixer | Lengt | Oper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 48.4 | 48.6 | 58.5 | 3.2 | | Lubrication success | AML-783 | 7 | 7 | 80 | 0x... | LU | 19/09/2019 | 1:25 PM | | 54 | 53 | 30 | | 11/... | 0 | 0 | 1 | defa. |
| | 56.9 | 57.9 | 69.4 | 4.22 | | | | | | 80 | 0x... | LU | 19/09/2019 | 1:24 PM | | 54 | 53 | 30 | | 11/... | 0 | 0 | 1 | defa. |
| | 46.7 | 47.6 | 53.5 | 2.19 | | Lubrication success | AML-783 | 6 | 6 | 80 | 0x... | LU | 12/09/2019 | 1:53 PM | | 54 | 53 | 30 | | 11/... | 0 | 0 | 1 | defa. |
| | 53 | 53.5 | 66.6 | 4.79 | | | | | | 80 | 0x... | LU | 12/09/2019 | 1:51 PM | | 54 | 53 | 30 | | 11/... | 0 | 0 | 1 | defa. |
| | 48.9 | 48.9 | 51.7 | 1.38 | | Lubrication success | AML-783 | 5 | 5 | 80 | 0x... | LU | 6/06/2019 | 8:31 AM | | 54 | 53 | 30 | | 11/... | 0 | 0 | 1 | defa. |
| | 49.2 | 49.9 | 62.9 | 4.84 | | | | | | 80 | 0x... | LU | 6/06/2019 | 8:31 AM | | 54 | 53 | 30 | | 11/... | 0 | 0 | 1 | defa. |
| | 39.2 | 39.5 | 47.4 | 2.57 | | Lubrication success | AML-783 | 11 | 11 | 80 | 0x... | LU | 2/05/2019 | 2:07 PM | | 54 | 53 | 50 | | 11/... | 0 | 0 | 1 | defa. |
| | 46.2 | 46.8 | 57.1 | 3.51 | | | | | | 80 | 0x... | LU | 2/05/2019 | 2:06 PM | | 54 | 53 | 50 | | 11/... | 0 | 0 | 1 | defa. |
| | 43.9 | 45 | 51.6 | 2.43 | | Lubrication success | AML-783 | 6 | 6 | 80 | 0x... | LU | 23/04/2019 | 8:22 AM | | 54 | 53 | 50 | | 11/... | 0 | 0 | 1 | defa. |
| | 49.5 | 50.7 | 66.7 | 7.24 | | | | | | 80 | 0x... | LU | 23/04/2019 | 8:22 AM | | 54 | 53 | 50 | | 11/... | 0 | 0 | 1 | defa. |
| | 43.9 | 45.3 | 51.1 | 2.29 | | Lubrication success | AML-783 | 1 | 1 | 80 | 0x... | LU | 9/04/2019 | 10:13 AM | | 54 | 53 | 50 | | 11/... | 0 | 0 | 1 | defa. |
| | 46.5 | 47.3 | 60 | 4.73 | | | | | | 80 | 0x... | LU | 9/04/2019 | 10:13 AM | | 54 | 53 | 50 | | 11/... | 0 | 0 | 1 | defa. |

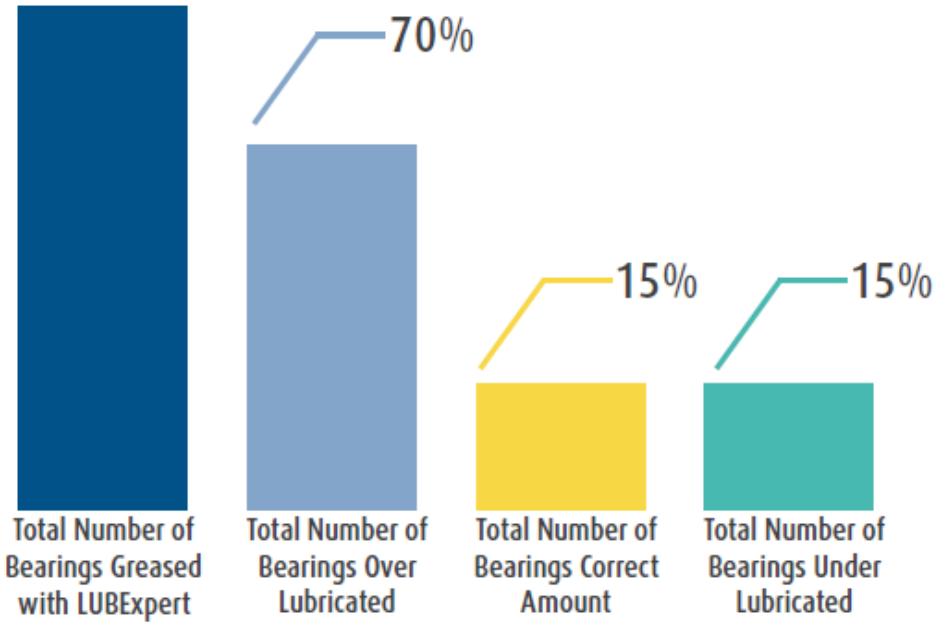
## Results

After having conducted numerous trials on a large volume of grease lubricated bearings from various plants which were previously greased using fixed replenishment rates calculated from grease application formulas and / or calculators.

In one example, using ultrasound (LUBExpert) to determine correct quantity of grease, the study

indicated that approximately:

- 70% of bearings were being Over Lubricated;
- 15% of bearings were Under Lubricated; and,
- 15% of bearings had the correct replenishment rate.




Results obtained from this trial were similar to results obtained from other plants.

## Conclusion

The greasing of bearings is tailored to the condition of each bearing rather than relying on fixed / calculated quantities condition-based lubrication.

Greasing using ultrasound:

- Improves equipment reliability and availability by ensuring the bearings receive the correct amount of grease;
- Information collected and stored in the lubrication database facilitates further optimization of lubrication schedules and reliability programs;
- Reduction in grease usage and optimization of schedules has cost savings implication.

# Diagnosing Bearing Failure During Re-Lubrication Tasks with LUBExpert

**Author:** Rob Dent and Gilles Lanthier
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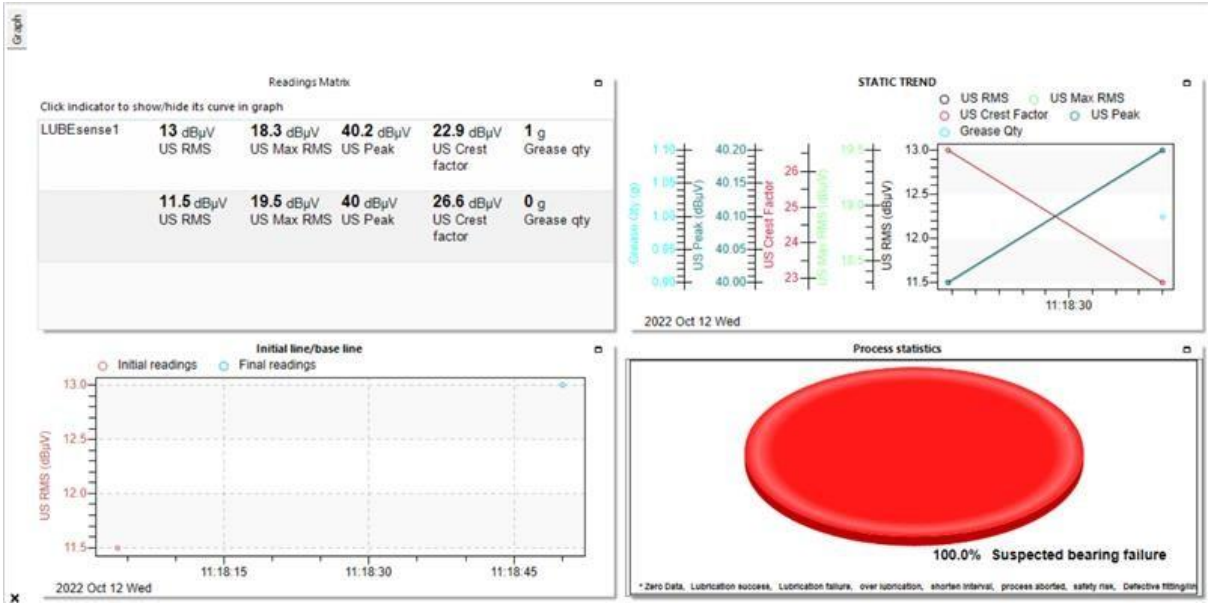
## Suspected Bearing Failure Discovered with LUBExpert Dynamic during Ultrasonic Greasing Task, Confirmed in UAS3

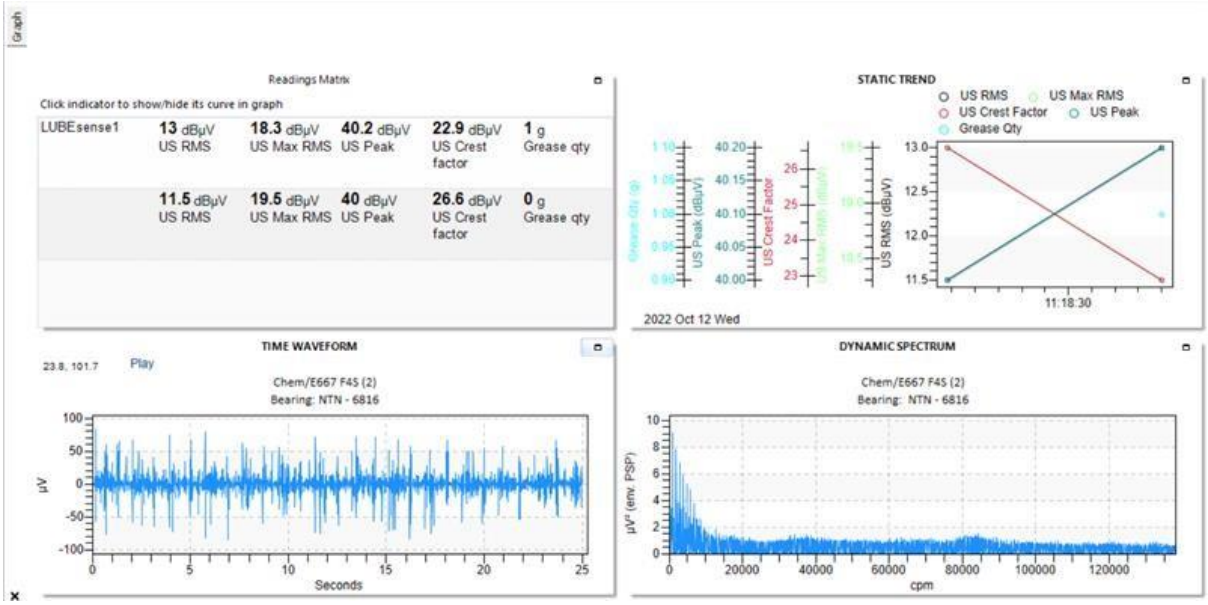
The outer race bearing defect was found by the Partnered Ultrasound Team during a routine lubrication route using a LUBExpert Dynamic.

SDT Field Services Technicians noticed the impact while listening to the lubrication task they were performing. And after greasing the bearing, its condition did not improve, indicating that the impact was not lubrication related.

After analyzing the dynamic ultrasound data in UAS3, it was confirmed that there was a suspected bearing failure.

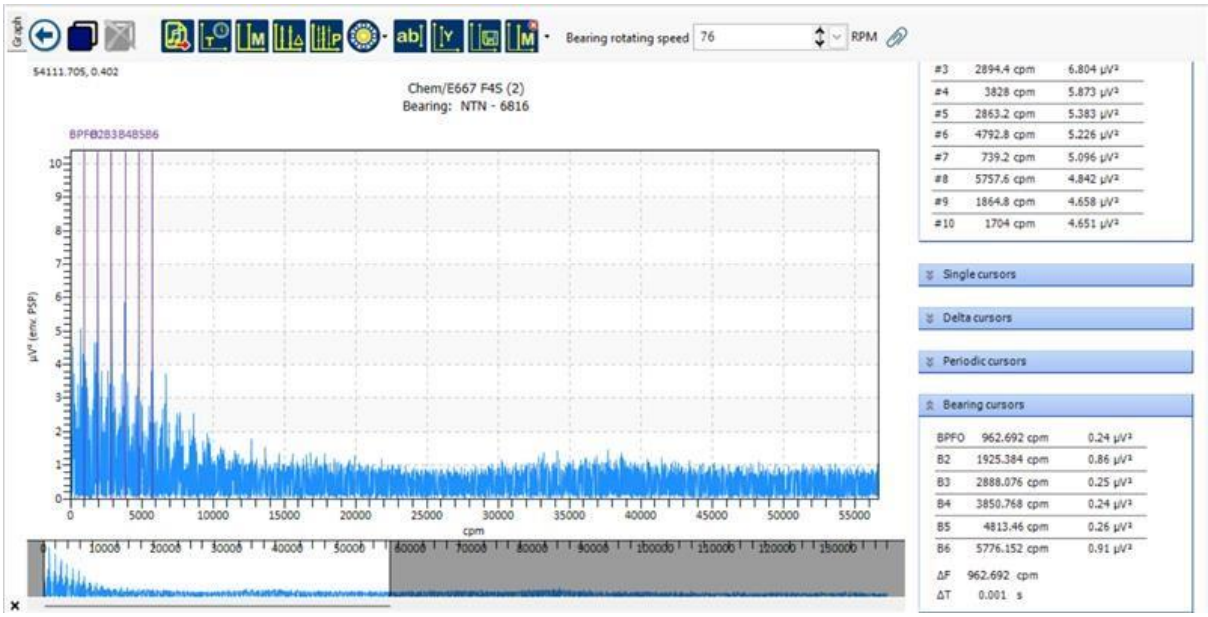



**UAS3 LUBExpert Dashboard Configuration 1**




**UAS3 LUBExpert Dashboard Configuration 2**

Further analysis using the Bearing Toolbox found that the impact was caused by an outer race defect.




**Failed Bearing 2 – Figure 2 – UAS3 Bearing Toolbox, BPFO Fault Frequency Cursors.**

A work order was promptly created to replace the bearing during the next planned shutdown.

What sets the LUBExpert apart from other ultrasound lubrication assistive devices is ability to listen to a bearing during a lubrication task and determine whether or not the presence of friction & impacting within the bearing are related to lubrication, or a different mechanical defect that greasing cannot fix.

# Monitoring an Extreme Slow Speed Wastewater Decanter with Ultrasound

**Authors:** Tristan Rienstra
**Email addresses:** tristan.rienstra@sdtultrasound.com

This large wastewater decanter centrifuge is tasked with continuously separating solid materials from liquids at a Canadian Pulp & Paper Mill.

Enormous quantities of water are used in the pulp and paper manufacturing process. For the process to be successful, fibres, such as pulp, wood, wood chips, and recycled paper must be suspended in water. In doing so, large amounts of wastewater are created. This wastewater must then be recovered so it can be reused in the future. Part of the wastewater recovery process involves using a Wastewater Decanter Centrifuge.

The Wastewater Decanter Centrifuge turns extremely slowly. The Bull Gear takes about 10 minutes for it to complete one full rotation, the pinion rotates at 2.95 RPM.

Due to the slow-speed nature of this asset, an ultrasound data collector with the ability to record large amounts of data, in the form of a long acquisition time, is the best tool for the job.

When monitoring this asset, the SDT Ultrasound Solutions Partnered Ultrasound Services Team chooses to take readings with the SDT340, as it is capable of taking 10 minute readings, which are necessary to capture one full rotation of this assets bull gear.

The 10-minute time waveform recording can be observed below in Figure 1.

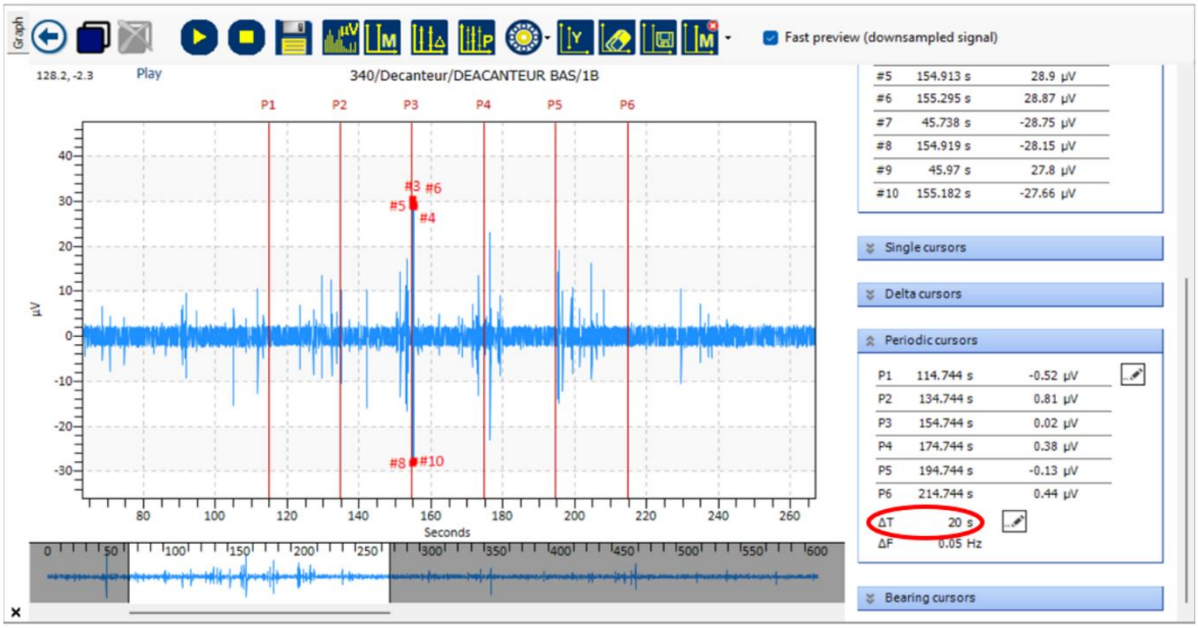



**Figure 1 - 10 Minute Time Waveform of Wastewater Decanter Centrifuge Pinion**

The motor powering the wastewater decanter is turning at 1785 RPM. The first reduction through a belt and planetary gearbox is 52.1 to 1. (1785/52.1=34.26).

The second reduction is at a ratio of 11.6 to 1. (34.26/11.6 = 2.95). Giving us the speed of the pinion.

Cracked and broken teeth generate high levels of ultrasound at 1 x RPM in the time waveform. Figure 2 depicts what a typical time waveform looks like when dealing with a cracked or broken tooth.

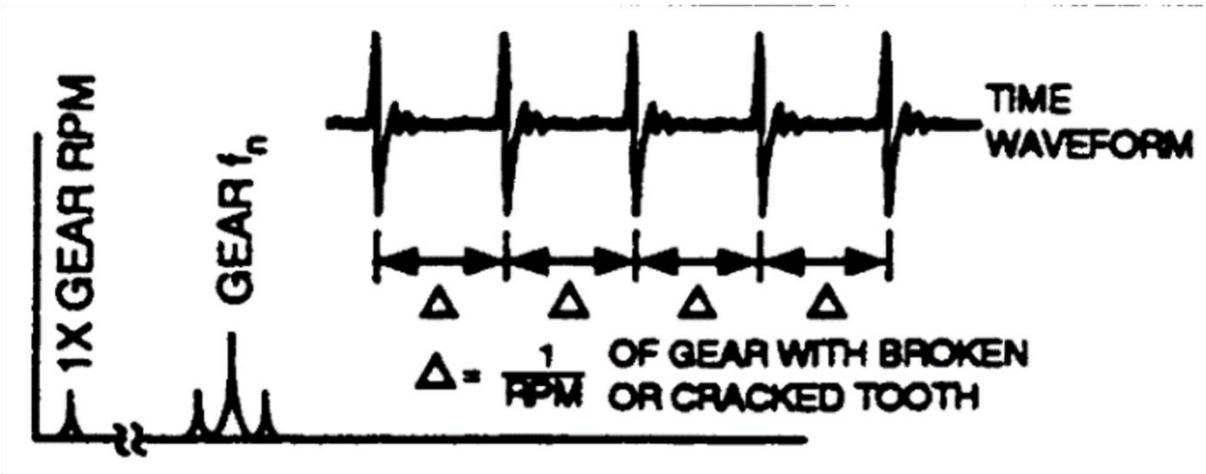



**Figure 2 - Cracked or Broken Tooth**

Observed in Figure 1, we can see a similar pattern to that in Figure 2. There is a pronounced spike every time the problem tooth tries to mesh with the teeth of the bull gear. The time between impacts corresponds to 1/RPM of the gear with the tooth problem. This data analysis lead SDT's Reliability Technicians to believe there is a cracked/broken tooth on the pinion gear.

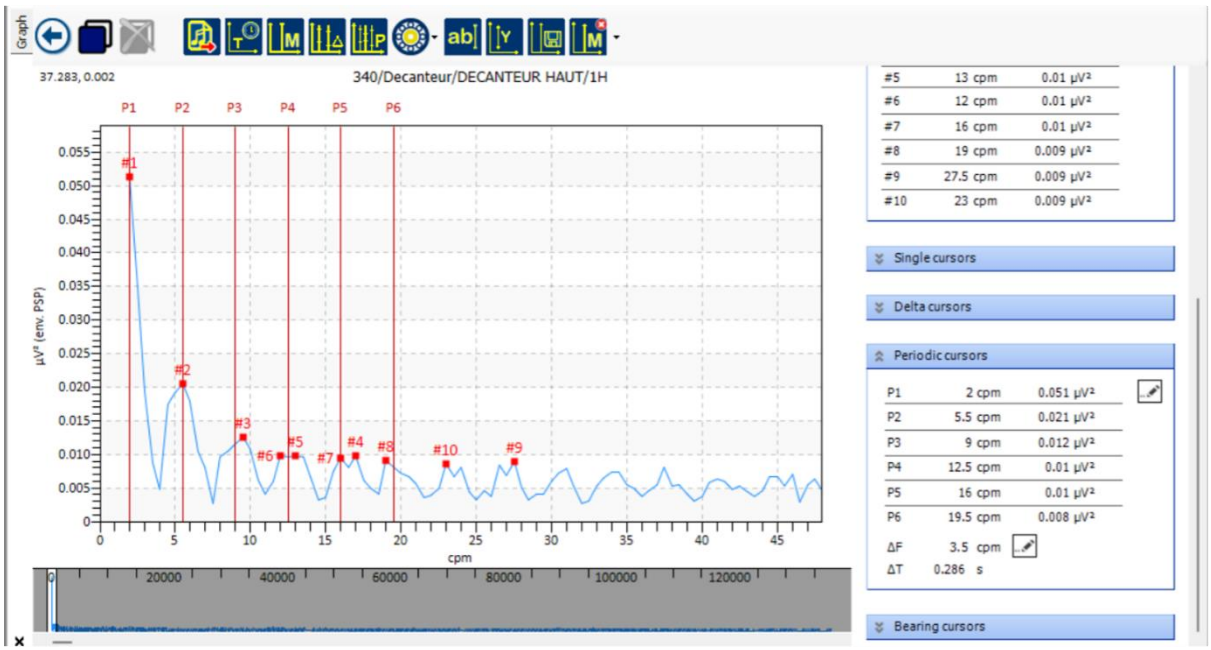



**Figure 3 - FFT on the Pinion**

As observed in the pinion's FFT, it can be seen that high levels of ultrasound above the sound floor are appearing at 1 X RPM.

Take into account that the resolution shows us a Delta F of 3.5 RPM. This number is not accurate as recordings were taken with too low of a measurement resolution. The real speed of the pinion is 2.95 RPM as shown in calculations earlier.

With the use of the SDT340 ultrasound data collector, the Partnered Ultrasound Team was able to record data a full rotation of an asset turning once every 10 minutes. With this data, they were able to detect a broken tooth on the pinion, despite the slow speed, and low aptitude of the impacts.

It would have been very difficult, if not impossible, to draw these conclusions with any other condition monitoring technology due to the low speed & amplitude of this defect.

# Ultrasound measurement on slewing ring and expertise after replacement

**Author:** Gauthier Ghislain
**Email addresses:** gauthier.ghislain@sdtultrasound.com

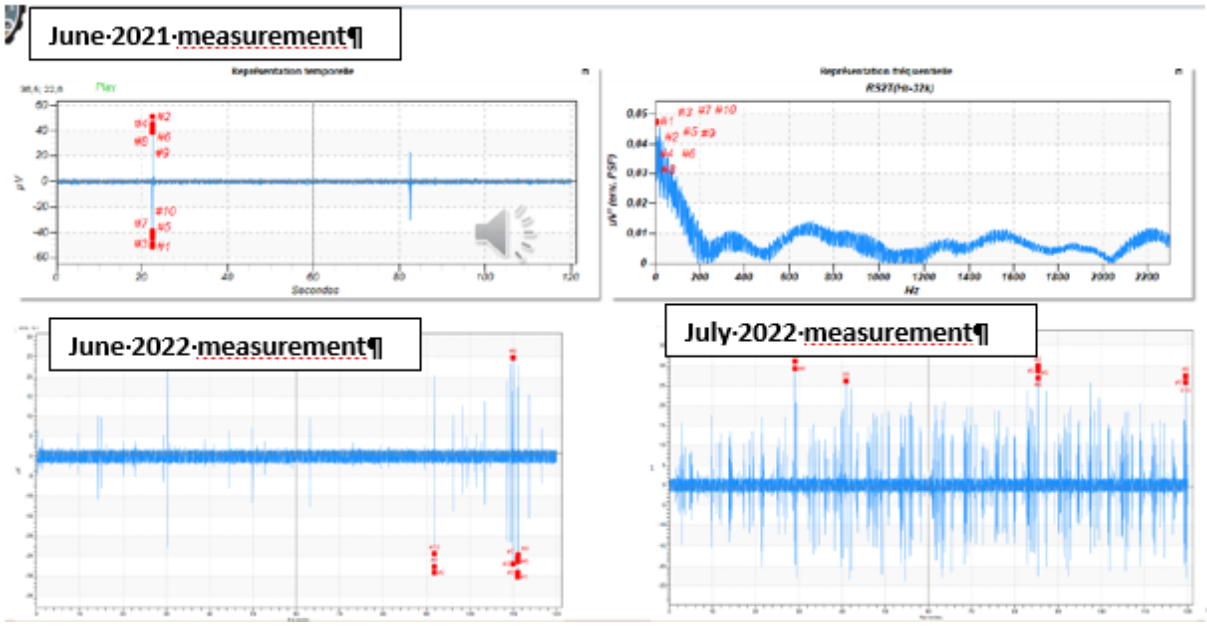
For years, the reclaimer at a paper mill in north-western France had worked reliably, pivoting on three pinions mounted on reducers. The reclaimer is used to collect wood chips from a pile and convey them by buckets. However, quite unexpectedly, the structure supporting this equipment collapsed. Fortunately, the company had implemented a monthly preventive maintenance program to monitor the condition of these slewing rings.

It was at this point that the company made a key decision. They decided to rely on technology to assess the severity of the ring's breakdown after the collapse. They used an ultrasound measuring device (SDT340), the only technology that could provide an in-depth analysis of the situation. Reference measurements taken prior to the incident were retained to enable the current state to be compared with the initial state.

The measurement process was complex. To make an accurate assessment, they had to rotate the equipment between two of the three sprockets for one rotation cycle, which took about two minutes. In addition, there was no known frequency, at least none provided by the manufacturer, for these

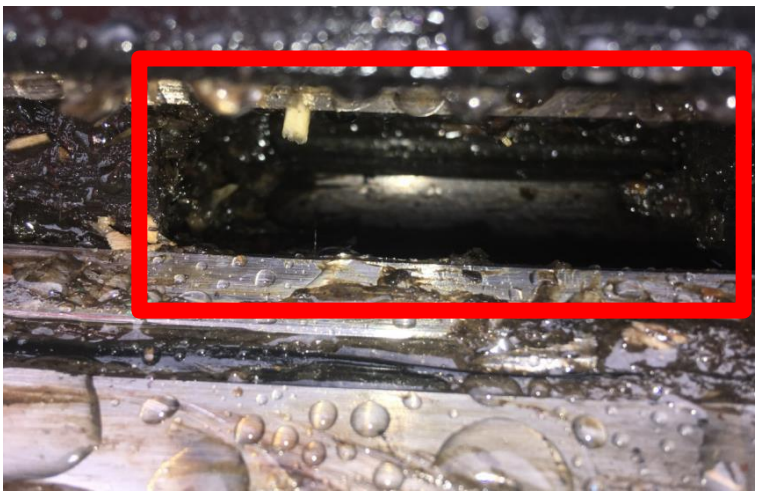
slewing rings. The speed of rotation was not always constant, making the task even more complicated.

However, the company was not discouraged. They knew that only a time waveform and careful listening could reveal the signs of a potential problem. By analyzing the data collected using ultrasound measurement technology, they were able to identify anomalies and deformations in the crown, indicating significant degradation.




The image above shows a rather evolutionary time waveform. Relatively normal measurements in June 2021 gradually shift towards the beginnings of unusual shocks in June 2022, culminating in a much more serious situation the following July.

After extensive work, the team was able to determine that some equipment was missing a number of rolling elements essential to its proper functioning. The missing rolling elements were probably due to wear of the "spacers" between the balls acting as cages.



Thanks to this early discovery, the company was able to take corrective action to avoid a major malfunction that would have had serious consequences for the safety and efficiency of their

products. They undertook immediate repairs and reinforced their preventive maintenance procedures.

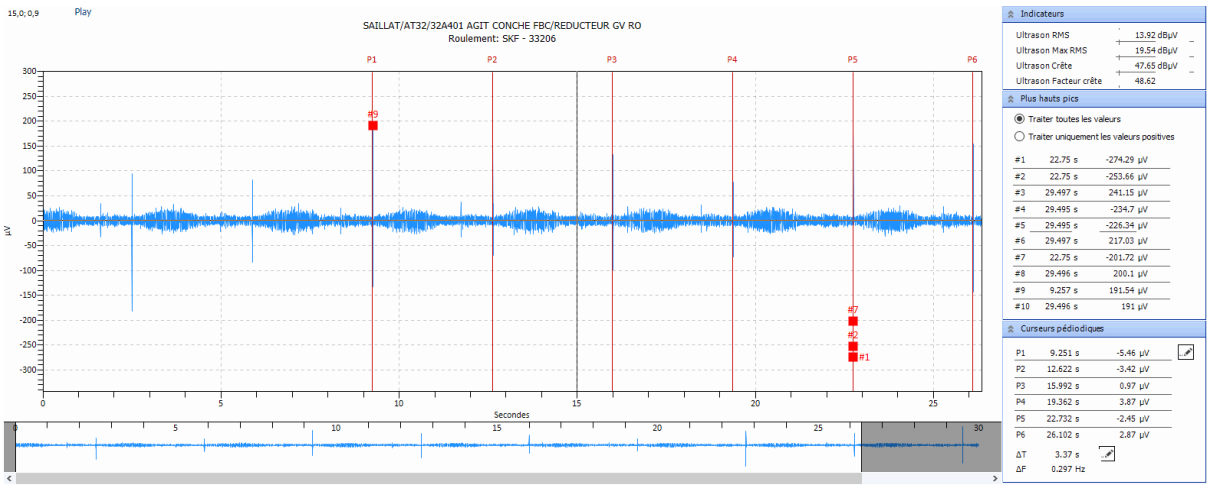
The decision to invest in ultrasound measurement technology proved to be a wise one for this company. Not only did it prevent a major incident, it also reinforced their reputation as an industry leader, demonstrating their commitment to product quality and safety. This success story illustrates how cutting-edge ultrasound technology, prevention and innovation can save companies from potentially catastrophic situations.

# Mechanical equipment, where ultrasound comes into its own

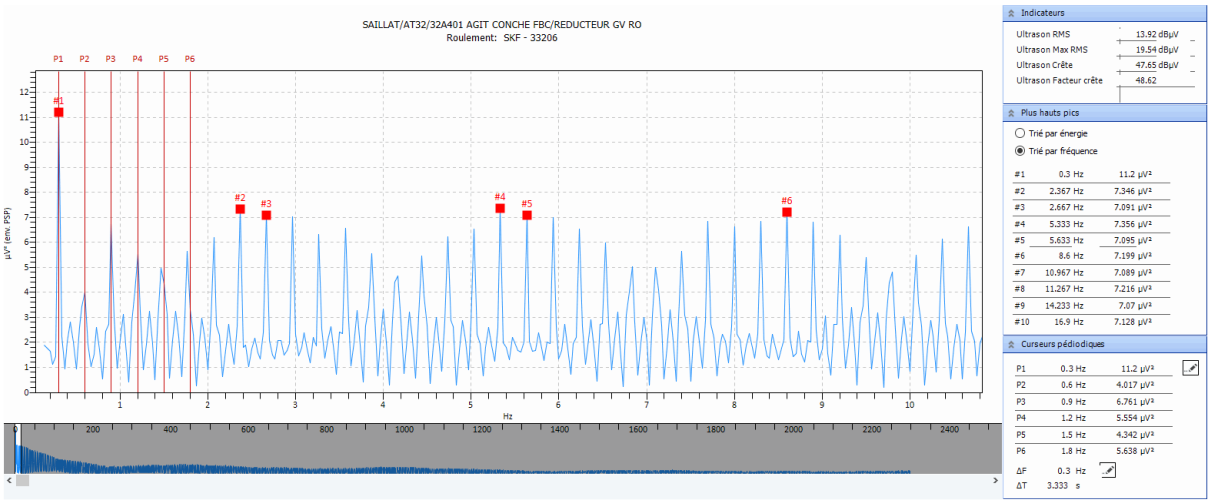
**Author:** Gauthier Ghislain
**Email addresses:** gauthier.ghislain@sdtultrasound.com

Recently, the maintenance team at a mill in north-west France shared with SDT an unusual but crucial piece of feedback on mechanical fault detection using ultrasound, highlighting how this method surpassed the capabilities of vibration analysis in accurately identifying the problem. This paper mill had a recurring problem with its filter. This filter, essential to their production process, had a problem with annoying noise and regular shocks to the agitator. This problem was seriously affecting their productivity and the quality of their final product.

One day, the team in question decided to solve this noisy mystery using the SDT340, a state-of-the-art ultrasound measurement device. They positioned it strategically to investigate the sources of this annoying noise. After careful ultrasound listening, they discovered something interesting: shocks at a frequency of 0.3 Hz on the GV/PV points, visible in the UAS3 software in the image below.




The time waveform and frequency spectrum clearly showed a clear impact at 0.3 Hz on the GV and PV points. The maintenance team then focused their attention on the coupling location, as this was where the noise seemed to originate.




By examining the kinematics of the system, they realized that the problem resided in the gearbox that drove the filter. This reducer was linked to coupling plates, and a rubber element called a flector was placed between the coupling fingers. This gearbox drove two shafts, one on each side.

Initial diagnosis revealed that the problem affected both the PV and the GV. By moving the ultrasound sensor, they noticed that the noise was most intense at the coupling bell. On closer examination, they found that the flector was completely torn, as shown in the image below, which explained the shocks and noise. The shocks showed a coupling backlash, causing a modulation on the spectrum that even masked the GV rotation frequency.

In comparison with a vibration analysis, the team confirmed that the shock values had increased, also revealing the frequency at 0.3 Hz. This was a crucial breakthrough, as the ultrasound analysis had pinpointed the precise location of the problem, which would not have been possible using vibration analysis alone.

The recommendation was clear: the flector was in such a state that it had to be replaced immediately to avoid further damage. Thanks to this innovative approach, which combined ultrasound technology with meticulous analysis, the company solved its lime sludge filter problem and was able to resume production without disruption or disturbing noise, marking a great success in their maintenance process.

# Water Treatment

## We succeeded, what is next?

**Author:** Haris Trobradovic
**Email address:** haris.trobradovic@sdtultrasound.com

Back in the fourth quarter of 2019, the SDT team assisted with the implementation of the LUBExpert (parallel to Condition Monitoring implementation) in a wastewater facility in SE Europe, with primary target of improving lubrication practice on 180 assets (more or less 700 bearings).

This task might sound simple and straightforward, still it highly depended on the many real condition facts. A relatively small team was working on several improvements at the same time: Condition Monitoring (CM) and Lubrication. A small team, in this case, means: two technicians engaged in CM activities, one grease technician and the maintenance manager playing the role of reliability engineer, lube manager, CM engineer as well as many others. Certainly, it was not an easy task for the team, and certainly it was not as it should have been, but that was the reality and what was approved by decision makers.

Obviously, that was one of those situations when management gives you less than you need to succeed, promising to give you more once you succeed. Catch-22, but it is something we face often, making the process more challenging and rewarding.

To make it happen, our grease technician was trained to the level of LUBExpert Strategist, understanding **Why** the job needs to be done, **What** needs to be done and **How**, and being able to perform entire setup, execution and reporting. Proper selection of lubricants, controlled purchase process, proper storage, cleanliness… all was included in the process, of course. Once started, the gained experience resulted in growing confidence, increased work efficiency, well organized work orders and smooth execution. Once a grease guy, now a LUBExpert Strategist.

However, there was another aspect of implementation that was highly important for the success of the entire program. Do more than required with less than needed.

The critical point of implementation was the proper positioning of each department (CM and Lube) and interdepartmental cooperation, considering available resources. The approach taken (knowing the LUBExpert's capabilities) was to break down departmental barriers and silos and organize it more like an army formation:

- first line of defense – grease bearings right and eliminate major cause of failures;
- scouting – frequent data collection and trending, share data and locate anomalies;
- light calvary – collect dynamic (TWF, FFT) data for analytic purposes;
- heavy artillery – deeper analysis, problem definition, root cause definition (and elimination).

Lots of work and lots of tasks for a small team.

As usual, Pareto's 80:20, fits in from all angles. 80% of problems come from 20% of activities, 20% of problems require 80% of available time to be analyzed … and so on.
Although it may sound ambitious, we assigned the first two tasks to our Lube team/technician:

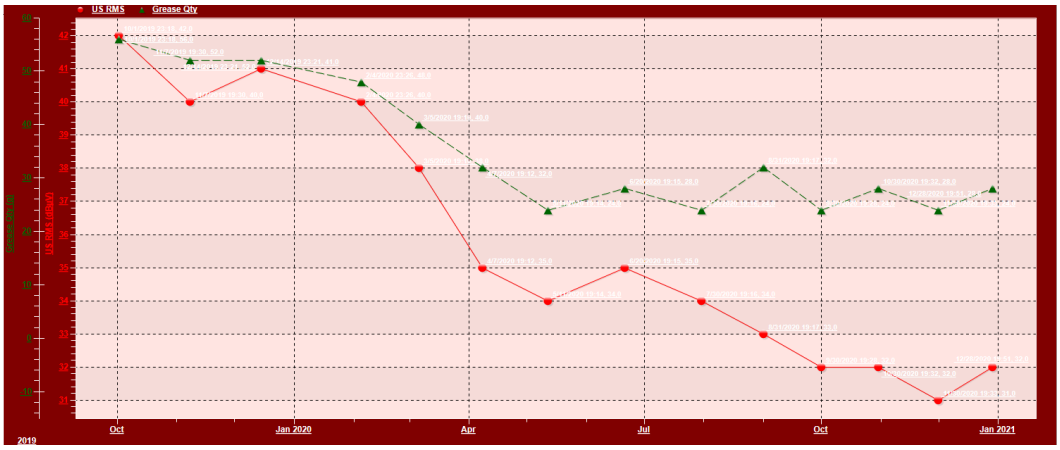
- First line of defense – Lubrication department job, surely
- Scouting – CM job, normally

Some call it too much of a burden, others think it is impossible, we see it as part of the LUBExpert strategy. Whoever is taking care of Lubrication, has his hands-on assets more frequently than anyone else in the Reliability team, and has the most interactive relationship with the asset. The LUBExpert Specialist (in this case also Strategist) collects data for Lubrication purposes, has an opportunity to monitor and trend data before and after replenishment condition, possess the data collected and analyzed during replenishment.

Knowing that, the LUBExpert Strategy easily takes care of the first two tasks, bringing huge benefit to the CM team by giving them the most valuable data, and consequently time! More available time for deeper analysis, problem definition, root cause search.

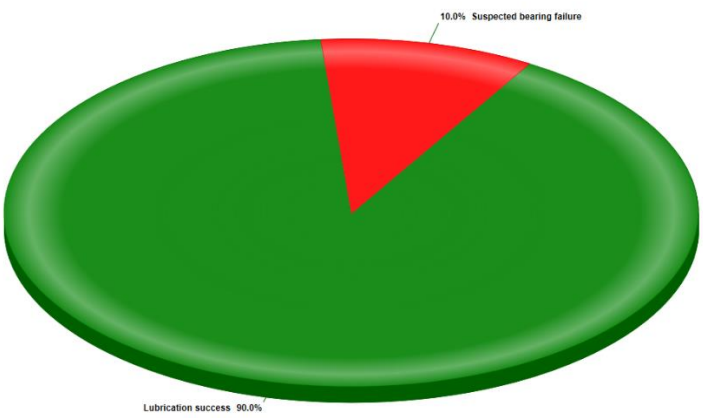
At the end of the first year of the LUBExpert program implementation:

- Lube technician took care of 35 – 40 bearings per day (per shift)
    - That includes work task preparation, data collection, on-site analysis based on triggered alarms, LUBExpert guided grease replenishment, data overview and possible strategy corrections, and reporting.
- All bearings showed an excellent response (as one in the picture 1 below), operating at the minimum friction and wear level:




**Picture 1**

- Process statistics (as shown in picture 2) showed high level of performance, correct lubrication practice and strategy settings, as well as additional observations and condition assessments:




**Picture 2**

- Q4 2020 compared to Q4 2019 shows significant decrease of bearings related failures in rotating assets;
- Q4 2020 shows no Lubrication related failures, except for the ones inherited from previous period;
- Full traceability and detailed data about each process achieved;
- Data shows that most of the previously used interval and quantity plans were incorrect;
- LUBExpert Strategy was successfully implemented.

In addition:

- The Lube technician delivered 12 500 Ultrasound readings to CM team, including static trend graphs, triggered alarms, before and after grease replenishment values, all relevant events, all taken actions;
- The Lube technician delivered 18 “Suspected bearing failure” warnings to CM team;
- The Lube technician delivered 10 “Safety risk” warnings to everyone’s attention.

The first year of implemented program can now be safely declared as successful. As usual, once you succeed, there comes the question: “What’s next?”

For the Lube team, “next” equals expanding the program to the entire plant and sustaining top performance.

For the CM team, “next” equals covering more assets, covering more failure modes, digging deeper into analysis to define a root cause, suggesting corrections to get rid of the root cause, and suggesting improvements.

So, first, we need to look at the accomplished results and assigned tasks, once again emphasizing the necessity to remove departmental division and silos mindset and conclude that both tasks are actually one. The question that we really needed to answer was: “How can the Lube team further assist the CM team to accomplish more with less or the same resources?”

Again, more work on the Lube tech’s shoulders?

Not really, the answer is: LUBExpert Dynamic.

LUBExpert Dynamic is equipped with an additional feature that collects Dynamic data (TWF, FFT) while performing usual LUBExpert work. No additional time needed, no additional training needed, no additional efforts, only additional benefits. Those benefits are exactly what the CM team needs to accomplish.

Now, out of four army style operating segments, we can add one more to the Lube team without creating any additional stress on our Lube tech, but freeing huge amount of time for our CM team:

- First line of defense – Lubrication department’s job, for sure
- Scouting – CM’s job, normally
- light calvary – collect dynamic (TWF, FFT) data for analytic purposes.

What does it mean for the Lube tech during his daily work? Absolutely nothing.

Dynamic data is collected in the background.

Remember this from above?

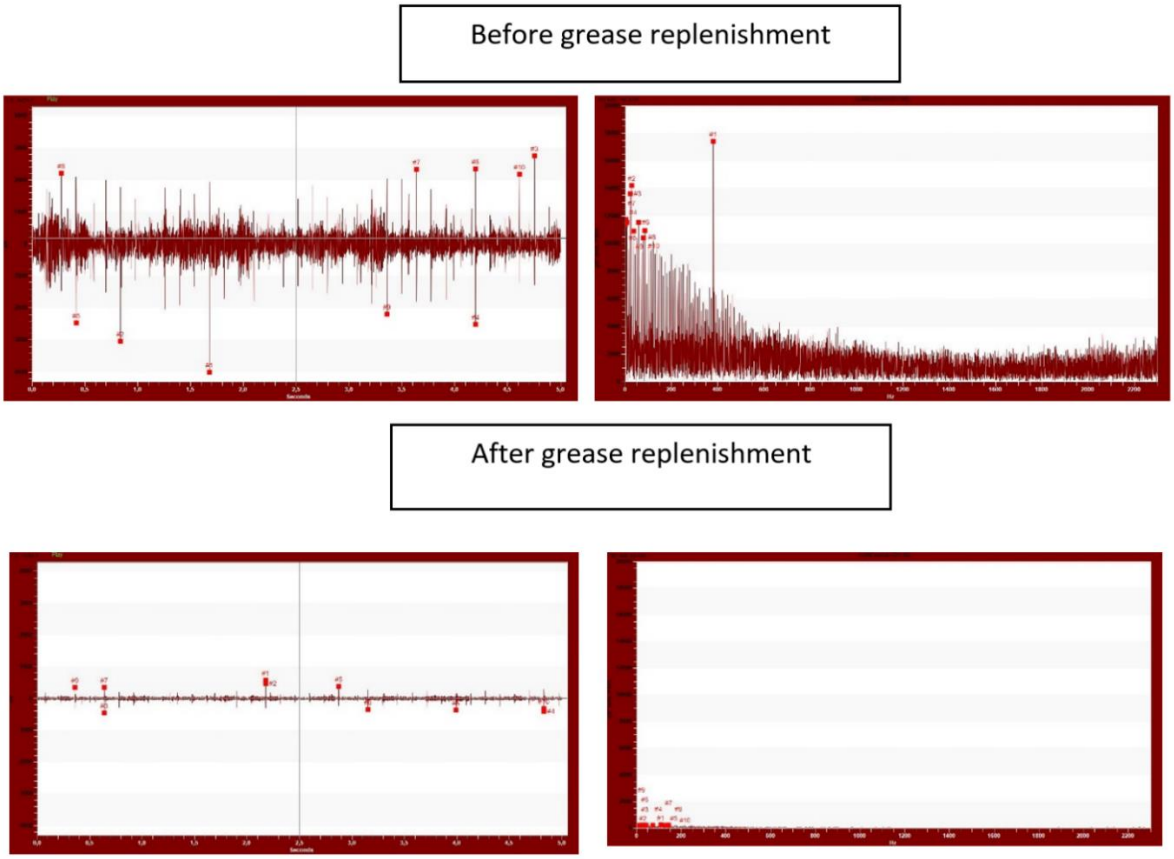
- The Lube technician delivered 12 500 Ultrasound readings to the CM team, including static trend graphs, triggered alarms, before and after grease replenishment values, all relevant events, all taken actions.

Now add the same amount of Time Waveform and Spectra, that normally requires the work of an additional technician.

One more task off the shoulders of the CM team and a huge opportunity for them to increase coverage, dig deeper and have more time for analysis and problem solving.

Each Condition Monitoring team knows exactly how big this benefit is and how it improves CM efficiency.

Here is what it looks like in the first week of implementation. Bearing successfully greased with declared condition as “Suspected bearing failure”, TWF and Spectra collected before and after grease replenishment (picture 3):




**Picture 3**

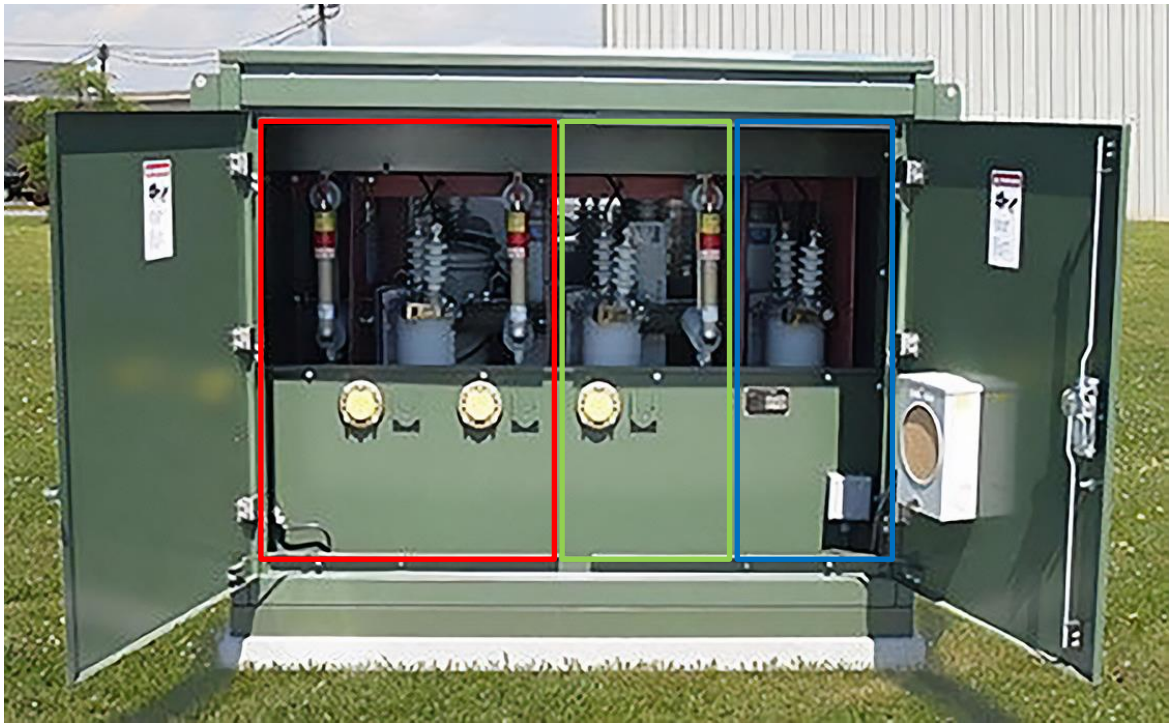
Lubrication as part of Condition Monitoring? Well, shouldn’t it be that way?

The first line of defense has just become a Maginot line.

## Pad Mounted Transformer

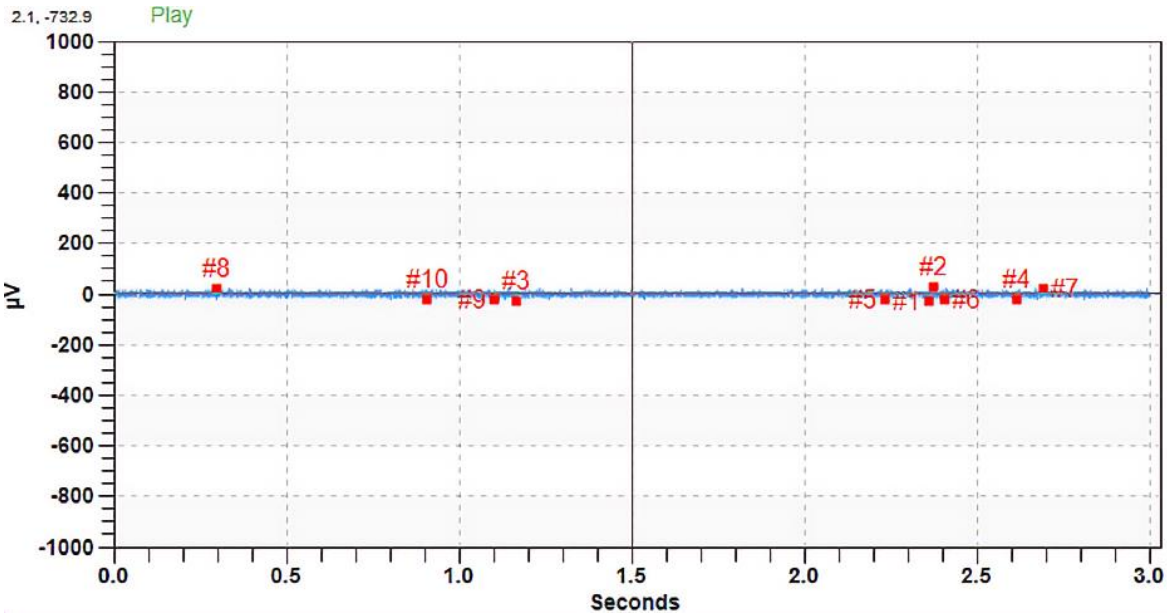
**Author:** SDT Ultrasound Solutions

A hydro company in Ontario, Canada used a parabolic dish to check the insulators within an electrical distribution panel after complaints of a smell in the area.

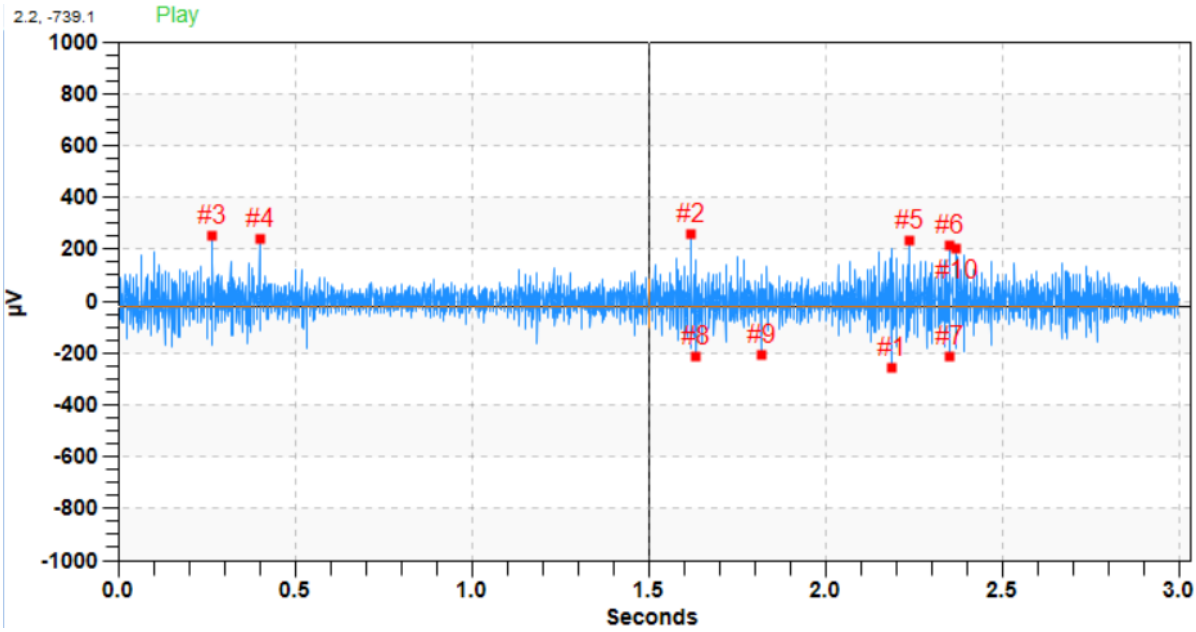


Scanning across the insulators very quickly identified the problem.

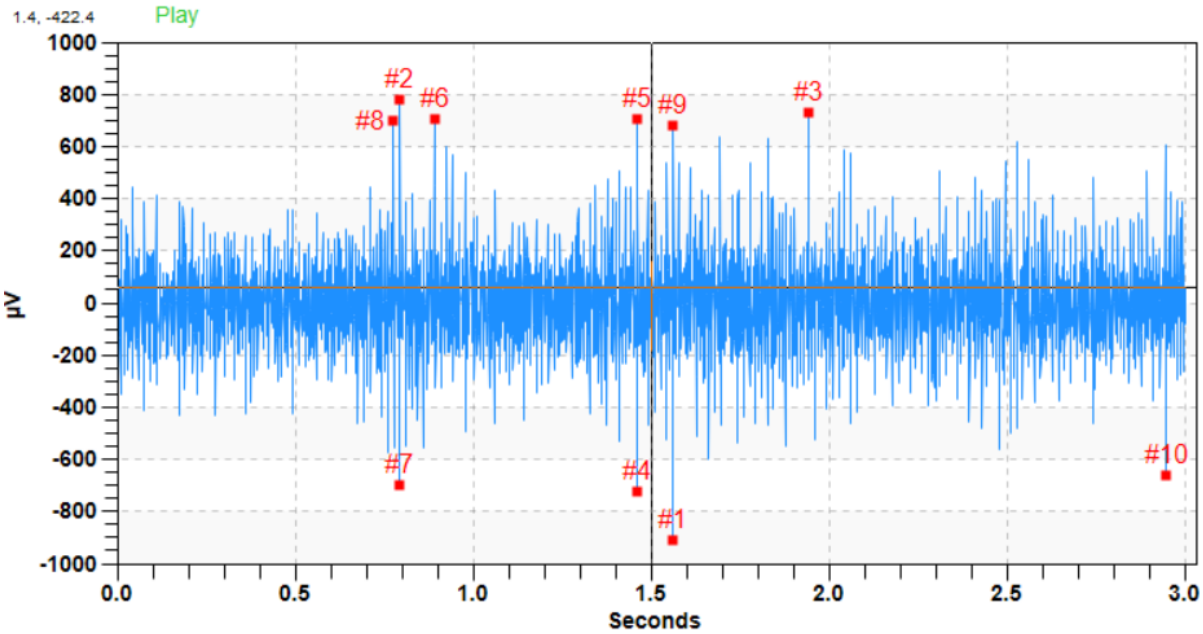
**Left Insulators: TWF**



### Middle Insulators: TWF

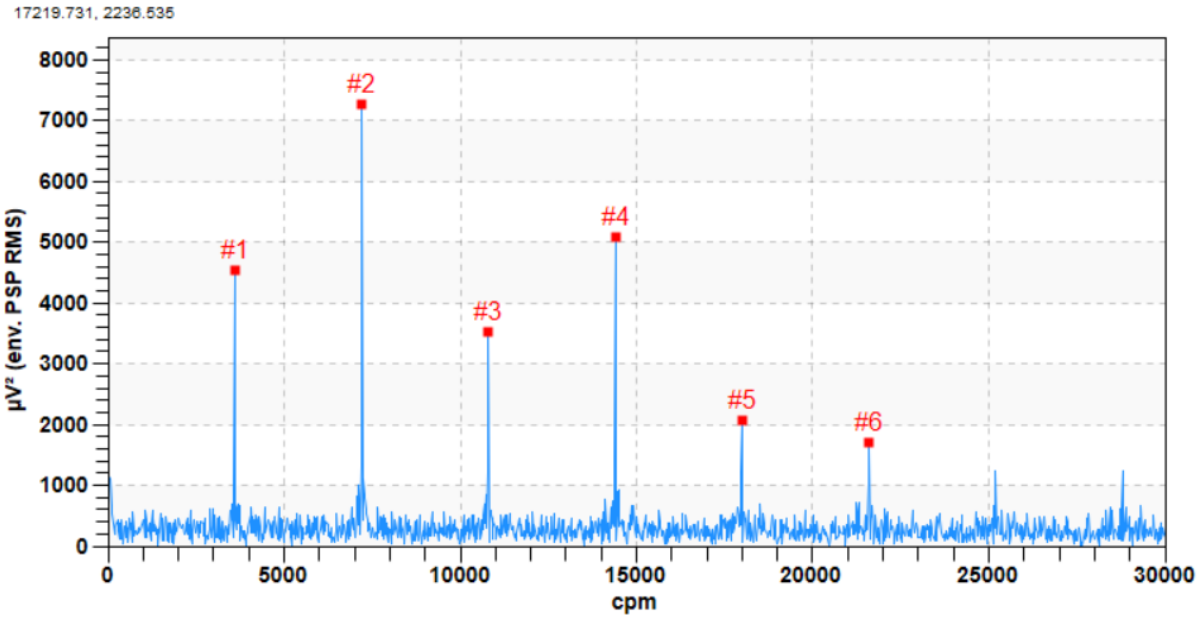



### Right Insulators: TWF




The time waveforms have been scaled identically. Ultrasound was present throughout the whole cabinet, but the source of the problem produced the loudest ultrasound. Corona was present.

The FFT below clearly showed the signals being produced at harmonics of 3 600 CPM or 60 Hz which is the electrical frequency used in North America.




**Highest Peaks**

- ○ Sorted by energy
- ◉ Sorted by frequency

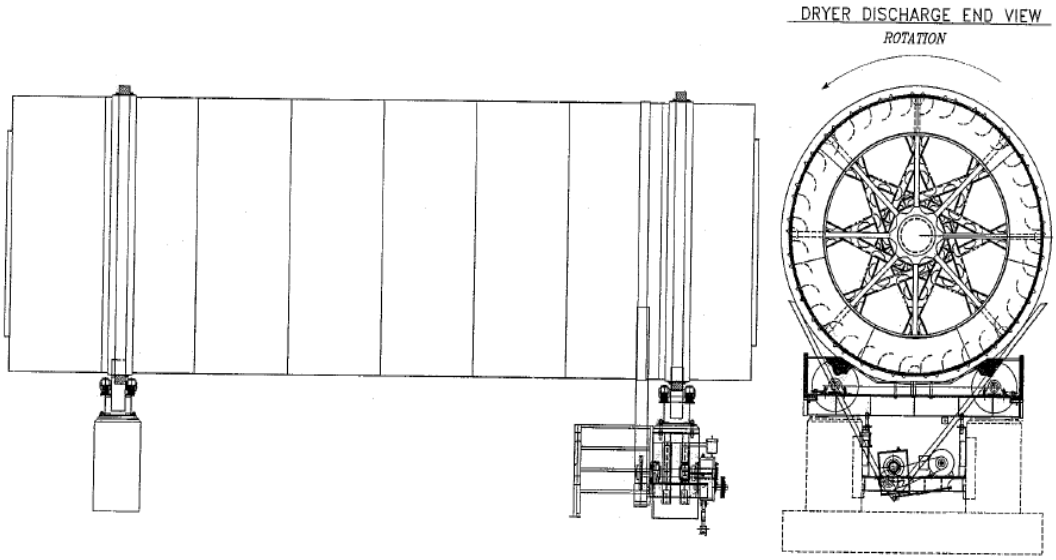
| | | |
|---|---|---|
| #1 | 3600 cpm | 4549.849 µV² |
| #2 | 7200 cpm | 7281.741 µV² |
| #3 | 10800 cpm | 3511.992 µV² |
| #4 | 14400 cpm | 5084.532 µV² |
| #5 | 18000 cpm | 2075.444 µV² |
| #6 | 21600 cpm | 1694.252 µV² |
| #7 | 32400 cpm | 1650.708 µV² |
| #8 | 36000 cpm | 1864.178 µV² |
| #9 | 39600 cpm | 1832.176 µV² |
| #10 | 43200 cpm | 1846.715 µV² |

# Agri-food Industry

## Low Speed Bearing 25 RPM

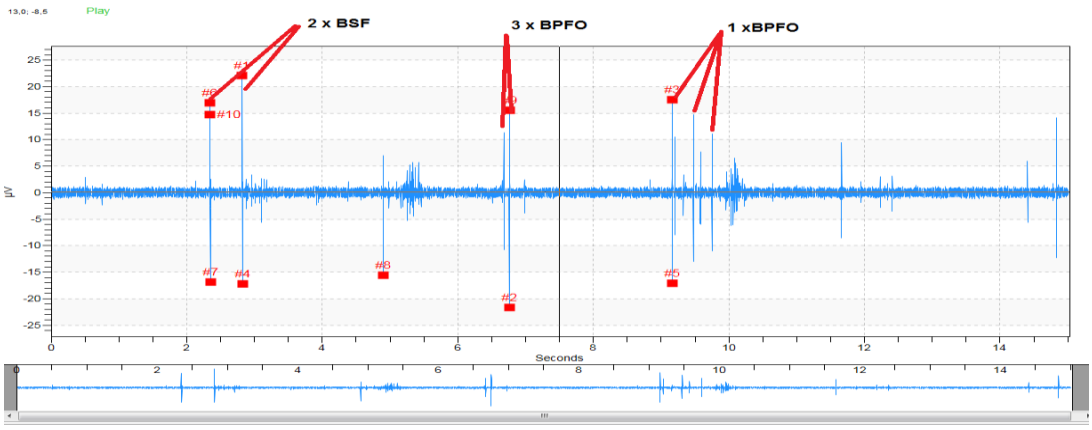
**Author:** SDT Ultrasound Solutions

In a factory, they have two dryers that allow them to dry a product destined for animal food. These large dryers have a drum 40 feet long, 13 ½ feet in diameter, which rotates about 4.2 RPM and has a weight of about 53 000 pounds and is supported by four trunnions. These consist of a roller that rotates at 25 RPM and two bearings Dodge P4B-IP-315R (it is a bearing 22 220 inside).

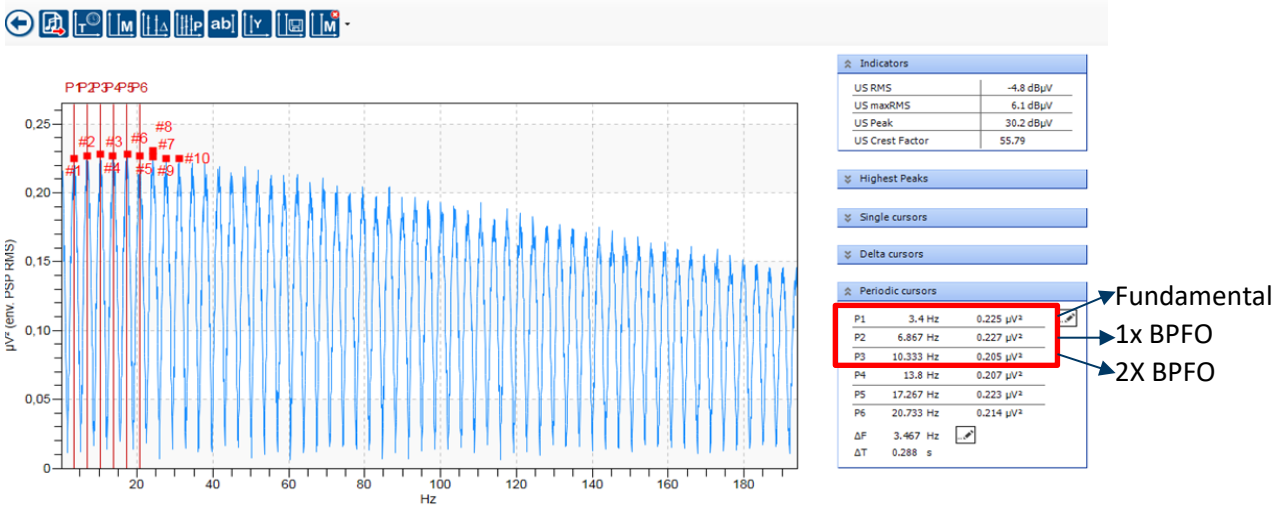



| Bearing defect frequencies of DODGE 22220 (Hz) | | | | | |
|---|---|---|---|---|---|
| | RPM | FTF | BSF | BPFO | BPFI |
| **1 fundamental** | .42 | .177 | 1.32 | 3.18 | 4.32 |
| **1 harmonic** | .83 | .353 | 2.64 | 6.36 | 8.64 |
| **2 harmonics** | 1.25 | .530 | 3.97 | 9.54 | 12.96 |
| **3 harmonics** | 1.67 | .707 | 5.29 | 12.72 | 17.28 |

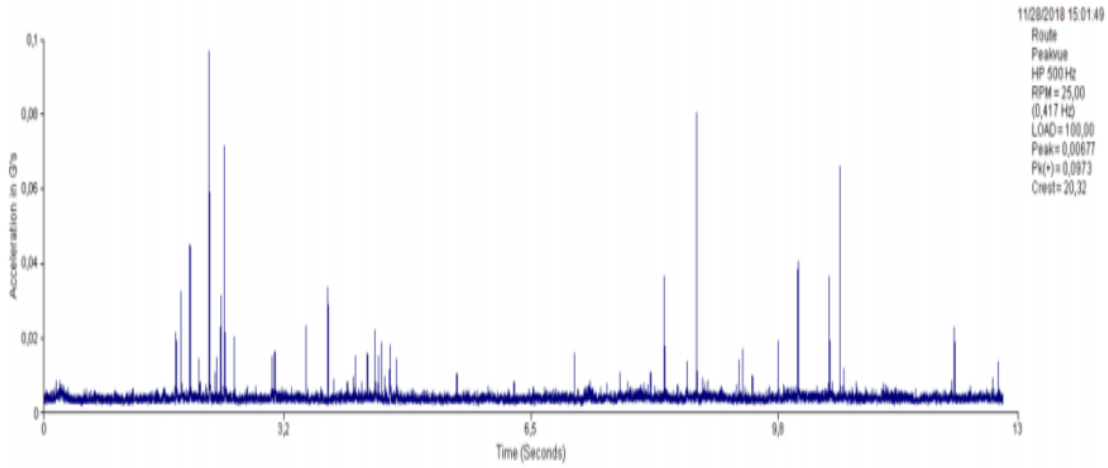
The ultrasound time waveform and spectra clearly showed impacts.

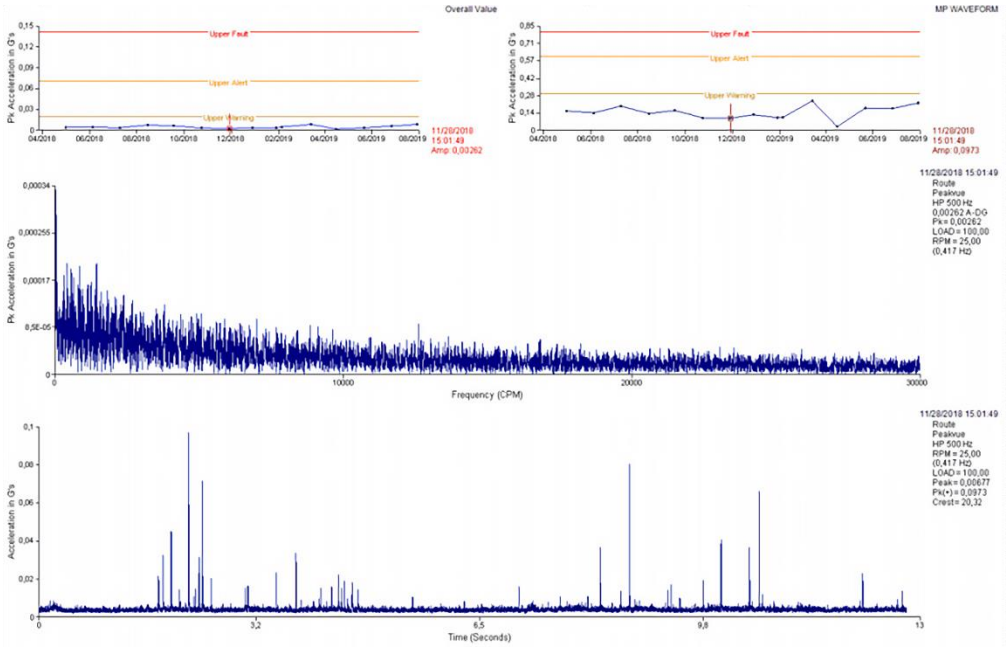



The ultrasound spectra showed the BPFO and many harmonics.

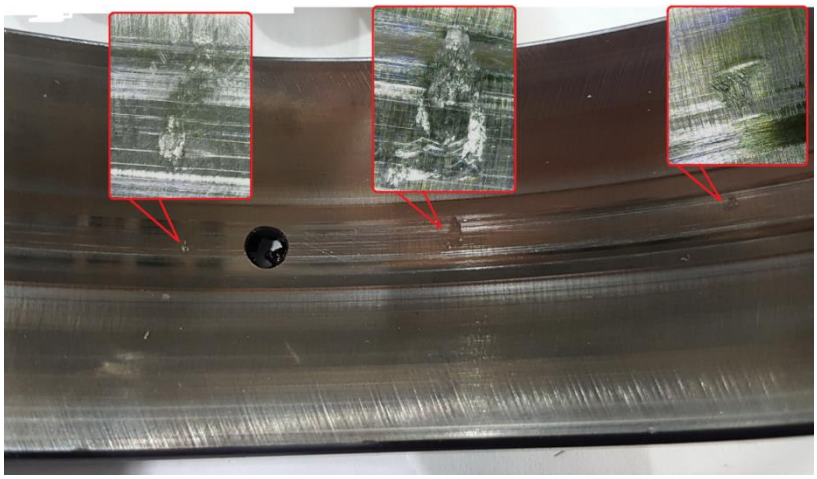



The vibration data did not reveal any noticeable problems because basically the accelerometer response is above 10 Hz.





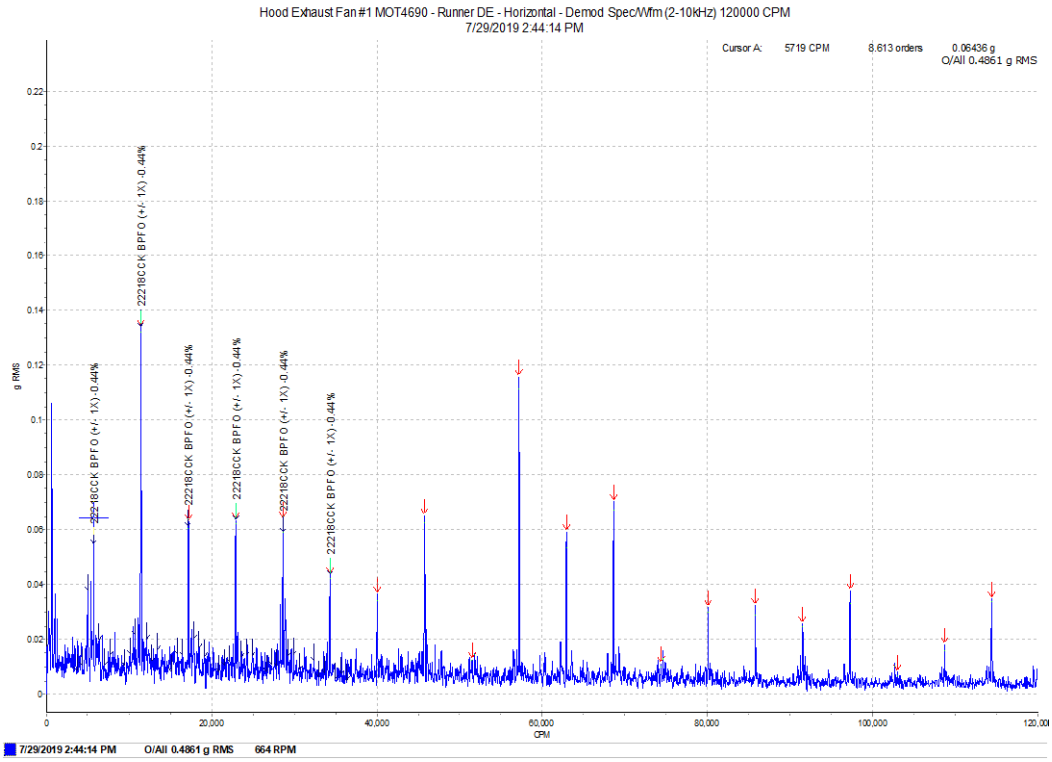

The bearing was inspected, and the outer race had cracks.



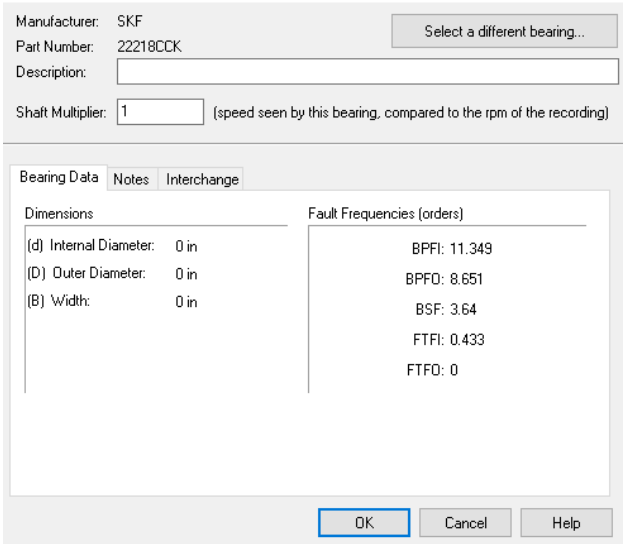
# Bad bearing on Exhaust Fan

**Author:** SDT Ultrasound Solutions

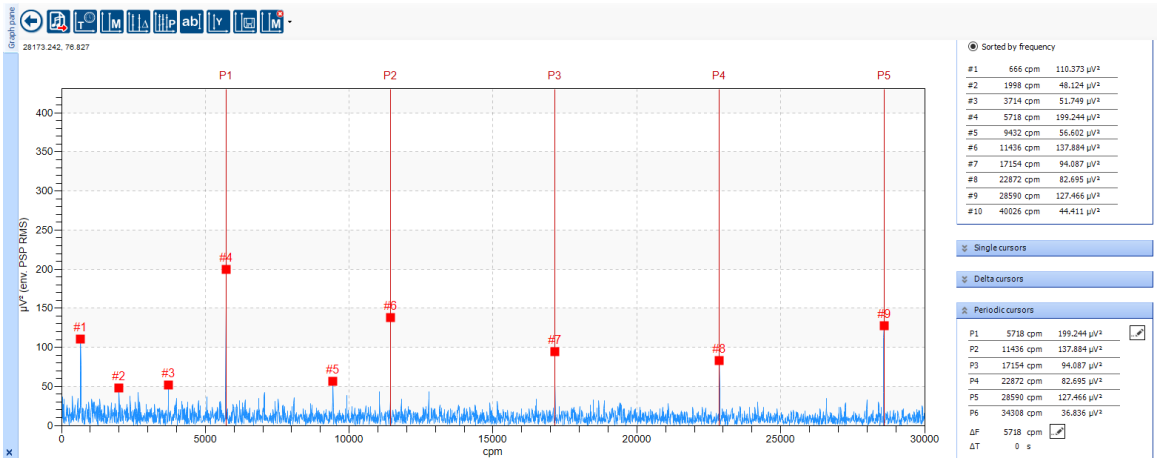
HFE

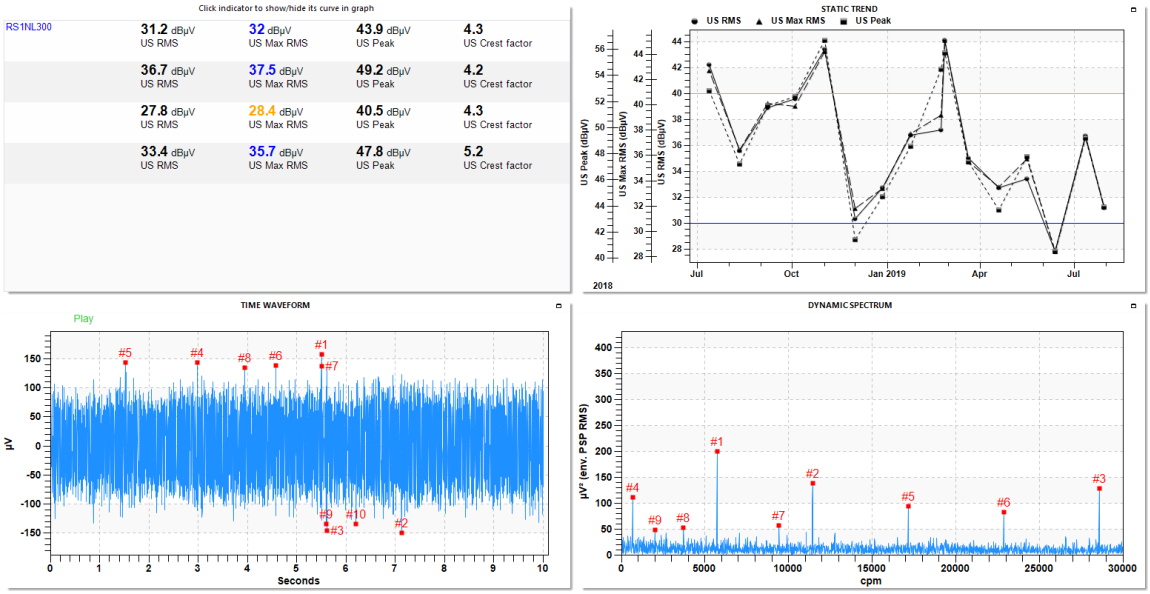



Fan running speed 665ish



## Ultrasound

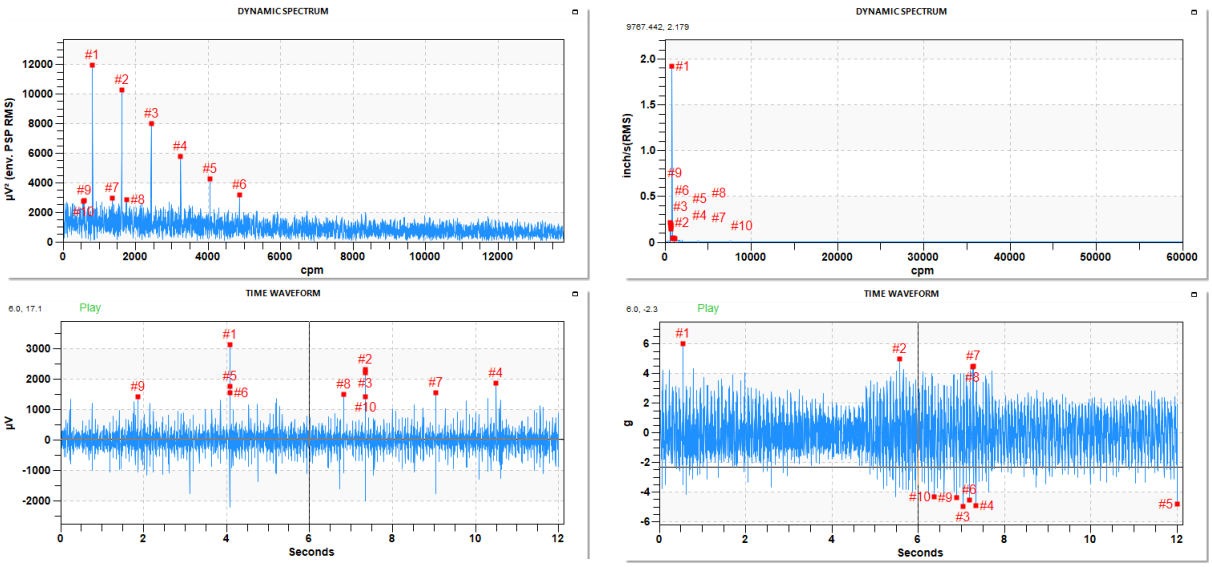

Graph curve
28173.242, 76.827
P1
P2
P3
P4
P5
µV² (env. PSP RMS)
cpm
Sorted by frequency
#1 666 cpm 110.373 µV²
#2 1998 cpm 48.124 µV²
#3 3714 cpm 51.749 µV²
#4 5718 cpm 199.244 µV²
#5 9432 cpm 56.602 µV²
#6 11436 cpm 137.884 µV²
#7 17154 cpm 94.087 µV²
#8 22872 cpm 82.695 µV²
#9 28590 cpm 127.466 µV²
#10 40026 cpm 44.411 µV²
Single cursors
Delta cursors
Periodic cursors
P1 5718 cpm 199.244 µV²
P2 11436 cpm 137.884 µV²
P3 17154 cpm 94.087 µV²
P4 22872 cpm 82.695 µV²
P5 28590 cpm 127.466 µV²
P6 34308 cpm 36.836 µV²
ΔF 5718 cpm
ΔT 0 s


Click indicator to show/hide its curve in graph
RS1NL300
31.2 dBµV US RMS
32 dBµV US Max RMS
43.9 dBµV US Peak
4.3 US Crest factor
36.7 dBµV US RMS
37.5 dBµV US Max RMS
49.2 dBµV US Peak
4.2 US Crest factor
27.8 dBµV US RMS
28.4 dBµV US Max RMS
40.5 dBµV US Peak
4.3 US Crest factor
33.4 dBµV US RMS
35.7 dBµV US Max RMS
47.8 dBµV US Peak
5.2 US Crest factor
STATIC TREND
US RMS
US Max RMS
US Peak
US Peak (dBµV)
US Max RMS (dBµV)
US RMS (dBµV)
Jul
Oct
Jan 2019
Apr
Jul
2018
TIME WAVEFORM
Play
µV
Seconds
DYNAMIC SPECTRUM
µV² (env. PSP RMS)
cpm

# Gravel sifter bearing

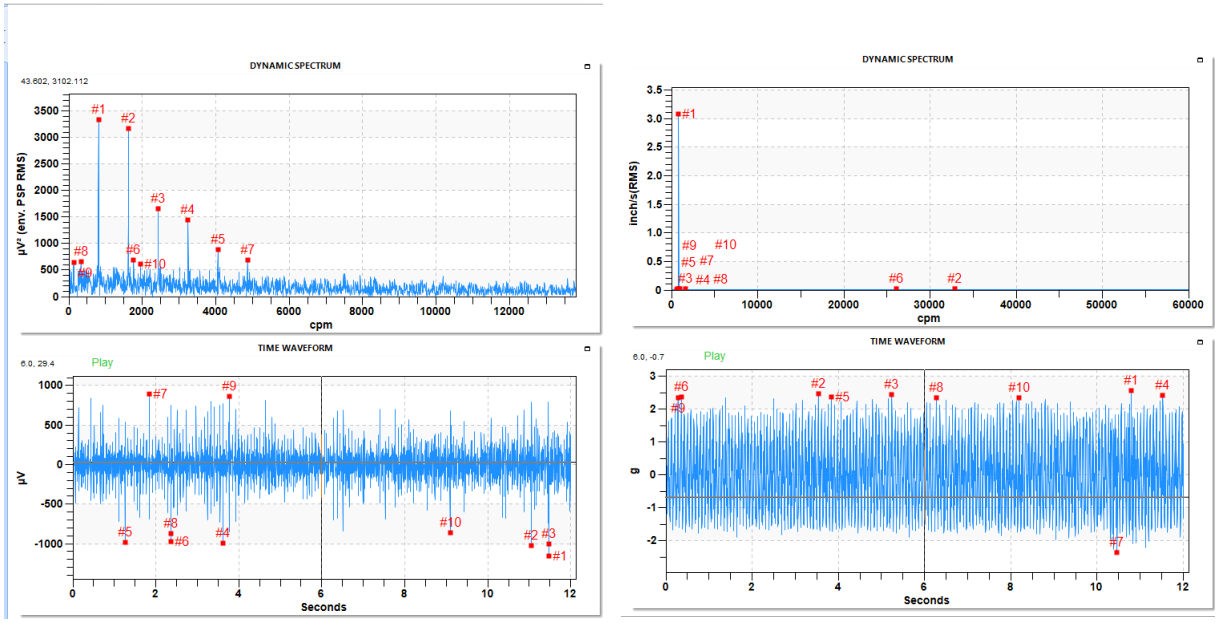
**Author:** SDT Ultrasound Solutions

Bearing #1 drive side.




Amplitude 12 000

Bearing #2




Amplitude 3 500

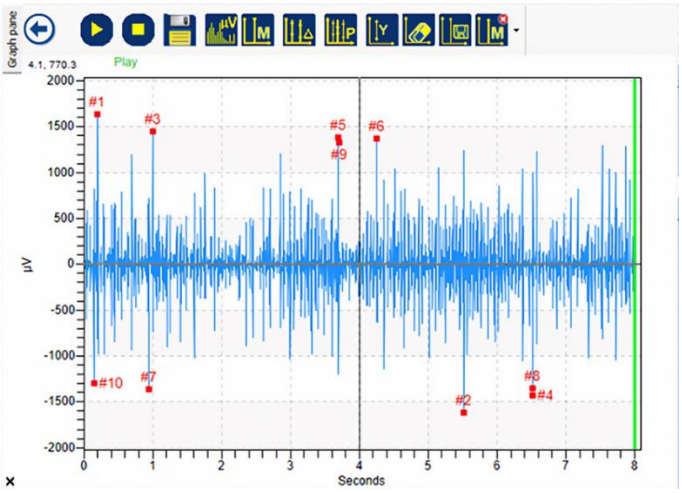
# Steel Mill

## John Garrison Main Hoist Input Shaft Bearing on Crane

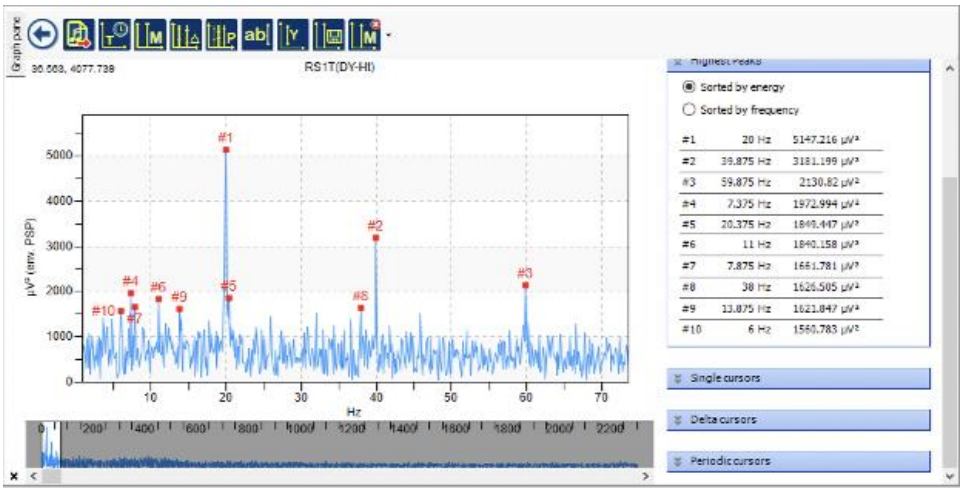
**Authors:** Tristan Rienstra and John Garrison
**Email address:** tristan.rienstra@sdtultrasound.com

On June 2, 2021, John Garrison was asked to check a main hoist input shaft bearing on a crane. Vibration analysis is not very useful for this application because of the amount of vibration and movement the crane makes. We knew ultrasound was the way to go.

Upon arrival to the crane, he began listening to the bearings on the input shaft and the brake drum side of the gear box. Immediately, John recognized something didn't sound right. He made it known to the crane technicians and went to upload the data to UAS3 so he could perform an analysis. John immediately recognized very high peaks in the wave form as well as an audio signal full of impacts.




He immediately went back to the crane technicians to review with them the data he had found. John briefed them on the 4 condition indicators (41.7 dBµv rms, 43.9 dBµv max rms, 65.9 dBµv peak, and 16.2 crest factor).




The crane crew technicians had two reservations... One that John hasn't been doing ultrasound analysis long, and the other was that this was the newest bearing on the crane being installed less than a month ago. The resulting action was that the bearings weren't changed even though the following week was a down day and the repair could have been planned.

Unfortunately, it wasn't and two weeks later the bearing failed. The unplanned downtime to repair the damaged input shaft and replace the bearing took approximately 6 hours. The loss of production was expensive enough, not to mention the cost of parts and labor.

Since the repair was made, the crane technicians have much more belief in ultrasound technology, and we have been routinely monitoring the bearings on the crane.

Below is the input shaft bearing right after being pulled out of the gearbox. As you can see all the rollers are gone and had to be fished out of the bottom of the gearbox. Fortunately, they didn't get caught in the gears causing further problems.

# Predicting and preventing transformer outages in a steel mill

**Author:** Allan Rienstra
**Email address:** allan.rienstra@sdtultrasound.com

Skip Young, a maintenance technician, has decreased untimely production shutdown by combining ultrasound inspection and infrared inspection at Gerdau Ameristeel's Calvert City, Kentucky Facility.

## A specific background

Processing steel requires continuous electric power supply. The maintenance team must therefore prevent the untimely failure of electrical components. Such failures are often due to the presence of partial discharges and will result in untimely production shutdowns. However, decreasing the failure rate is not enough. Anomalies must be detected as early as possible. The later the detection, the higher the repair costs for the component or the longer its replacement or production restart will be delayed. An efficient solution consists in detecting anomalies, as early as possible, by combining ultrasound analysis and infrared imaging of electrical systems, such as substations, transformers, etc.
Gerdau is one of the world's leading steel producers. Gerdau Ameristeel, the American arm of Gerdau, operates 19 mills in North America. Ultrasound and infrared inspections are used to prevent electrical outages in the group's mills. The example of how ultrasound technology prevented a transformer outage was provided for this paper by Skip Young, a technician with the facility in Calvert City, Kentucky.

## Partial discharge is the root of all evil

Most high-voltage electrical faults are the result of partial discharges. But partial discharges also affect low-voltage switch gears.
Standard IEC 60270 defines partial discharge as a localized electrical discharge that partially shorts out the insulating void between the conducting parts. It is called "partial" because it only affects part of the insulator. It is a destructive phenomenon due to the damage to the insulator, which in turn can result in its total destruction.

## An insidious enemy

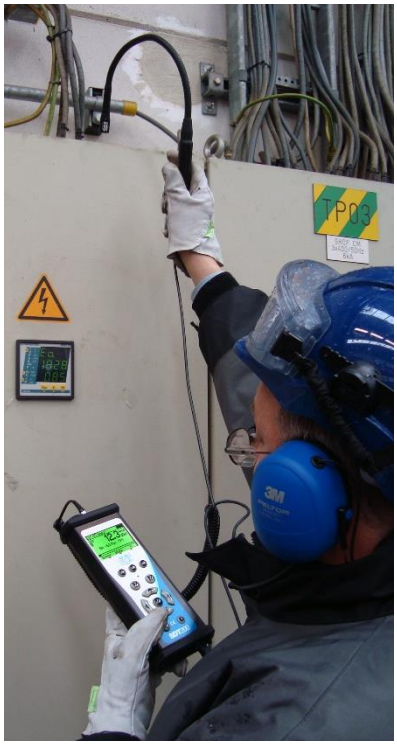
From the first occurrence of the defect to sudden breakdown, partial discharge is not easy to detect, at least in the absence of suitable means: equipment is running as new and partial discharge has no incidence on its performance. Furthermore, the residual lifetime of a component exposed to partial discharges is not easily predictable. Indeed, it depends on other factors that are impossible to assess and can vary in time. The main factors are operating voltage, ambient temperature, humidity, and pollution, which is often found in steel mills.
So, here is the issue: no breakdown resulting from partial discharges – and this is often a major breakdown – is acceptable from an economic standpoint. The best way to prevent such a breakdown is to perform inspections on a regular basis. Now, what technology should we use?

## Ultrasound AND infrared: the winning pair

These are not competitive, but complementary technologies.
For example, arcing generates a strong heat release. On the contrary, corona and tracking discharges do not feature any heat build-up, except at a very advanced stage. We will see hereafter that early detection is also essential. Therefore, the response is clear: the best strategy consists in combining ultrasound and infrared inspections.

## Early detection for simple and low-cost maintenance

If the partial discharge is detected early, the maintenance team has more time ahead before repairs are required. They can then confidently plan a maintenance operation during the next scheduled production shutdown. But that's not all. Early detection of anomalies has a financial impact too. Required maintenance will remain simple, hence inexpensive. It will consist in cleaning, dusting, and tightening all connections. No comparison with long and expensive maintenance operations, such as full overhaul or replacement of subsystems.




## Required diagnosis

Detecting partial discharges is not enough. The maintenance department will have to issue a precise diagnosis in order to assess the defect severity. That is, reliably decide on the level of urgency of the operation.

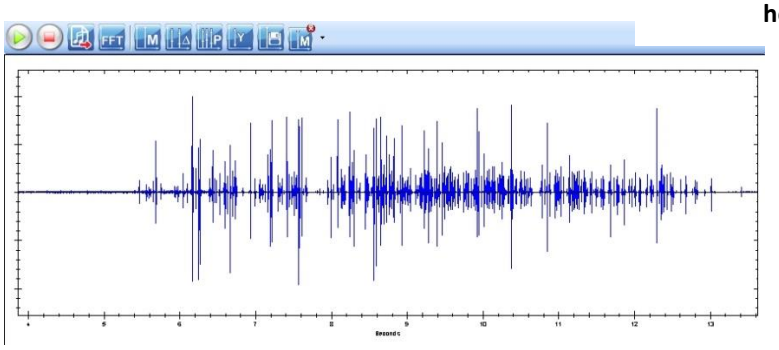
However, partial discharges are a specific application where defect severity does not depend on the measurement amplitude. The signal shape and content, which are not easily identified by listening, are used to detect the presence of corona and/or tracking and/or arcing discharges. This is the reason why SDT offers several technical solutions to address this specific issue. The 4 condition indicators – RMS, Max RMS, Peak and Peak factor – are the first line of defense. The second tool available to the operator is an audible rendering in real time via heterodyne. Finally, time and frequency signal analysis using the Ultranalysis Suite software is the final piece in the jigsaw puzzle that allows issuing a reliable diagnosis. The case study presented below is a perfect example of the usefulness of these different tools.

## The Gerdau case study

During an inspection, Skip Young detected the existence of a partial discharge on a phase of a transformer head using his SDT270 collector. By comparing the 4 condition indicators obtained after collecting static measurements, he was able to conclude that this was not a minor defect like nuisance corona. The thermogram showed no hot spot. Skip concluded that it was not a resistive defect of the arcing type.

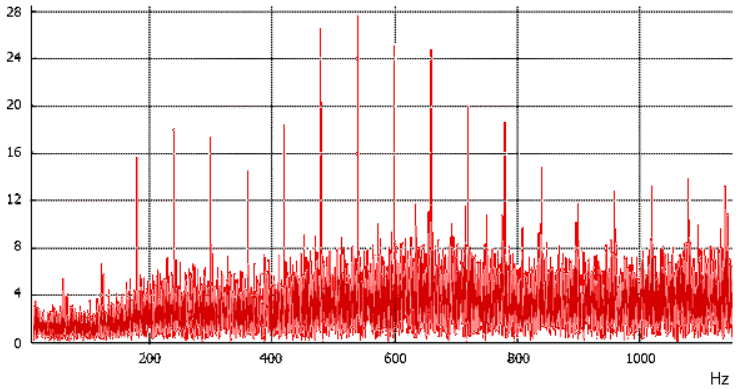
Time signal analysis clearly shows the presence of tracking.


**The thermogram showed no hot spot.**



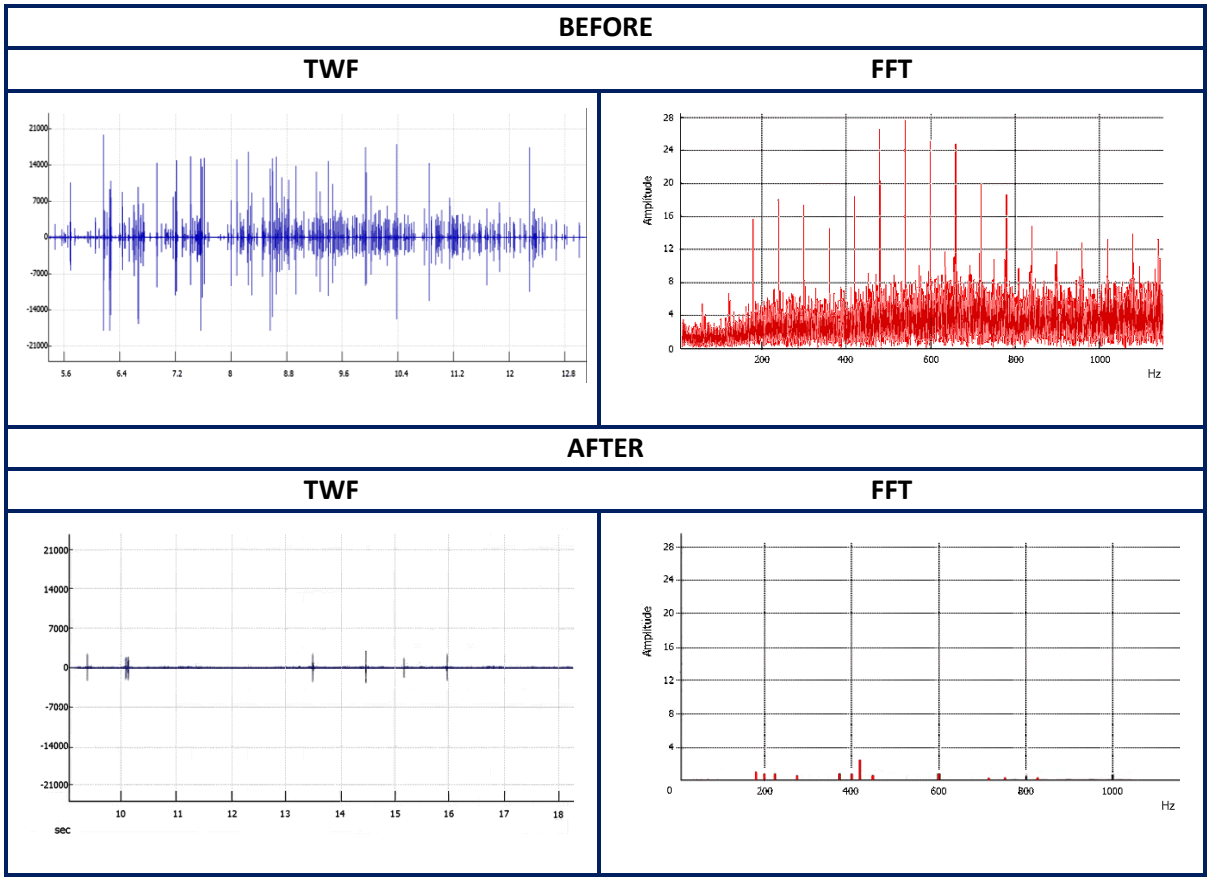
**The time signal shows the presence of short-lived successive flashovers that are not repetitive and are typical of tracking.**

Tracking was confirmed by analyzing the spectrogram. However, it also revealed the presence of a destructive corona.




**The frequency signal shows peaks at the fundamental frequency (60 Hz) and at its harmonics, which is typical of a destructive corona. It also shows noise between the peaks, which is typical of tracking.**

After analyzing the data originating from the static measurements and time and frequency representations, the company decided upon scheduling a maintenance operation during the next shutdown planned for the transformer. It simply consisted in cleaning the transformer head.
Finally, a new data collection was carried out after restarting the system. The curves below show the results obtained before and after the maintenance operation. They clearly demonstrate that the problem was solved through quick and inexpensive cleaning.




**Top: measurements prior to maintenance. Bottom: after maintenance. Please note that time and frequency representations are on the same scale.**

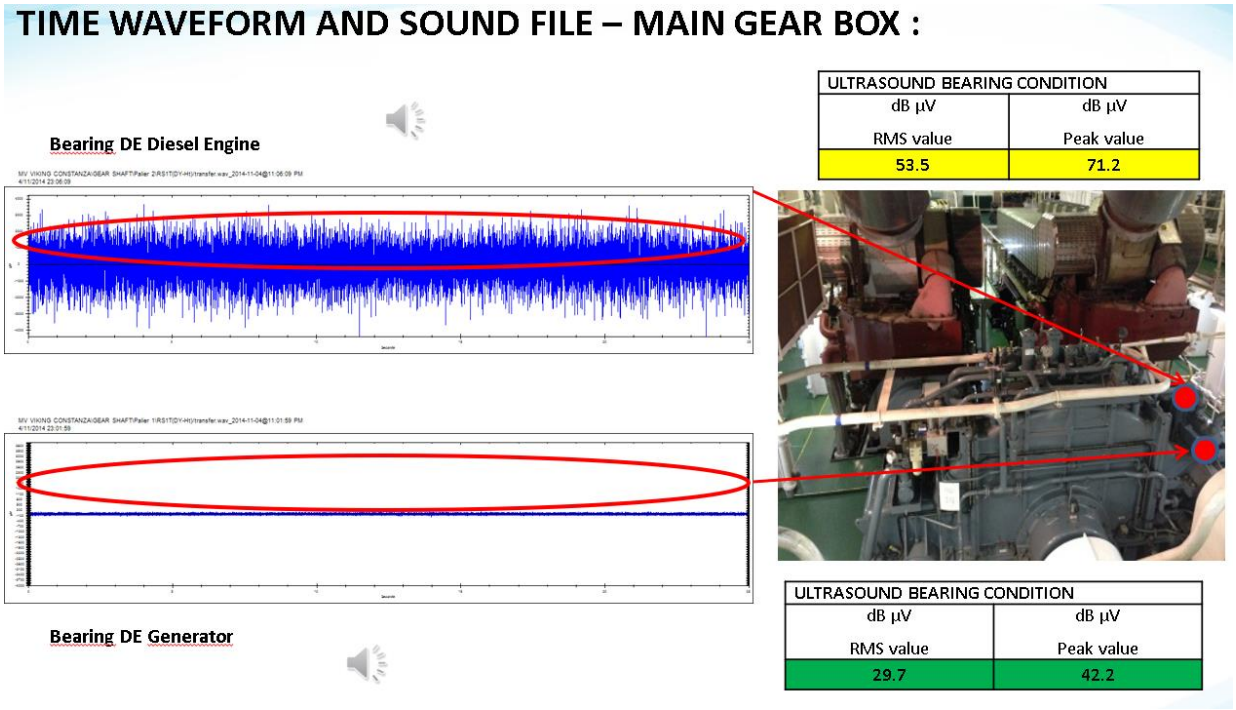
## Conclusion

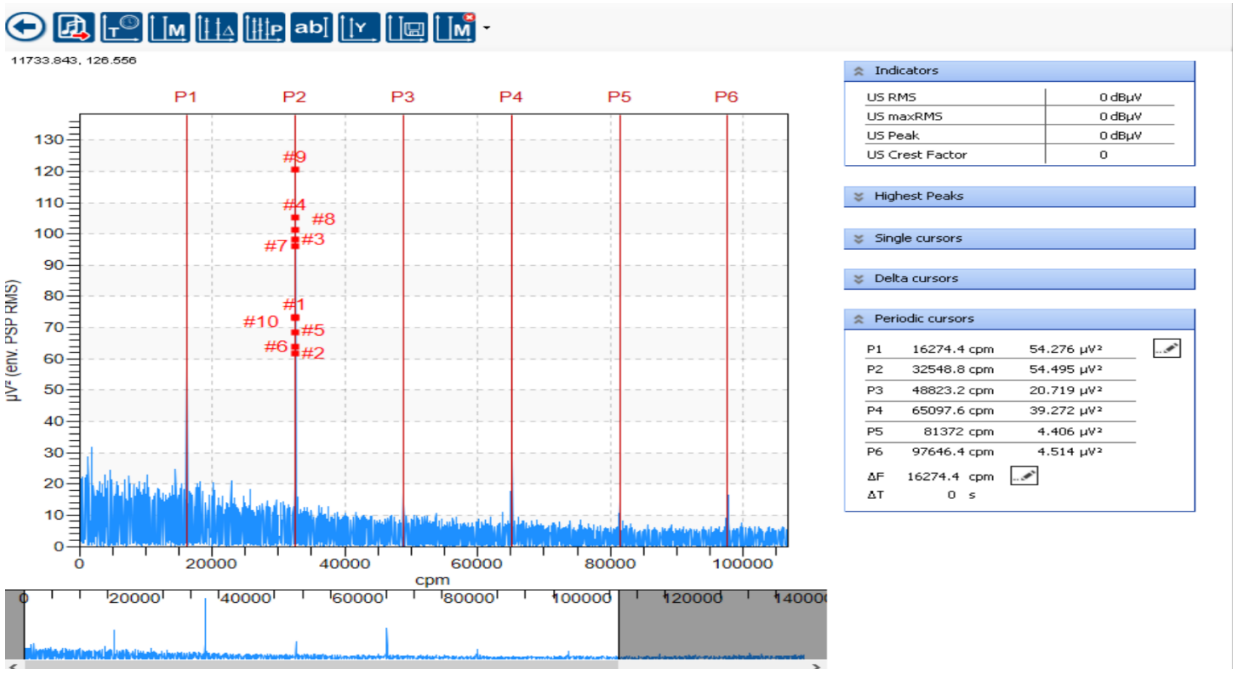
Damages caused by partial discharges are admittedly not a common occurrence. However, they are not acceptable because of their disastrous financial consequences. Also, their occurrence and their evolution are not easily predictable. The best option consists in inspecting the facilities on a regular

basis and using appropriate means. Optimum efficiency is attained by combining ultrasound measurements and infrared thermography. The Gerdau example is a perfect illustration thereof.
A low-end camera will not be suitable to search for this type of defect. Neither will a low-end ultrasound measuring instrument. A listen-only “detector” is also to be avoided. It is imperative that the user issue a reliable diagnosis and answer the following question: “How much time do we have before the facility is affected by irreversible damage?” The user will need overall condition indicators, signal acquisition, and time and frequency representations.
Finally, the performance of the instruments used will ensure the early detection of partial discharges, which means simple and inexpensive asset condition monitoring.

## Gearbox Example 1

**Author:** Patrice Dannepond



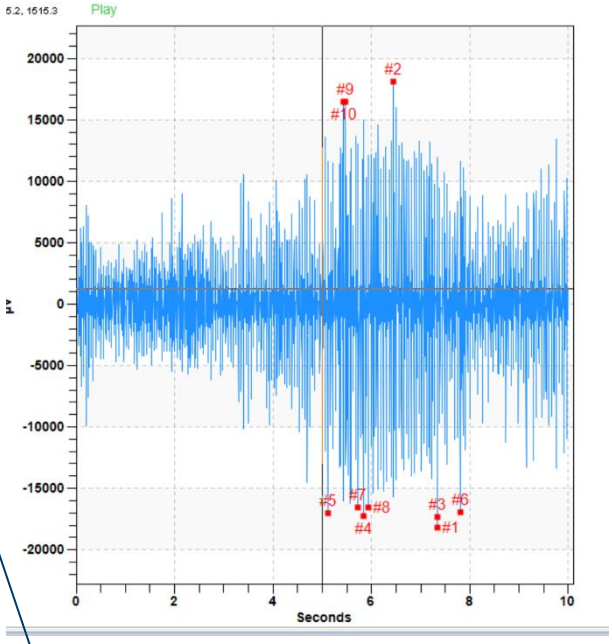



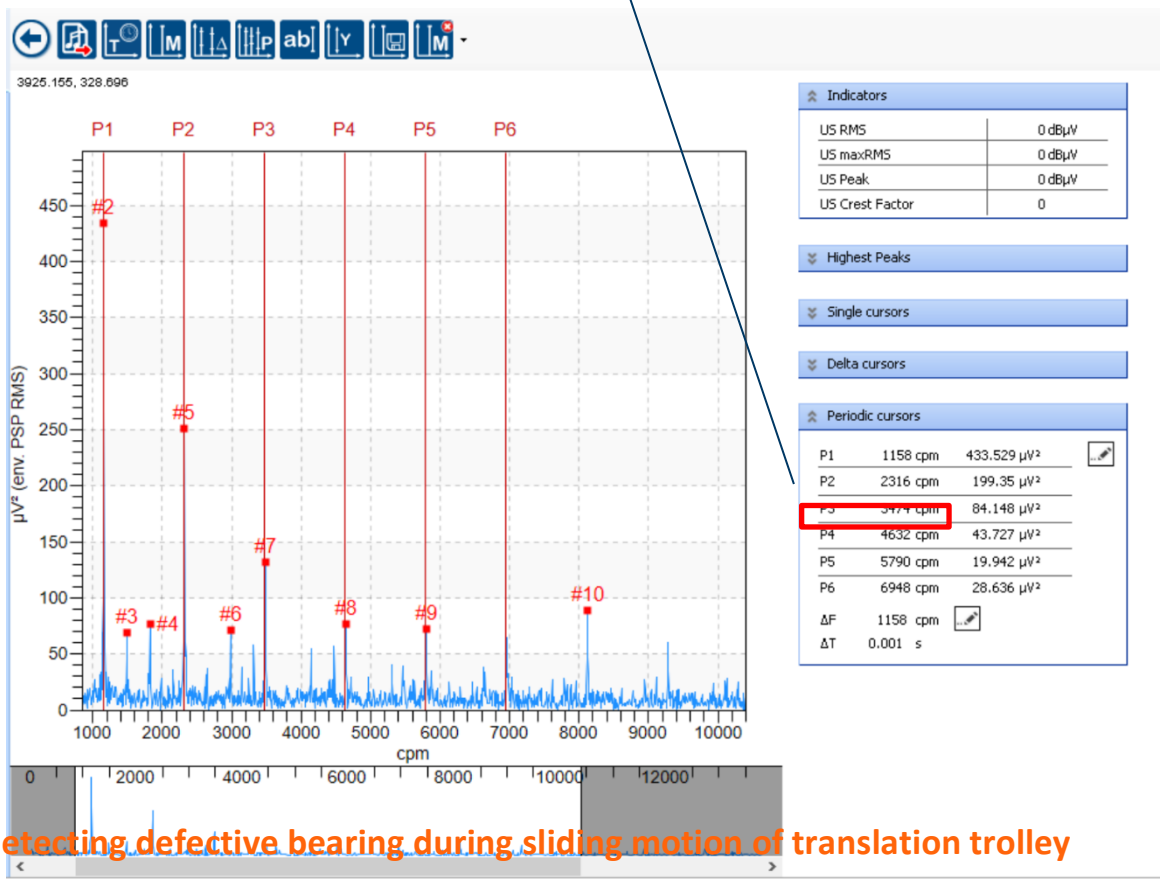
## Gearbox Example 2

**Author:** Patrice Dannepond

Bad gear on shaft 2

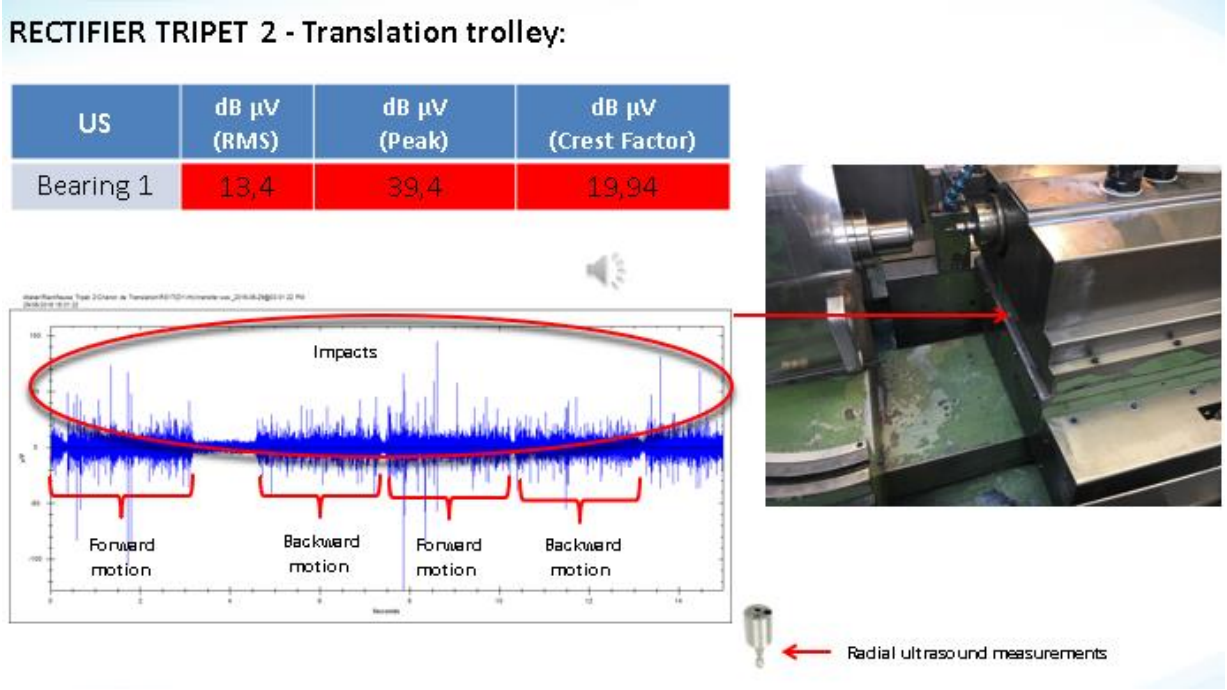
| | rpm | Hz | period |
|---|---|---|---|
| input speed | 1460 | 24.33333 | 0.041096 |
| 22320 | | | |
| 31319 | | | |
| gear teeth 1 | 29 | | |
| GMF1 | 42340 | 705.6667 | 0.001417 |
| gear teeth 2 | 36 | | |
| shaft 2 speed | 1176.111 | 19.60185 | 0.051016 |
| 22330 | | | |
| gear teeth 3 | 16 | | |
| GMF2 | 18817.78 | 313.6296 | 0.003188 |
| gear teeth 4 | 65 | | |
| shaft 3 speed | 289.5043 | 4.825071 | 0.207251 |
| 22322 | | | |
| gear teeth 5 | 17 | | |
| GMF3 | 4921.573 | 82.02621 | 0.012191 |
| gear teeth 6 | 67 | | |
| output speed | 73.45631 | 1.224272 | 0.816812 |
| 23148 | | | |

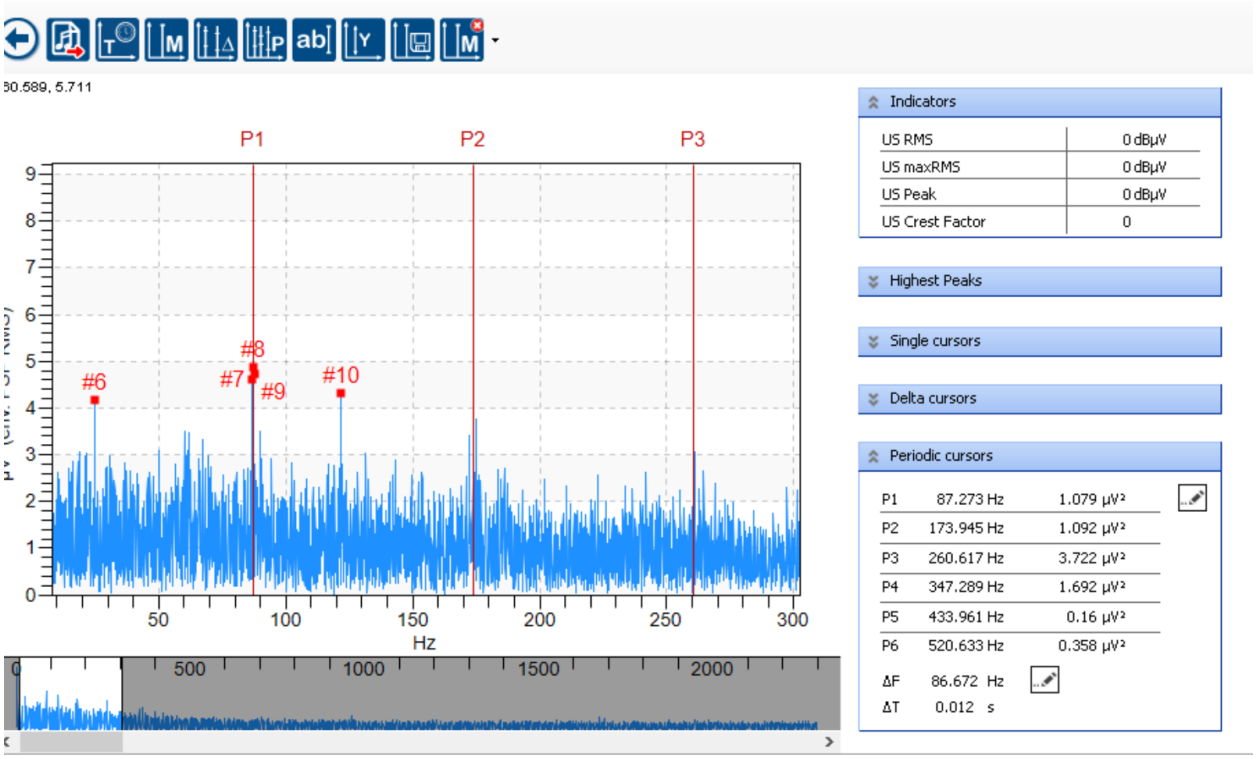



## Detecting defective bearing during sliding motion of translation trolley

**Author:** Patrice Dannepond

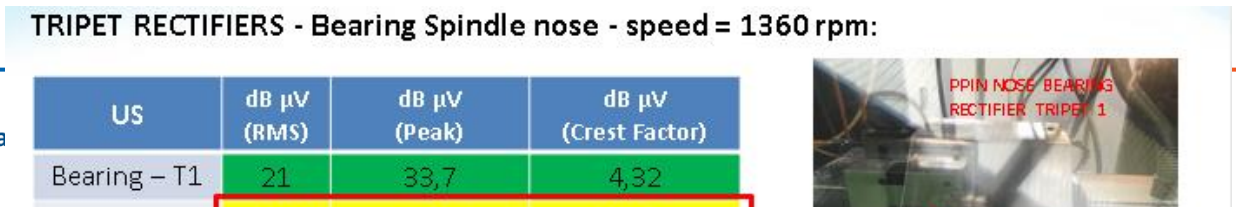


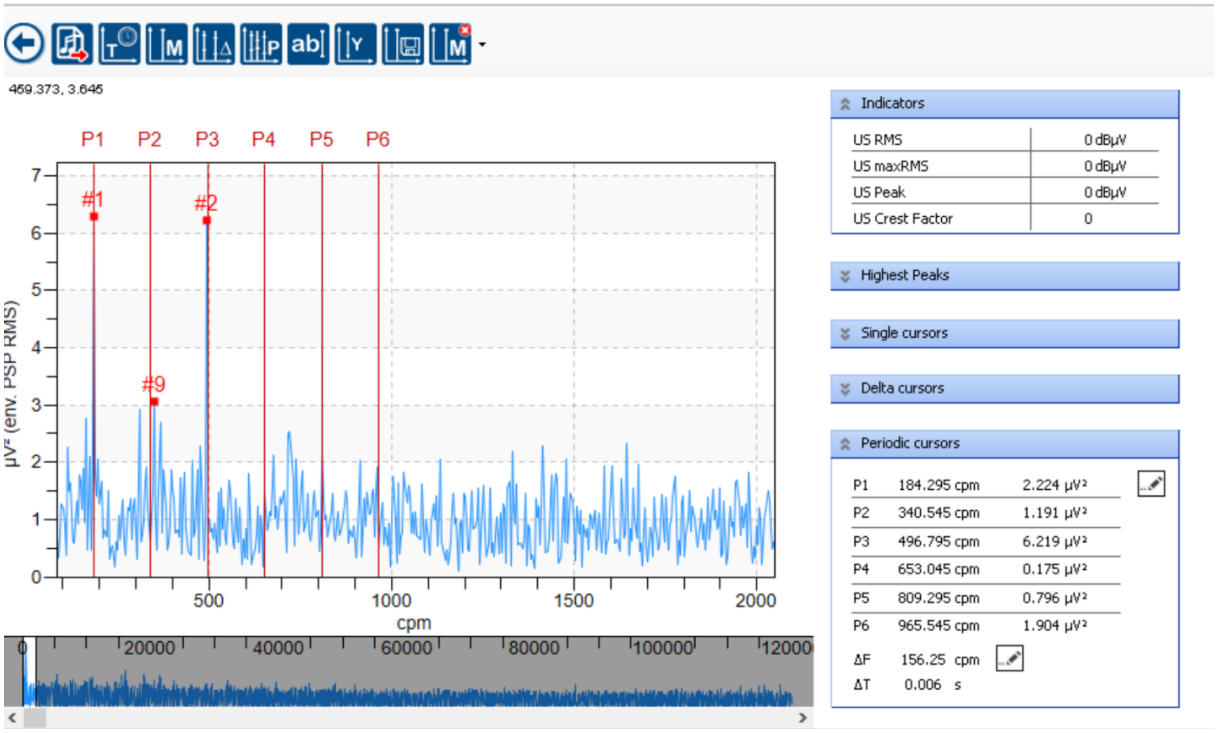




Possible bearing problem. Harmonics of 86 Hz.

## Lathe

**Author:** SDT Ultrasound Solutions

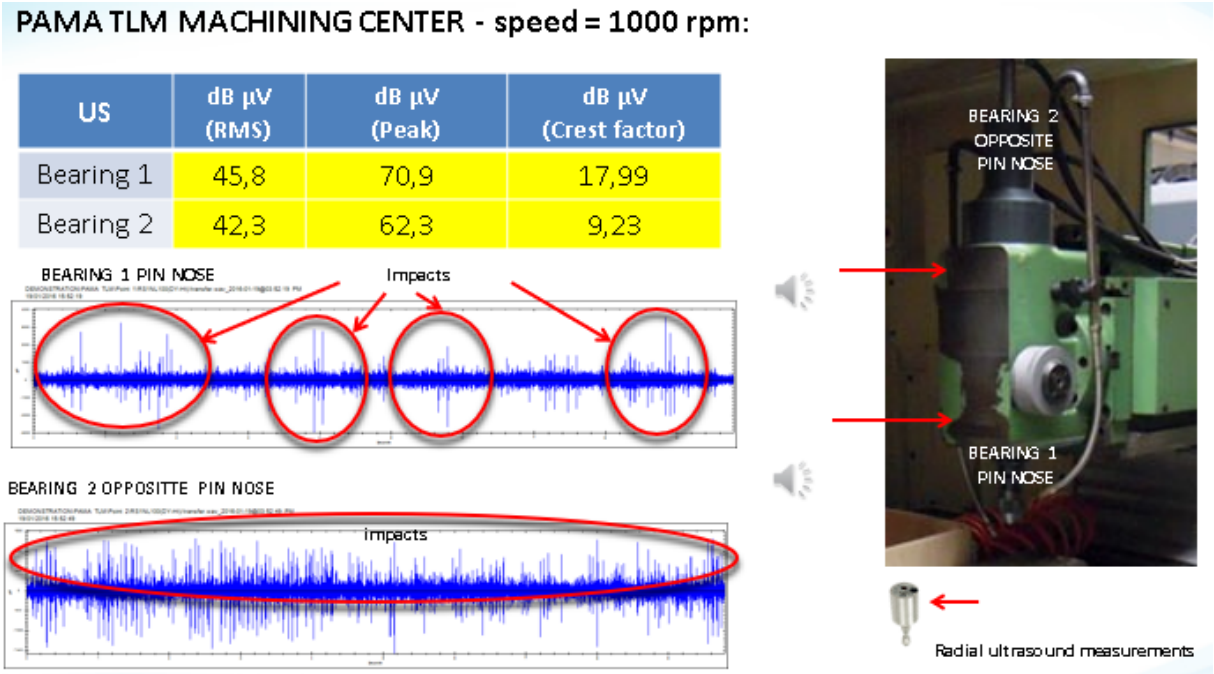




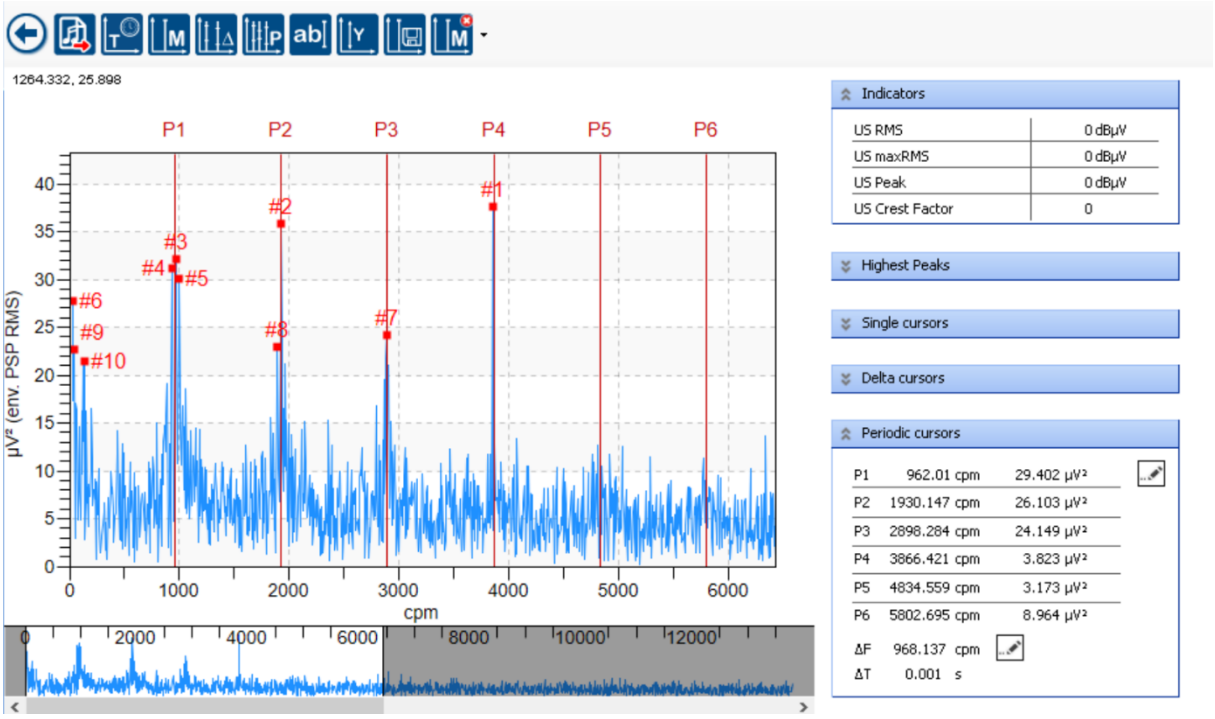

Random impacts. No exact multiple harmonics. Lubrication issue.

## Milling machine

**Author:** SDT Ultrasound Solutions




| US | dB µV (RMS) | dB µV (Peak) | dB µV (Crest factor) |
|---|---|---|---|
| Bearing 1 | 45,8 | 70,9 | 17,99 |
| Bearing 2 | 42,3 | 62,3 | 9,23 |




1 X RPM harmonics in ultrasound spectrum from bearing shows looseness. Bearing fit tolerances are out.

## Energy Savings 4.0

**Author:** Benoît Degraeve
**Email address:** benoit.degraeve@sdtultrasound.com

In the industry, one of the most common applications when using ultrasonic detectors is to search for leaks to achieve energy savings. For both service providers and maintenance engineers, the hardest task is not to localize the leaks, which is child's play if you have the appropriate tool, but to generate a report, organize the required repairs and communicate on the resulting savings within the company.

In 2018, we worked with a company located in the North of Manchester, which, for many years, has used measuring instruments to detect leaks. However, no energy savings have been observed nor measured. As a result, the team was experiencing a loss of motivation and had given up on its cost reduction strategy. Thus, our customer's request was simple: give new life to their projects. The first steps consisted in clearly redefining everyone's role. The second step was to train the team to the use of newly available tools: leak detector and mobile applications. The third step was to set up a "think tank" inviting all stakeholders to reflect on the best approach to adopt to manage and organize a leak detection campaign before, during and after our intervention (see diagram below). Finally, the fourth step was to celebrate our results with all the people involved in the project. After two days on site, everyone precisely knew what was expected of him/her. 17 leaks were localized, representing potential yearly savings of 3 934 GBP (4 481 EUR) and, after the quick repair of 7 leaks, actual savings of 1 648 GBP (1 877 EUR).
As a result, the inspector has a better control of his/her network and of compressed air losses and actual needs; the purchasing officer can calculate the return on investment; the technician feels valued by the savings generated by his/her work; and finally, everyone is thankful to the sponsor for (re)establishing communication between the different departments.

| Summary of the inspection : | |
|---|---|
| Number of leaks found : | 17 |
| Potential savings* ($m^3/h$) : | 27.7 |
| Potential savings* (£/year) | 3934 |
| Actual savings** ($m^3/h$) : | 11.6 |
| Actual savings** (£/year) : | 1648 |

Electric cost (£/kWh) : 0.081
Energy needed to generate compressed air (kW/1000cfm) : 0.2
Hours of compressors operation per year : 8760.0

**Automatic savings sheet generated by the mobile application**

| Leak details N° | 1 | Severity : | |
|---|---|---|---|
| Location | | Sensor | |
| Felt Line | | Flexible Sensor | |
| Distance | | RMS value (dBµV) | |
| 20.00 | | 45.0 | |

| LEAK ESTIMATION | |
|---|---|
| Loss (m³/h) | Loss (£/year) |
| 1.5 | 218 |
| Comments | |
| | |

**Automatic work order generated by the application**

# Petrochemical Industry

## Time-Based greasing? Sure?

**Author:** Haris Trobradovic
**Email address:** haris.trobradovic@sdtultrasound.com

It makes sense to be reminded, from time to time, that calendar is not always the best decision-making tool. Actually, it rarely is.

Because, if it was, you would have been dragged out of your 65th birthday party and taken to a hospital for a hip replacement, since statistics say that hip failures happen from that age on, and if your hip is just fine… bad luck, they will "repair" it anyway.

Personally, I somehow prefer it to be done based on REAL CONDITION of MY hip, not statistics and calculations. And, luckily for all of us, that's exactly how medicine does it.

Unfortunately, bearings do not always have the luxury we have, the luxury to be examined before someone injects something into our bloodstream or replaces some of our "parts".

Fortunately, more and more "doctors and nurses", in Maintenance and Reliability, care enough and know enough to question the calendar and actually ask the patient (bearing) three simple and effective questions:

- Do you need grease?
- How much?
- Do you feel better now?

You just need to speak the bearing language, and you'll get your answers loud and clear.

Recently, Mr. Alican Gozuacik and I spent 4 days in training with high performing Jotun team in Turkey, led by Mr. Bahadir Buyukeren, with Hakta Zeren and Kamil Okcu.

It is also important to mention Mr. Serdar who was not involved in training until the very end but played a highly important role in greasing bearings right.

So, let's see what we had on the menu:

Two fans with the same specs (not using word identical as I do not believe in it, but "same" fans), operating in the same conditions (according to how the process is supposed to work) and treated with copy/paste time-based lubrication plan.

- Direct drive, 55 kW motors, with 6 313 and 6 315 bearings.
- Lubrication plan based on recommendations:
    - 13 grams every 4 000 hours, both DE and NDE on both motors.
- No Ultrasound history data available – no alarms applied at this point.

As assuming seems to be the keyword in many lubrication programs, let me join the club and assume something myself.

I assume that the recommendation is wrong.

As it was time to replenish the grease in both motors (according to those 4 000 hours), we used the opportunity to do it. But this time with LUBExpert.

After a couple of minutes of basic instructions to Mr. Serdar, he was on his way to replenish grease based on real condition and real bearings' needs. We did nothing, we simply enjoyed the scene.

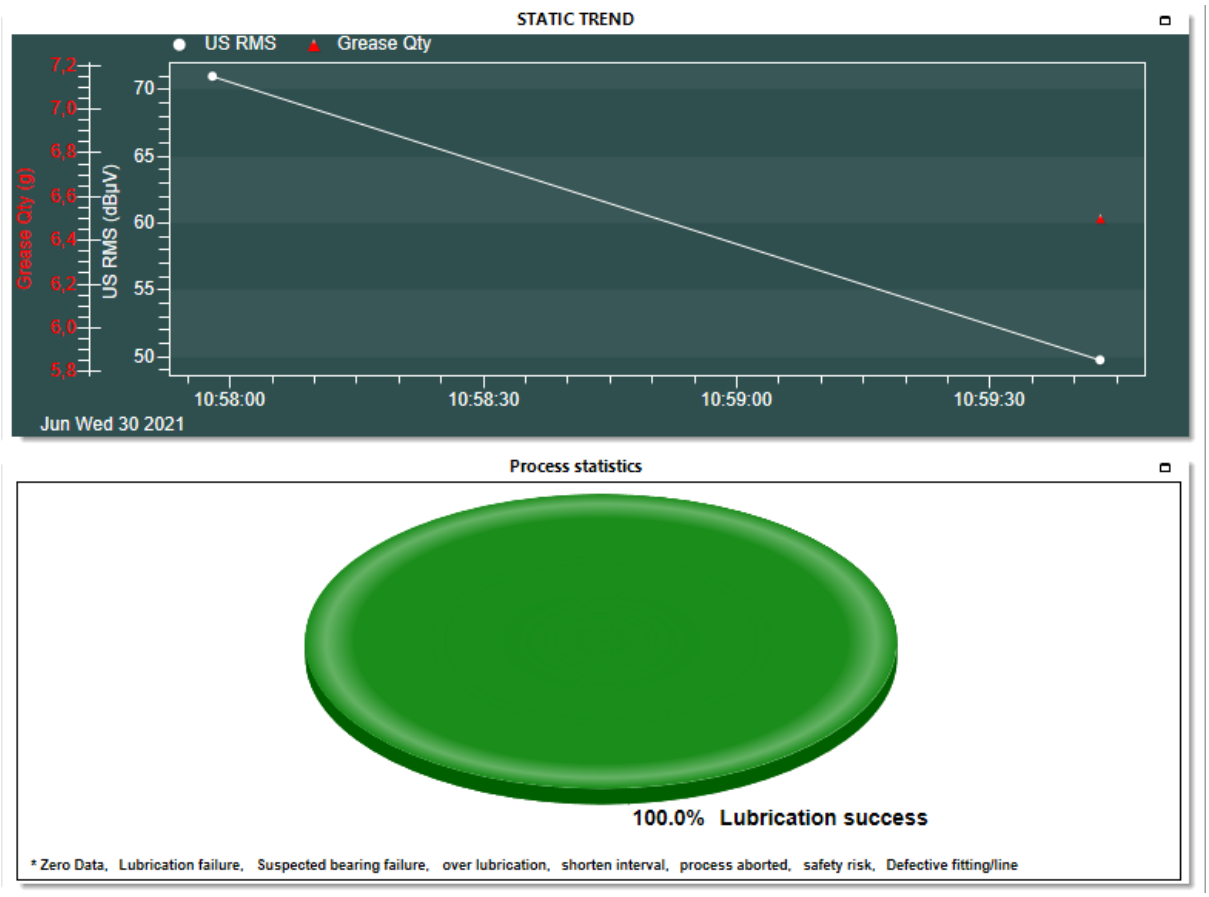
And, surprise, surprise… what happened during grease replenishment was not even close to what time-based recommendations were directing Mr. Serdar to do.

## Fan 2 Motor NDE:

Planned quantity: 13 grams / proven wrong

Applied: 6.5 grams

Outcome: Lubrication success




Readings | Alarms | Events

Jotun Lube/Line 2 FAN Direct Drive/Motor NdE/LUBEsense1(ST-Ht)

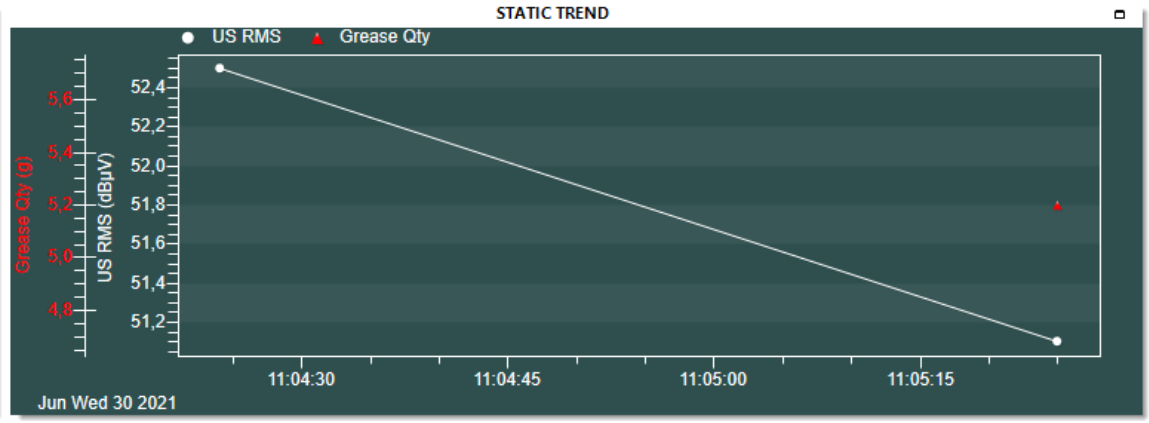
| RMS | Lube Alarm | Lube Alarm Level | Grease Name | Nb. Grease Shot | Grease Qty | Sensor Name | Length (Sec) | Operator |
|---|---|---|---|---|---|---|---|---|
| 49,7 | | Lubrication success | LGHP | 5 | 6.5 | LUBEsense1 | 4 | default |
| 71 | | initial reading | LGHP | 0 | 0 | LUBEsense1 | 4 | default |

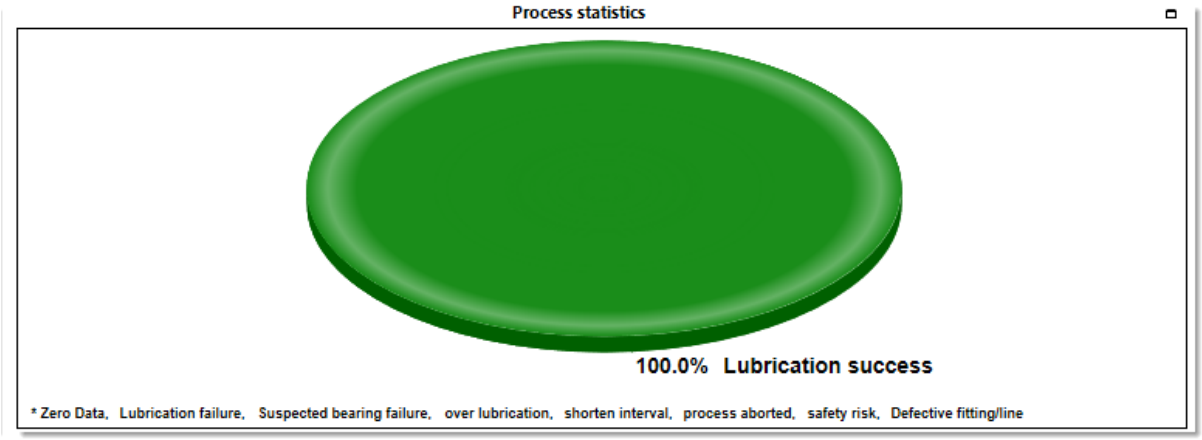
## Fan 2 Motor DE:

Planned quantity: 13 grams / proven wrong

Applied: 5.2 grams

Outcome: Lubrication success




Readings | Alarms | Events

Jotun Lube/Line 2 FAN Direct Drive/Motor DE/LUBEsense1(ST-Ht)

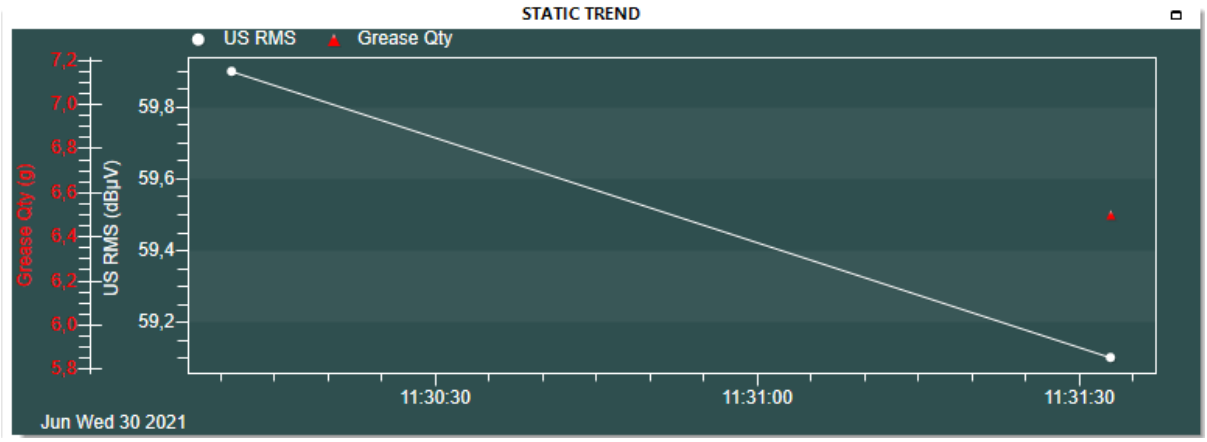
| RMS | Lube Alarm | Lube Alarm Level | Grease Name | Nb. Grease Shot | Grease Qty | Sensor Name | Length (Sec) | Operator |
|---|---|---|---|---|---|---|---|---|
| 51,1 | | Lubricationsuccess | LGHP | 4 | 5,2 | LUBEsense1 | 4 | default |
| 52,5 | | initial reading | LGHP | 0 | 0 | LUBEsense1 | 4 | default |

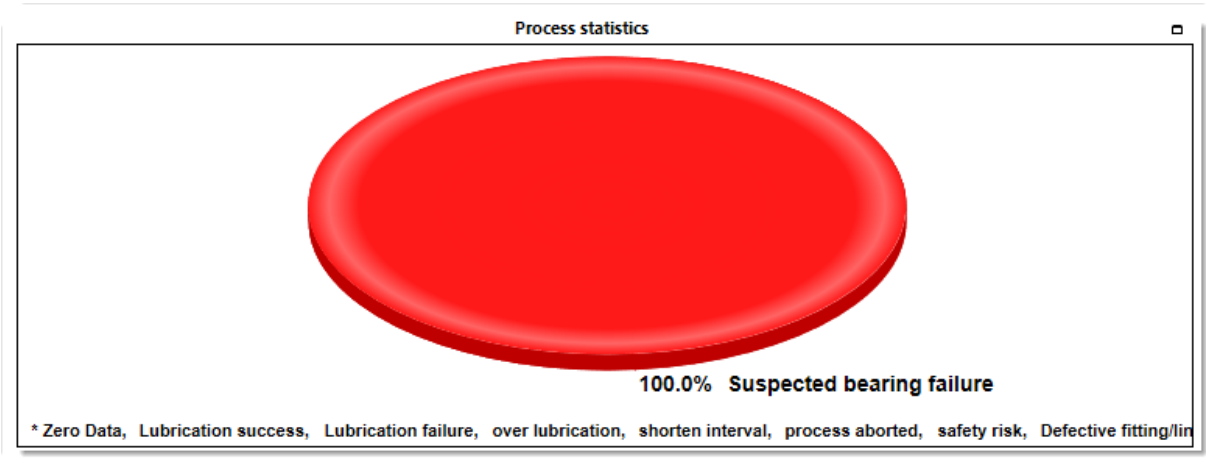
## Fan 1 Motor NDE:

Planned quantity: 13 grams / proven wrong

Applied: 6.5 grams

Outcome: Suspected bearing failure – Data reported to CM team




Readings | Alarms | Events

Jotun Lube/Line 1 FAN Direct Drive/Motor NdE/LUBEsense1(ST-Ht)

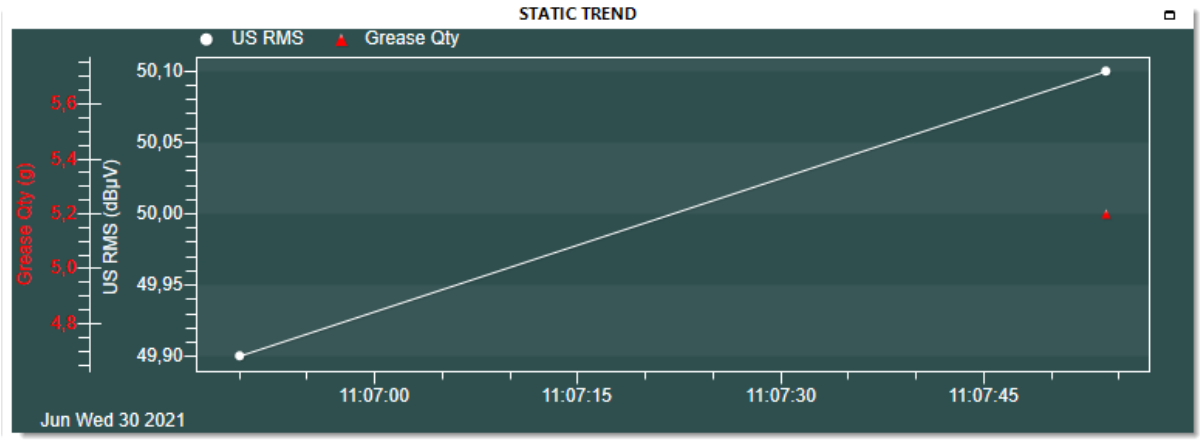
| RMS | Lube Alarm | Lube Alarm Level | Grease Name | Nb. Grease Shot | Grease Qty | Sensor Name | Length (Sec) | Operator |
|---|---|---|---|---|---|---|---|---|
| 59,1 | | Suspected bearing failure | LGHP | 5 | 6.5 | LUBEsense1 | 4 | default |
| 59,9 | | initial reading | LGHP | 0 | 0 | LUBEsense1 | 4 | default |

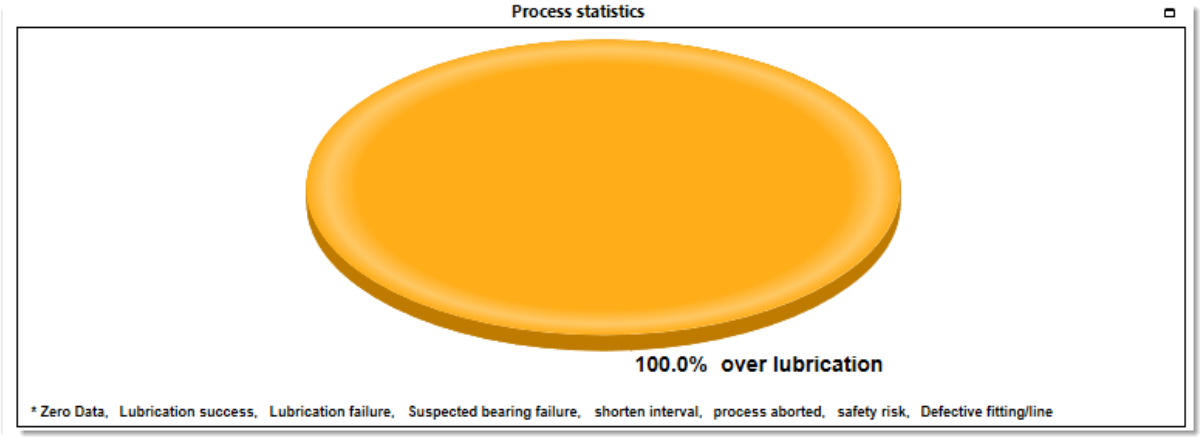
## Fan 1 Motor DE:

Planned quantity: 13 grams / proven wrong

Applied: 5.2 grams

Outcome: Over Lubrication – Bearing didn't need any grease




Readings | Alarms | Events

Jotun Lube/Line 1 FAN Direct Drive/Motor DE/LUBEsense1(ST-Ht)

| RMS | Lube Alarm | Lube Alarm Level | Grease Name | Nb. Grease Shot | Grease Qty | Sensor Name | Length (Sec) | Operator |
|---|---|---|---|---|---|---|---|---|
| 50,1 | | over lubrication | LGHP | 4 | 5,2 | LUBEsense1 | 4 | default |
| 49,9 | | initial reading | LGHP | 0 | 0 | LUBEsense1 | 4 | default |

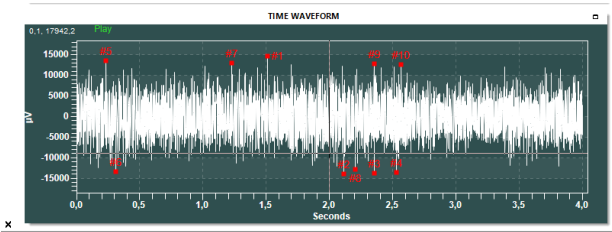
## Worth mentioning:

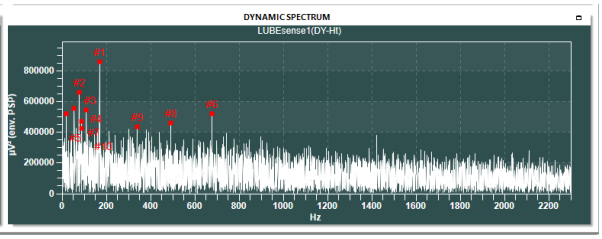
Mr. Serdar performed the task perfectly and with no assistance from our side.

In addition, LUBExpert collected the Dynamic data (TWF and Spectrum) for each bearing before and after the grease replenishment process.

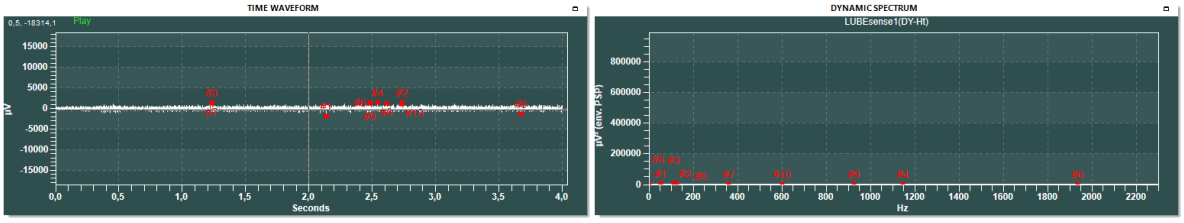
That makes Mr. Serdar a member of the Condition Monitoring team, providing highly valuable data.

Before:




After:




Let us conclude this interesting and clear case:

- The needs of each bearing were different, opposite to what was assumed;
- None of those needs matched the Time-Based plan;
- Following the Time-Based plan would have actually hurt the bearings;
- The job was done easily, correctly, fast, and effectively.

Obviously, there is a good way and a bad day to replenish grease.

Your bearings – your choice.

## On-Condition or Time-Based?

**Author:** Allan Rienstra
**Email address:** allan.rienstra@sdtultrasound.com

Maintaining plant assets in an optimal state of lubrication is a topic receiving lots of attention. Maintenance and Reliability practitioners dedicate teams to the task but not every organization achieves world-class results. As much as 80% of all bearing failures are attributed to poor lubrication practices including:

- Using the wrong lubricant
- Lubricant deterioration
- Lack of lubricant
- Too much lubricant
- Contamination
- Mixing grease types
- Using sealed bearings but still providing a grease nipple access point on the motor (whoops!)

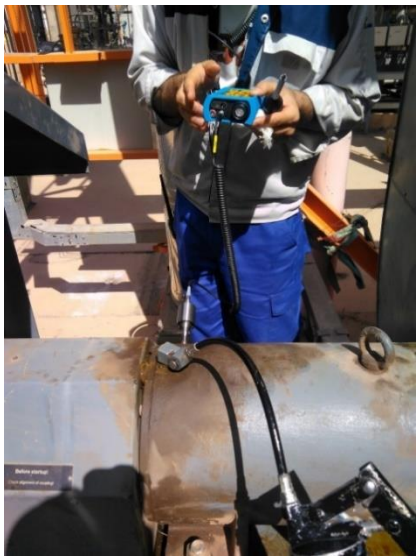


**Figure 2 - Collecting ultrasound data with SDT270 while replenishing lubricant.**

One glaring mistake that contributes to early bearing failure is over/under lubrication. Over and under lubrication is the product of scheduling grease replenishment on a time-based instead of a condition-based schedule, and not knowing how much grease to inject.

Too often bearings are being fed new grease before it's required. Other times the grease gun comes out too late. Some lubrication technicians guess the quantity of grease to inject and don't even know how much grease is dispensed with a stroke of their grease gun. Bearing manufacturers provide formulae for calculating a theoretical grease capacity for each bearing but not everyone knows how to use them. Still others simply follow guidelines given by the motor manufacturer. Often this "bad advice" is stamped directly on the motor.

To drive home this point, Haris Trobradovic, one of SDT's many globe-trotting corporate trainers recently delivered training to a petrochemical facility in the Middle East.

"During the training, we performed measurement practice on several machines (Figure 1). One of the machines was a fan, scheduled for re-lubrication in a few days" recalls Haris. "The customer's standard greasing practice is to follow manufacturer's recommendations for both interval and amount. In other words, they grease on a time-based schedule and trust the

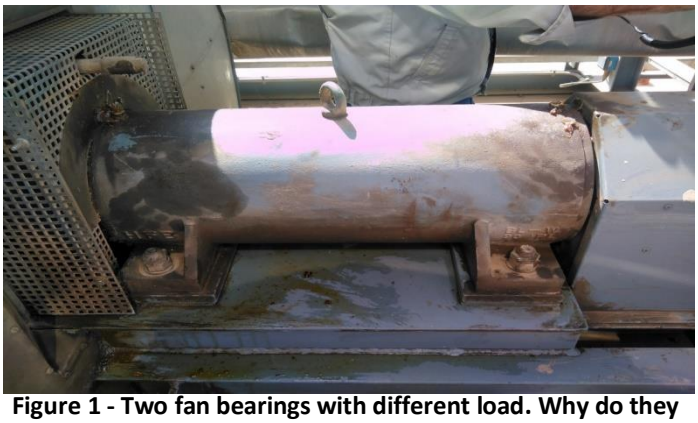


**Figure 1 - Two fan bearings with different load. Why do they share the same grease replenishment protocol?**

motor manufacturer to guide on quantity."

Haris Trobradovic used the opportunity and performed re-greasing exactly as recommended by the OEM, even though the Condition Monitoring team had a different opinion. Their ultrasound data did not indicate any need for grease replenishment, after having added a small amount of lubricant followed by a measurement. The CM team members are strong advocates for on-condition lubrication and doing away with time-based.

Following the facility's lubrication procedure raised several red flags. Figure 2 shows two bearings driving the fan. Why would two identical bearings, but with different loads, have the exact same grease replenishment protocols? Maybe it's purely out of convenience; since the lubricator is there to grease the drive end bearing, might just as well pump a few strokes into the non-drive end.

Another issue that disturbed the SDT trainer was the instructions stamped on the motor plate. See Figure 3 – Maintenance of the bearings with grease quantity regulator". This stamp instructs the owner of the motor to add 32.7 grams of grease (grease type not identified) every 3 068 operating hours. Haris wondered if the OEM took into consideration the installation of the motor in a climate that is very hot and humid in the summertime, but cold, snowy, and dry in the winter.

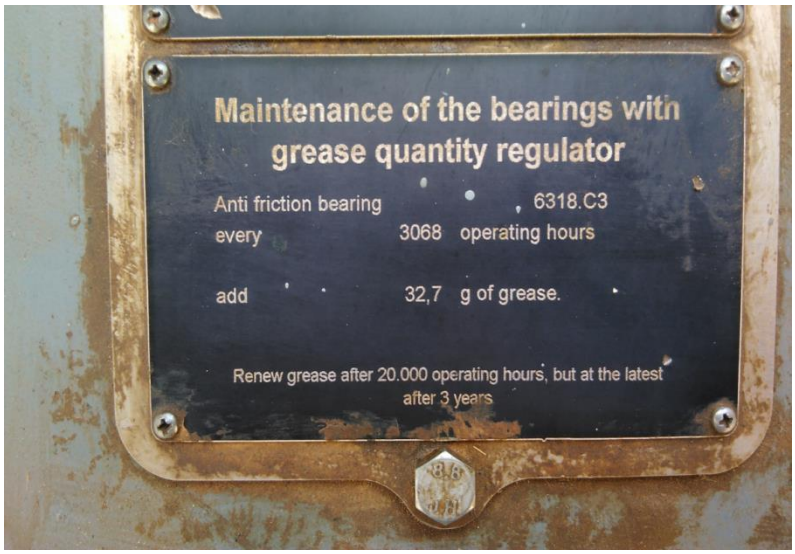



**Figure 3 - This motor had a secondary plate reminding lube-techs which grease type to use.**

One refreshing fact was an additional plate (Figure 4) with details about the grease type used in the bearing. Mixing incompatible grease types is an often-cited cause of premature bearing failure. This same reminder is provided by the SDT LUBExpert Ultrasound Tool. Prior to beginning a lubrication task LUBExpert reminds the operator of the correct grease type to use.


**Figure 4 - OEM instructs the owner to grease on a time-based schedule without considering the operating environment.**

Continuing with the experiment, Haris and the CM team attached the grease gun to the SDT equipment and greased the drive end bearing following OEM recommendations. Figure 5 is a screen

shot captured from UAS, the companion software to LUBExpert. The top trend is the drive end bearing. Within four minutes, the overall RMS increased by 7 dBµV while the Crest Factor and Peak spiked sharply.

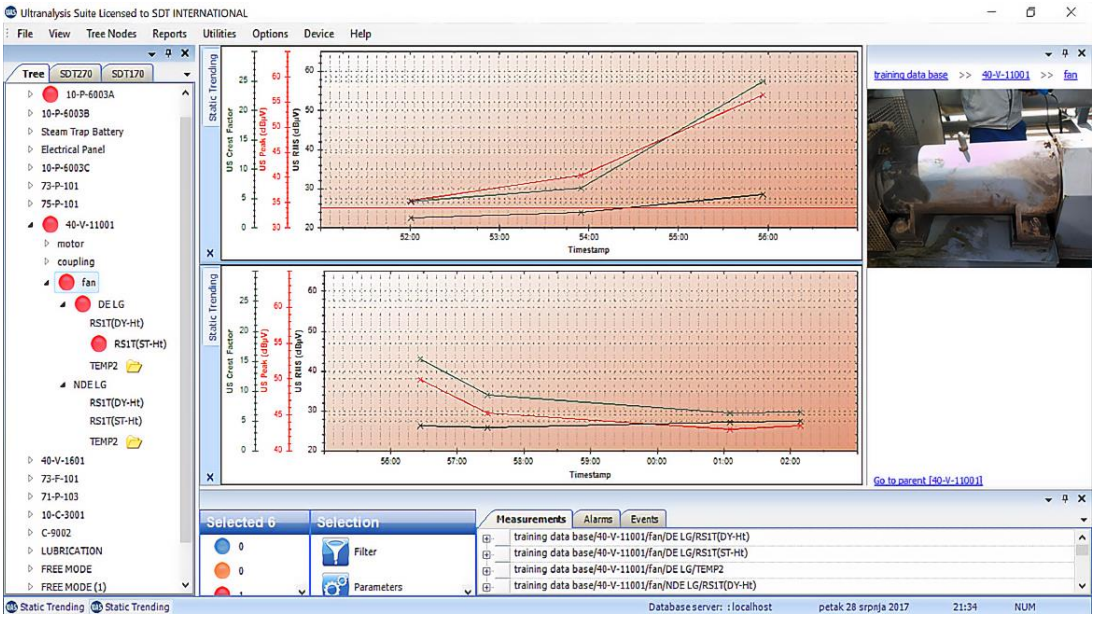



**Figure 5 - Top trend graph illustrates drive end bearing after lubrication. It is badly.**

The bottom trend is from the non-drive end bearing. Adding the requisite amount of grease had no positive outcome for the Overall RMS which stayed stable at 26 dBµV. The drop in Crest Factor and Peak readings, however, indicates the bearing may be entering a failed state. More frequent condition monitoring with complimentary technologies such as vibration analysis will ensure any machine downtime is scheduled on the client's terms, not the machine's.

For those unfamiliar with these data formats, Overall RMS, Max RMS, Peak, and Crest Factor are used to bring synthetic meaning to ultrasound STATIC data. Sadly, following OEM procedure resulted in over lubrication of the DE bearing.

To drive home the point, Haris also captured DYNAMIC signals from the drive end bearing. As seen in Figure 6 the time signal before (bottom) and after (top) reveals new peaks and impacts forming. Over lubrication causes pressure to build inside the bearing. Ideally, the lubricant wants to feed from the

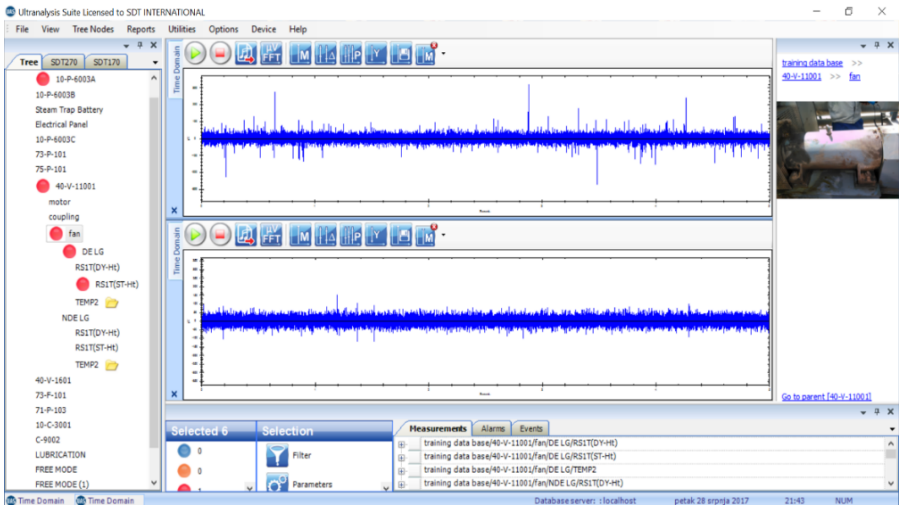



**Figure 6 - Dynamic data from drive end shows the emergence of defects (top) after bearing was over-greased following OEM recommendations.**

thickener to form a thin film between the rolling elements and the race. It can't do this if there's too much grease and pressure. The result is increased friction and impacting, two phenomena easily detected with ultrasound specialty tools like SDT's LUBExpert.

Finally, Haris collected DYNAMIC time signals on the non-drive end bearing. In Figure 7 the bottom time signal shows dominant peaks that are clearly random impacts. After lubrication those peaks are gone, as you can see in the top time signal, Figure 7. It appears that replenishing the grease in the non-drive end had some positive benefits, and those benefits are clearly illustrated in UAS.

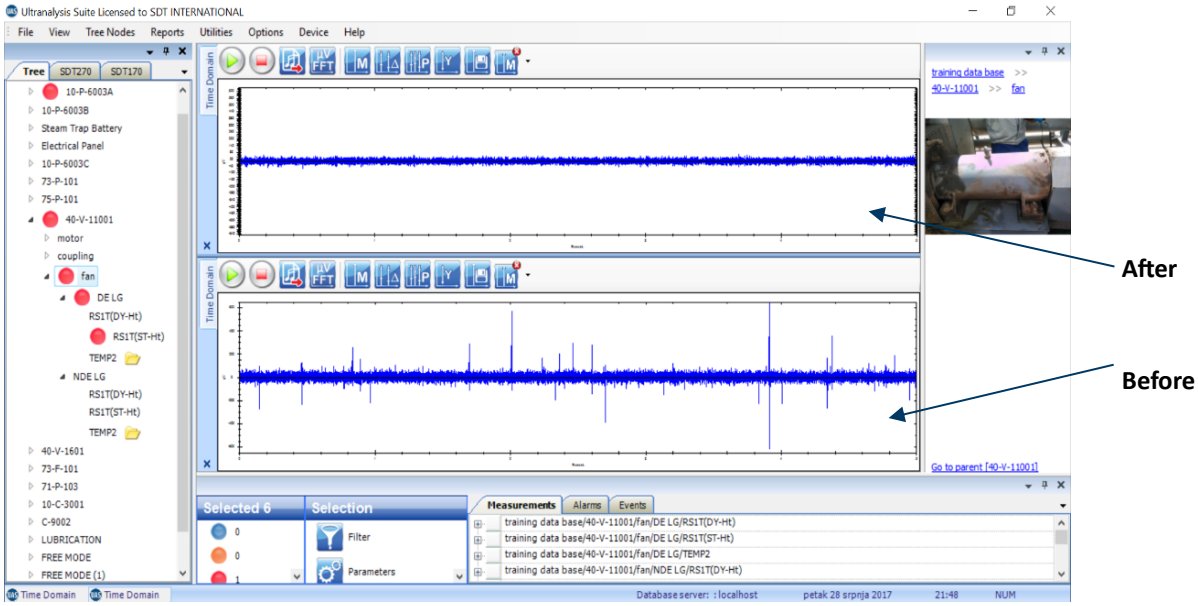



**Figure 7 - The non-drive end bearing has defects as shown by this dynamic time signal. Ultrasound assisted lubrication with SDT allowed the CM team to identify this potential fault.**

The bottom line is that following OEM recommendations to replenish lubrication on a time-based or time-in-service protocol are proven wrong time and again. Following the greasing instructions stamped on the motor plate led to the drive end bearing being over greased and reducing life expectancy.

Another interesting takeaway here is that while an ultrasound lubrication solution – LUBExpert – was used to monitor the effects of adding grease, the added benefit for the CM team is the indication that a failure state may exist. There was a day not too long ago when the lubricator was counted on for keeping his finger on the pulse of the plant. Solutions like SDT's LUBExpert are restoring important responsibilities to a task that recently has been given to "lower-skilled" tradespeople.

It's past time that lube-techs be recognized for the important role they can play contributing to plant reliability.

# Replacing a Time-Based Task with Condition Monitoring

**Authors:** Gilles Lanthier and Greenfield Ethanol in Quebec
**Email address:** gilles.lanthier@sdtultrasound.com

## Replacing a preventive maintenance practice with condition monitoring technology

We have a 350-foot-long belt conveyor in our facility that contains 270 small bearing rolls, 33 return rollers in addition to the drive rollers and others. Given the difficult and dangerous access to these rollers, they have been excluded from our vibration routes in the past. To alleviate this situation, a preventive maintenance route was established. A person with a list of rolls and went on site to do a visual and auditory inspection to determine which rolls to replace. This technique was long and dangerous since it was necessary to open each running conveyor cover to perform this inspection. This practice was very subjective, and the results varied greatly from technician to technician.


ÉTHANOL GREENFIELD

"ROUTE DE LUBRIFICATION ET D'INSPECTION"

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ROUTE: Inspection des Rouleaux

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| #84 | | | | | | | |
| #85 | | | | | | | |
| #86 | | | | | | | |
| #87 | | | | | | | |
| #88 | | | | | | | |
| #89 | | | | | | | |
| #90 | | x | | | | | |

ÉTHANOL GREENFIELD

"ROUTE DE LUBRIFICATION ET D'INSPECTION"

Horaire: Mensuel

ROUTE: Inspection des Rouleaux

Rouleaux Retours

| Rouleaux | Saisi | Bruit | À Planifier | Roulcau guide vert |
|---|---|---|---|---|
| #1 | | | | |
| #2 | | | | |
| #3 | | | | |
| #4 Guide | | | | |
| #5 | | | | |
| #6 | | | | |
| #7 | | | | |
| #8 | | | | |
| #9 | | | | |
| #10 | | | | |
| #11 | | | | |

| Rouleaux | Saisi | Bruit | À Planifier | Roulcau guide vert |
|---|---|---|---|---|
| #12 | | | | |
| #13 | | | | |
| #14 | | | | |
| #15 Guide | | | | |
| #16 | | | | |
| #17 | | | | |
| #18 | | | | |
| #19 | | | | |
| #20 | | | | |
| #21 | | | | |
| #22 | | | | |

| Rouleaux | Saisi | Bruit | À Planifier | Roulcau guide vert |
|---|---|---|---|---|
| #23 | | | | |
| #24 | | | | |
| #25 | | | x | |
| #26 | | | | |
| #27 | | | | |
| #28 | | | | |
| #29 Guide | | | | x |
| #30 | | | | |
| #31 | | | | |
| #32 | | | | |
| #33 | | | x | |

Date d'Inspection

Inspecteur

Supervizeur

In the past, we used ultrasound only for air leak detection and for lubrication routes without exporting data to a software. Now, with the help of the Ultranalysis suite software, our use of ultrasound is getting closer to common vibration techniques. We began by measuring several pieces of equipment with our SDT270 and its dedicated ultrasound sensors to familiarize ourselves with the equipment and software.

Since our vibration program is important in the plant, I wanted to integrate ultrasound into our existing predictive maintenance practices. That's when we came up with the idea of using it on our CB-1310 conveyor. At first, in 2016, we built a route only at the level of the return rollers. A reading on the roll frame gave us good signal quality for the application.

At this time, the previously established preventive maintenance route was still performed. We used these latest inspections to establish a basic level of alarm based on the provided ultrasound indicators. By comparing the two routes for a few months, we arrived at similar results. Subsequently, we refined our alarms to make sure we could see the problems in advance. Following the satisfactory results obtained, we applied the same method on the carrier rollers without even opening the covers.


After a dozen collections, we can say today that the results are very promising. One year ago, since implementing this new ultrasonic strategy, we no longer need to do the preventive maintenance route.

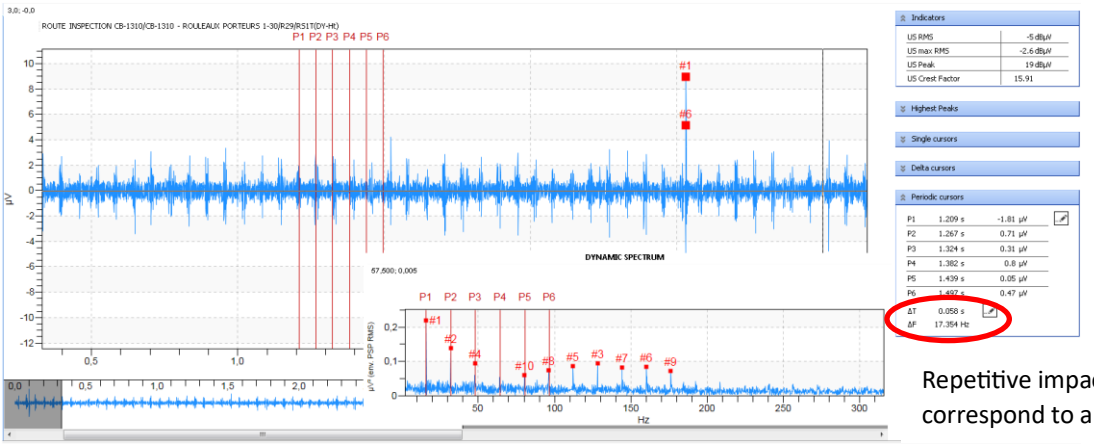
Since I am a vibration analysis technician, I use ultrasound by applying the same techniques I use in vibration. In both cases, I analyze the time waveform and / or spectral (FFT) except that I am measuring ultrasound instead of displacement (vibration).

Here are some examples of defects found on our rolls. Unfortunately, for our carrier rollers, I check three rolls at a single reading point, and I can not say precisely which one is in fault. These rolls are manufactured with two bearings 6304-2RS / C3 and it is the outer ring of the bearing that rotates at a speed of 238 RPM.

### These are the default frequencies for a SKF 6304 bearing

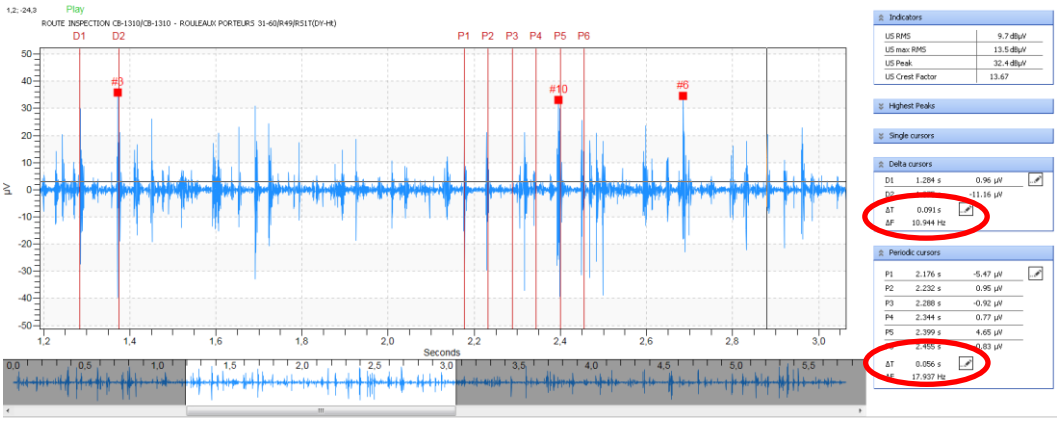
| | | | |
|---|---|---|---|
| | $f_e$<br>Rotational frequency of outer ring | 3.97 Hz | |
| FTF | $f_c$<br>Rotational frequency of the rolling element and cage assembly | 2.51 Hz | |
| BSF | $f_r$<br>Rotational frequency of a rolling element about its own axis | 6.97 Hz | linked to August 20 |
| BPFI | $f_{ip}$<br>Over-rolling frequency of one point on the inner ring | 17.6 Hz | linked to January 3 & 25 |
| BPFO | $f_{ep}$<br>Over-rolling frequency of one point on the outer ring | 10.2 Hz | linked to January 25 |
| 2 x BSF | $f_{rp}$<br>Over-rolling frequency of one point on a rolling element | 13.9 Hz | linked to August 20 |

January 3, 2018: Roller Bearing R29 Internal Rolling Cage Failure (BPFI)




Repetitive impacts (ΔF = 17.3) correspond to a defect at BPFI

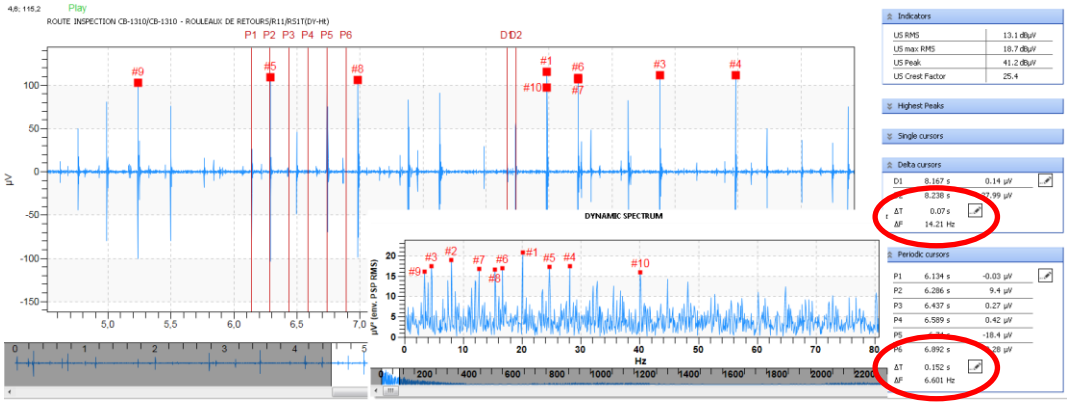
January 25, 2017: Roller bearing R49 presence of internal and external bearing failure (BPFI and BPFO) may be that it was on two different rolls.




See table at BPFO

See table at BPFI

August 20, 2018: Roller back R11 bearing ball bearing frequency (BSF)




See table at BSF and 2x BSF

During the analysis, we see on neighboring readings the presence of the roll in fault but at lower amplitude. This helps us confirm the faulty roll section. Of course, there are many other parameters to consider, such as dirty rolls and the like. Listening to the time wave also helps to confirm a potential problem.

In conclusion, the program is working very well, and the alarm level currently set allows us to identify each time there is an appearance of a defect on a roll. We do not really need to identify the specific fault of the bearing each time because the rolls are not expensive enough to spend so much time.

In our study case, the typical defects are identified at low rotating speed, where in practice, vibration technics reach their sensitive limits.

# Bearing Fault Detection in a Biomass Conversion Facility

**Authors:** Allan Rienstra and Patrice Dannepond
**Email addresses:** allan.rienstra@sdtultrasound.com

Today I want to share with you a story of how SDT helped one client identify failure conditions on large, low speed spherical roller bearings. It is an interesting tale about a facility that serves a dual purpose, reducing greenhouse gas and fossil fuel emissions while producing energy and resources through the conversion of household waste.

## Energy from Waste

The power grid is fed from many sources. Coal, nuclear, and gas fired generation plants, solar and wind, just to name a few. And then there is Biogas, a methane-rich product originating from the decomposition of organic waste. Biogas conversion has gained traction in Europe. However global acceptance of biogas as a legitimate fuel is held back by the abundance of and low price demanded for natural gas. Reliability through ultrasound is one way biogas conversion facilities can avoid cost escalation and remain an attractive alternative fuel.

Biomass energy technologies extract energy resources from virgin and waste biomass. Biomass is non-fossil, energy-containing forms of carbon. Virgin forms include plants and vegetation. Waste forms include municipal solid wastes, residual by-products from forestry and agriculture, as well as non-hazardous industrial wastes.

Biomass energy is used for the production of heat, steam, and electricity. It also creates fuels that can serve as suitable alternatives for fossil fuels, most common being methane gas. Extracting the chemical energy content inherent in non-fossil organic materials is the job of a biomass conversion facility.

## Converting Household Waste to Methanol and Fertilizer

Anaerobic digestion is a biological process that decomposes organic matter by means of microbial flora. It is a natural process occurring in the absence of oxygen within a closed containment. It is an innovative process for treating household waste.

Located in Montpellier, France, AMETYST is the largest biomass conversion facility in the region. It has the capacity to convert 203,000 tonnes of household and bio-waste each year. By diverting this waste away from landfill sites, AMETYST is capturing greenhouse gases and putting them to work. In a normal year 14.4 million cubic metres of methane biogas is converted and used for the production of electricity and heat, equivalent to 30,000 megawatts of electricity. 24,000 tonnes of compost go back to the community for use in landscaping, and 4000 tonnes of organic waste compost is used for natural soil amendments for agriculture.

## Methane Ovens

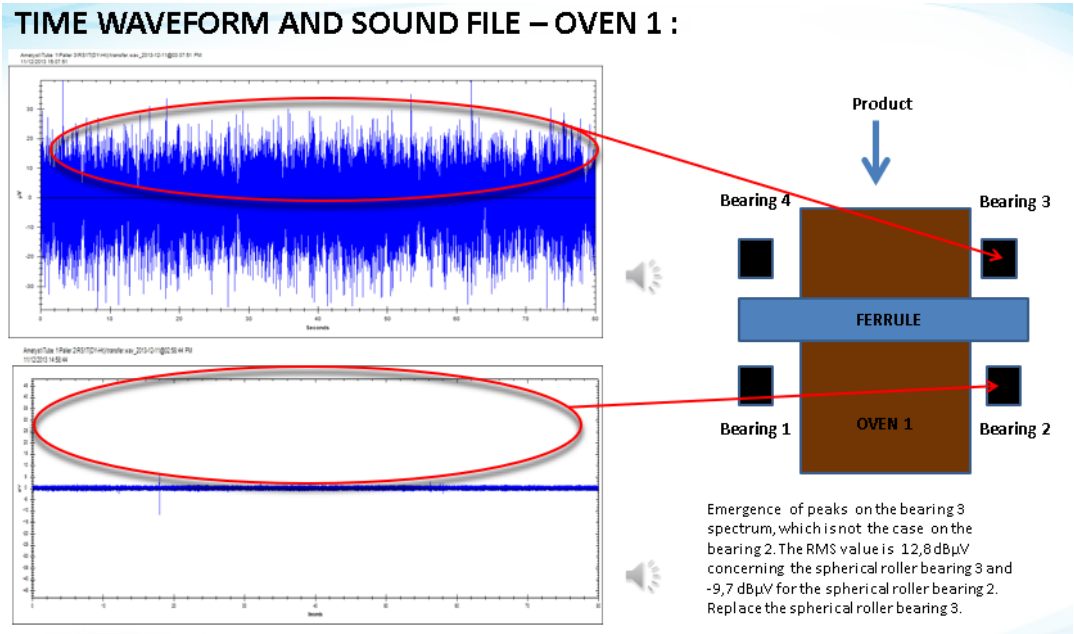
After sorting and pre-composting, the organic matter moves through anaerobic digestion units converting household waste to biogas and compost. Basically, these are large ovens rotating slowly around two large outer rings on each end. Each ring is supported by four massive spherical roller bearings.

Recently, the bearing on Oven 2 had failed and was replaced. SDT's field specialist for the French region, Patrice Dannepond, was called to site to collect ultrasound data on oven 1 and oven 2 to confirm their condition and help plan for similar failures. Ultrasound technology was chosen because of its ability to monitor and assess the condition of bearings rotating at such low speeds.

## Oven 1

By capturing static and dynamic ultrasound data using an SDT270DU and a resonant contact ultrasound sensor, Patrice measured, listened, and analyzed the eight ring support bearings. Bearings 1 through 4 support the Product Entry side on Oven 1. High static RMS values were detected on bearings 3 and 4. Bearing 1 and 2 measured minus 9 dBrms while 3 and 4 were 12.8 and 14.2 dBrms.

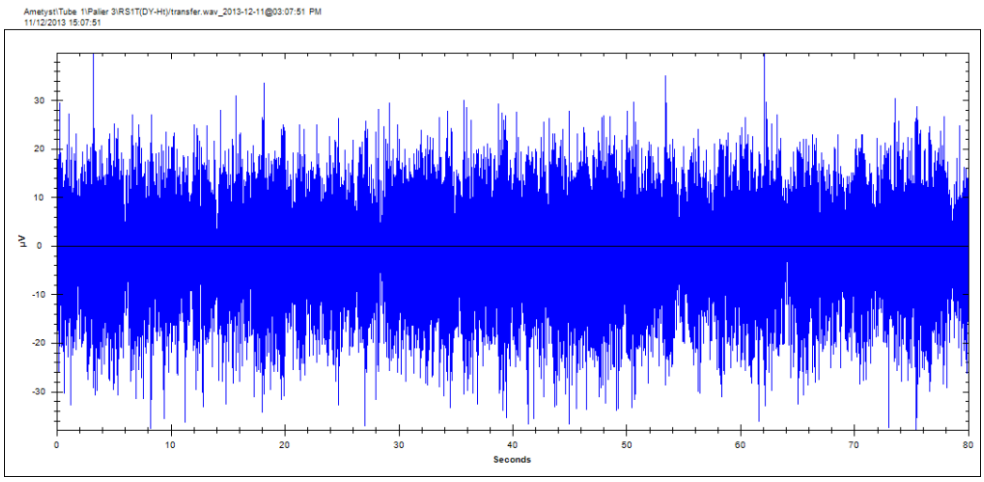
| | dB uV (RMS) | dB uV (Max RMS) | dB uV (Peak) | dB uV (Crest Factor) |
|---|---|---|---|---|
| **Bearing 1** | -9.6 | -7.2 | 11.2 | 11 |
| **Bearing 2** | -9.7 | -5.6 | 15.8 | 18.7 |
| **Bearing 3** | 12.8 | 17.5 | 32.1 | 9.2 |
| **Bearing 4** | 14.2 | 19 | 32 | 7.76 |
| **Bearing 5** | -9.9 | 3.9 | 21.7 | 38 |
| **Bearing 6** | -10 | -7.2 | 7.5 | 7.41 |
| **Bearing 7** | -10.3 | -8.4 | 13 | 14.12 |
| **Bearing 8** | -6.8 | 12.7 | 30.5 | 72.83 |

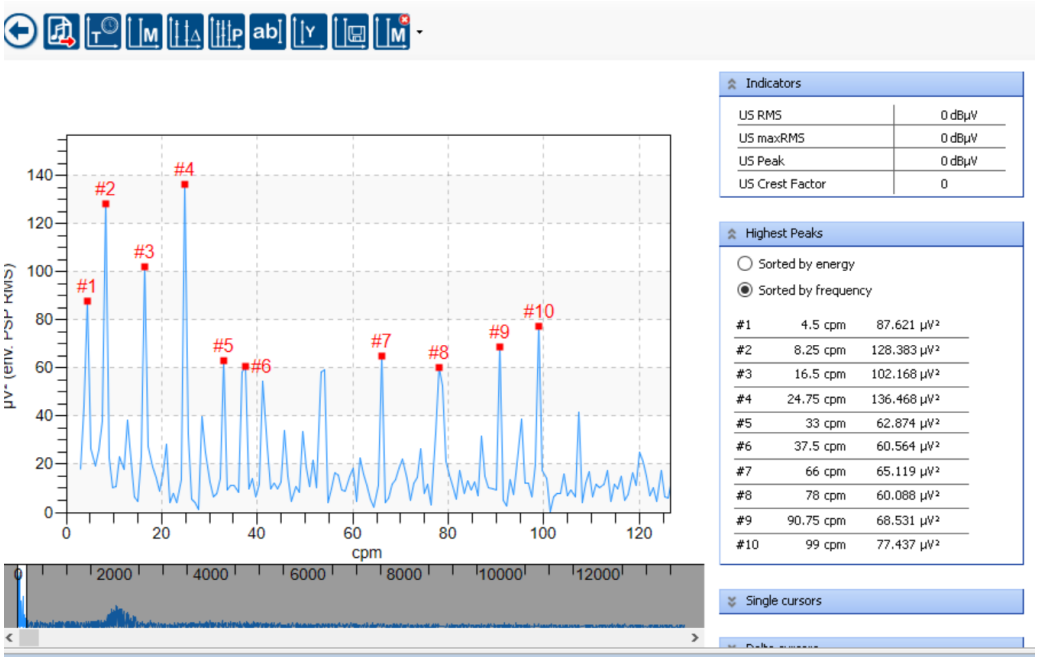



We noted earlier that the rotational speed of the oven is 1 RPM, and the bearing is 4 RPM. For a good analysis of low-speed bearings at least 3 to 4 full rotations are desired. To be safe, Patrice set his SDT270DU to capture an 80 second dynamic signal. Looking at the dynamic data in the time trace the emergence of peaks on bearing 3 and 4 are consistent with the static RMS values. Looking at the time waveform of bearing 4 Patrice notes the presence of impulses each 14.48 seconds. This is consistent with the running speed of the bearing.

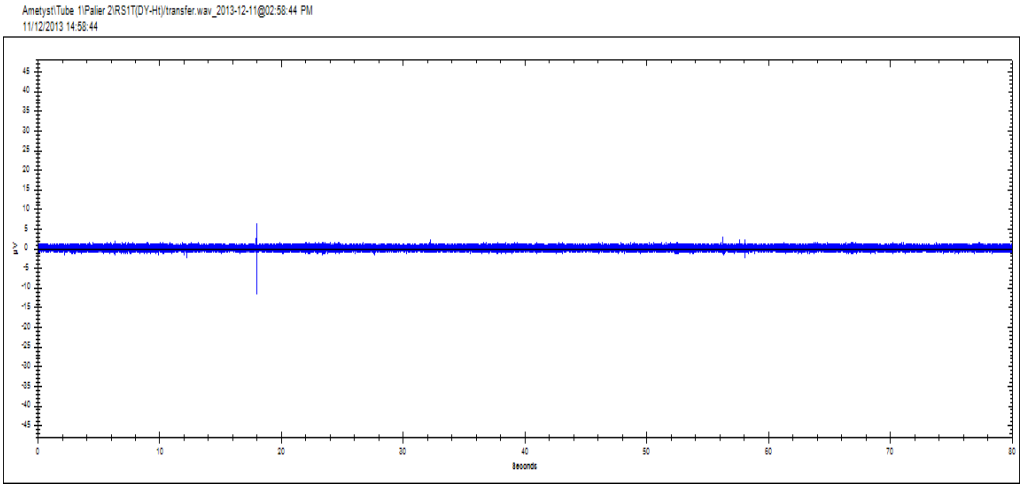
The conclusion was to replace both #3 and #4 bearings. Bearings 5 through 8 on the Product Exit side of the oven returned low dB RMS values and no impulses were detected in the time trace. All four bearings were given a pass.

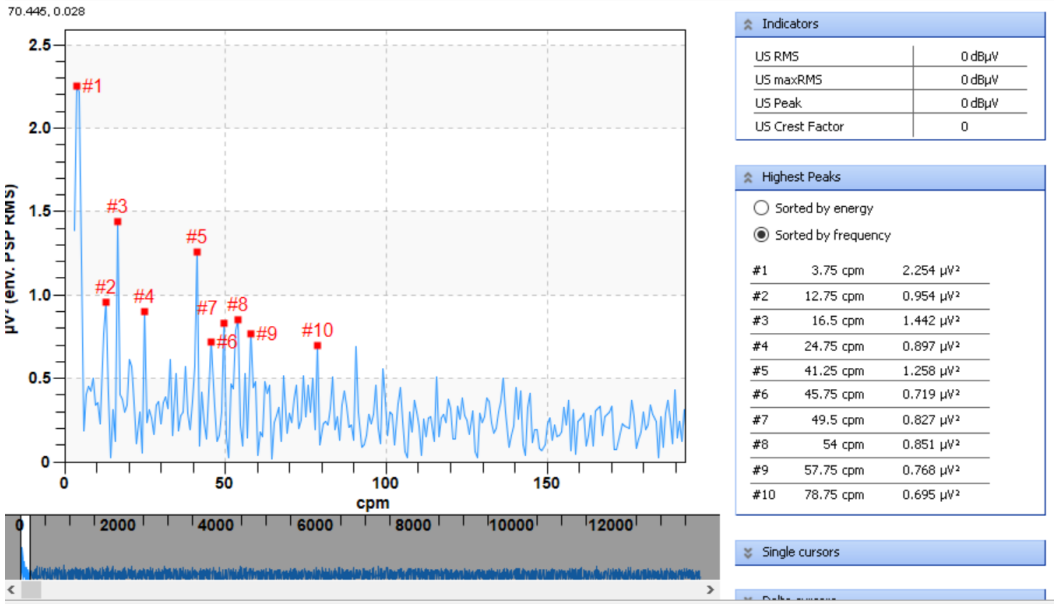
Bearing #3

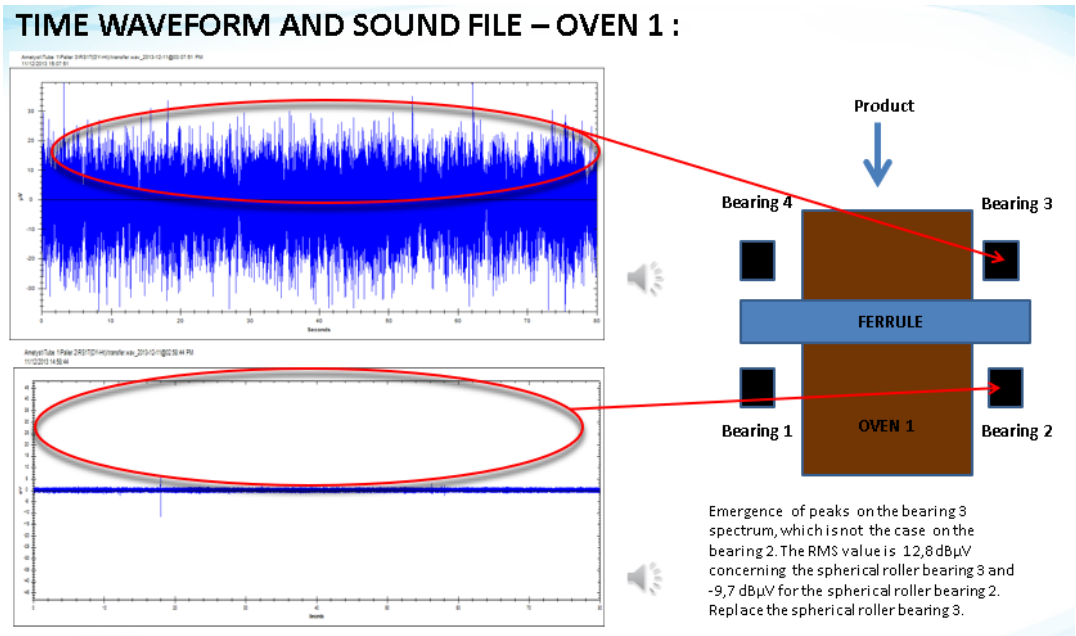



Indicators
US RMS 0 dBµV
US maxRMS 0 dBµV
US Peak 0 dBµV
US Crest Factor 0
Highest Peaks
Sorted by energy
Sorted by frequency
#1 4.5 cpm 87.621 µV²
#2 8.25 cpm 128.383 µV²
#3 16.5 cpm 102.168 µV²
#4 24.75 cpm 136.468 µV²
#5 33 cpm 62.874 µV²
#6 37.5 cpm 60.564 µV²
#7 66 cpm 65.119 µV²
#8 78 cpm 60.088 µV²
#9 90.75 cpm 68.531 µV²
#10 99 cpm 77.437 µV²
Single cursors
cpm

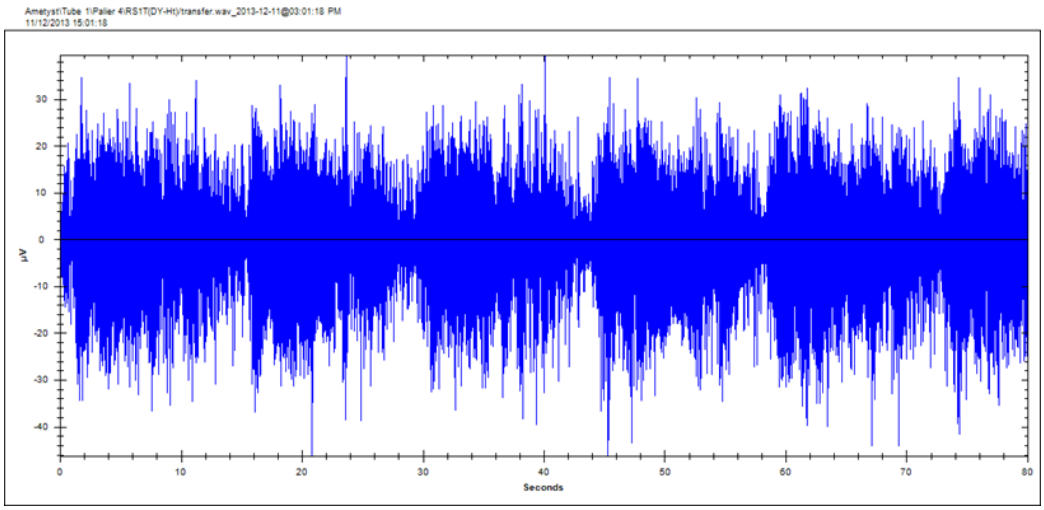
Bearing #2

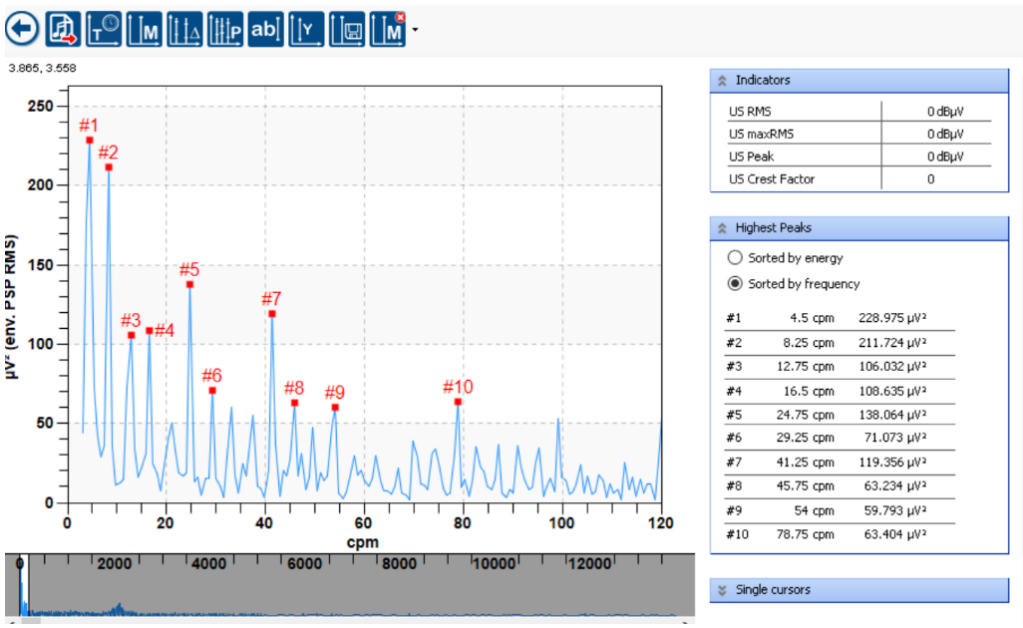

Ametyst\Tube 1\Palier 2\RS1T(DY-Ht)\transfer.wav_2013-12-11@02:58:44 PM
11/12/2013 14:58:44
Seconds


70.445, 0.028
Indicators
US RMS 0 dBµV
US maxRMS 0 dBµV
US Peak 0 dBµV
US Crest Factor 0
Highest Peaks
Sorted by energy
Sorted by frequency
#1 3.75 cpm 2.254 µV²
#2 12.75 cpm 0.954 µV²
#3 16.5 cpm 1.442 µV²
#4 24.75 cpm 0.897 µV²
#5 41.25 cpm 1.258 µV²
#6 45.75 cpm 0.719 µV²
#7 49.5 cpm 0.827 µV²
#8 54 cpm 0.851 µV²
#9 57.75 cpm 0.768 µV²
#10 78.75 cpm 0.695 µV²
Single cursors
cpm

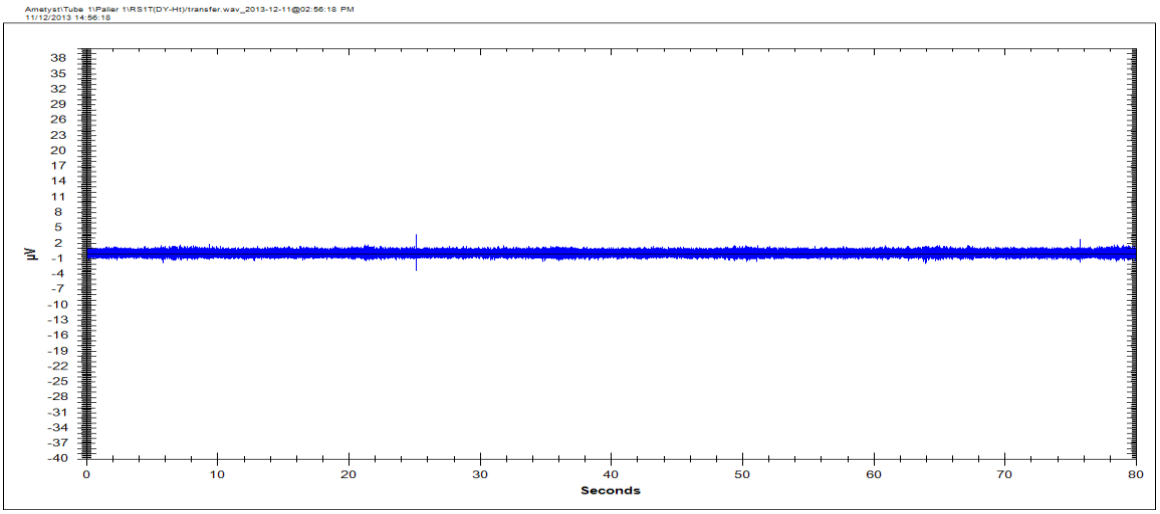

TIME WAVEFORM AND SOUND FILE – OVEN 1 :
Product
Bearing 4
Bearing 3
FERRULE
Bearing 1
OVEN 1
Bearing 2
Emergence of peaks on the bearing 3 spectrum, which is not the case on the bearing 2. The RMS value is 12,8 dBµV concerning the spherical roller bearing 3 and -9,7 dBµV for the spherical roller bearing 2. Replace the spherical roller bearing 3.

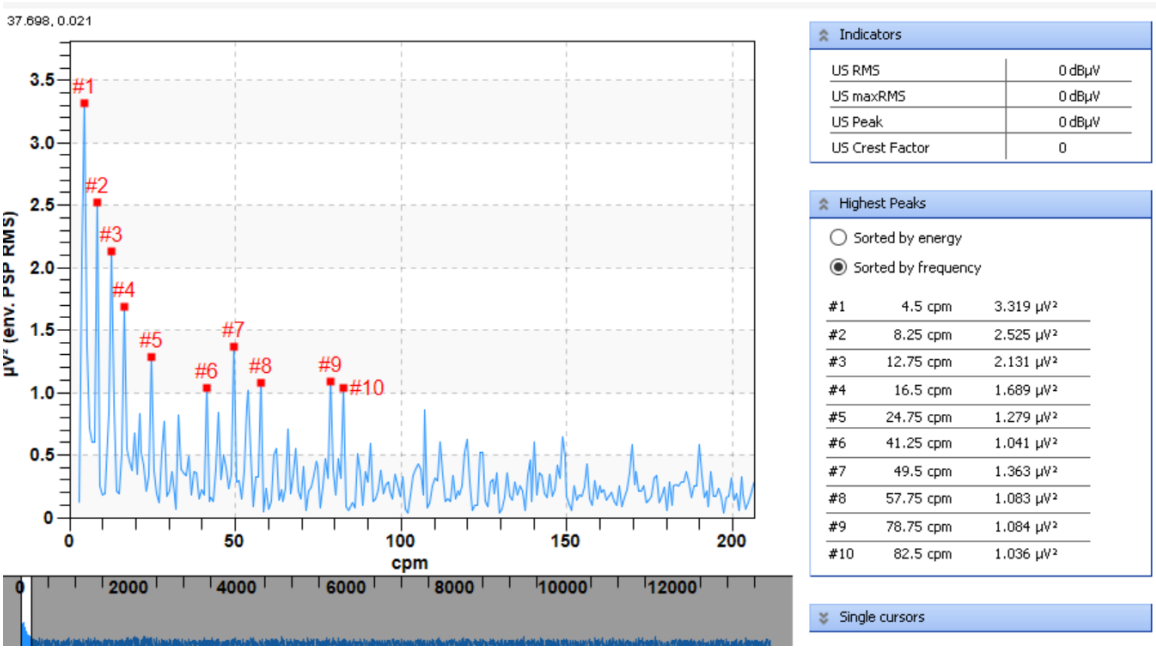
Bearing #4


µV
Seconds


3.865, 3.558
µV² (env. PSP RMS)
cpm
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
Indicators
US RMS 0 dBµV
US maxRMS 0 dBµV
US Peak 0 dBµV
US Crest Factor 0
Highest Peaks
Sorted by energy
Sorted by frequency
#1 4.5 cpm 228.975 µV²
#2 8.25 cpm 211.724 µV²
#3 12.75 cpm 106.032 µV²
#4 16.5 cpm 108.635 µV²
#5 24.75 cpm 138.064 µV²
#6 29.25 cpm 71.073 µV²
#7 41.25 cpm 119.356 µV²
#8 45.75 cpm 63.234 µV²
#9 54 cpm 59.793 µV²
#10 78.75 cpm 63.404 µV²
Single cursors

Bearing #1




## Oven 3

Looking first at the Product Entry side of Oven 3 it was noted that all four bearings exhibited a higher level of ultrasound than the peer bearings on Oven 1(3.5/-5/2.4/-1/3 Oven 3) Vs (-9.6/-9.7/12.8/14.2 Oven 1). Bearing 2 and 4 are quieter than bearing 1 and 3. The time signals do not show any dominant peaks to suggest bearing wear. This is confirmed by the consistency and low values seen in the Crest Factor results. A ninth dynamic measurement taken on the body of the oven for 5 seconds helped confirm the assessment that an alignment issue exists between the support ring and the oven.

Evaluating the Product Exit side of Oven 3 it was noted that all four bearings returned acceptable and low dB RMS values. The only data that triggered an alarm from Patrice was the high Crest Factor and Max RMS values returned by Bearing 8. Taking the dynamic signal into the Time Trace Patrice saw the emergence of peaks at the rotational speed of the bearing 4.4 RPM.

Compared to bearings 3 and 4 on Oven 1, Bearing 8 on Oven 3 is in a less advanced state of failure. As bearing 8 is just beginning to demonstrate early warning signs it was recommended to increase the frequency of monitoring.

## Conclusions

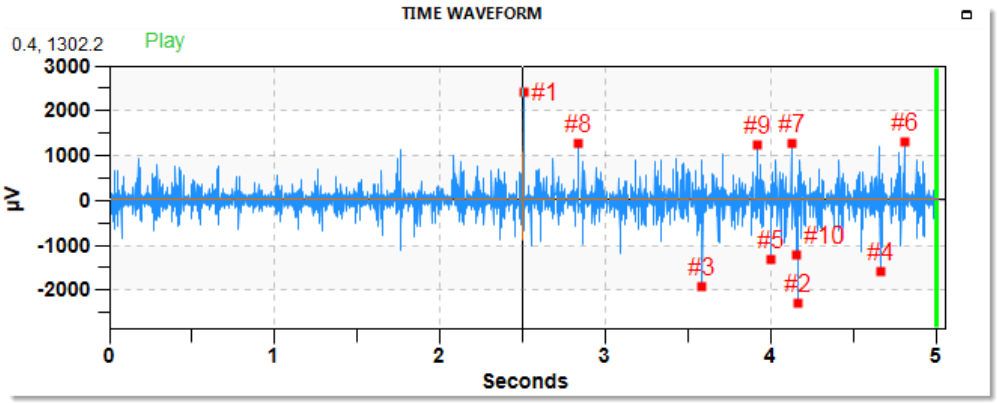
Biogas conversion facilities such as the one featured in Montpellier, France are being built all over Europe and North America. They represent tremendous opportunities to recover energy and fuel from waste that would otherwise sit in piles at a landfill. Reaping non-fossil energy is one reward. Reducing greenhouse gas emissions is the second. The low price of natural gas is still a big factor keeping these facilities from going mainstream.

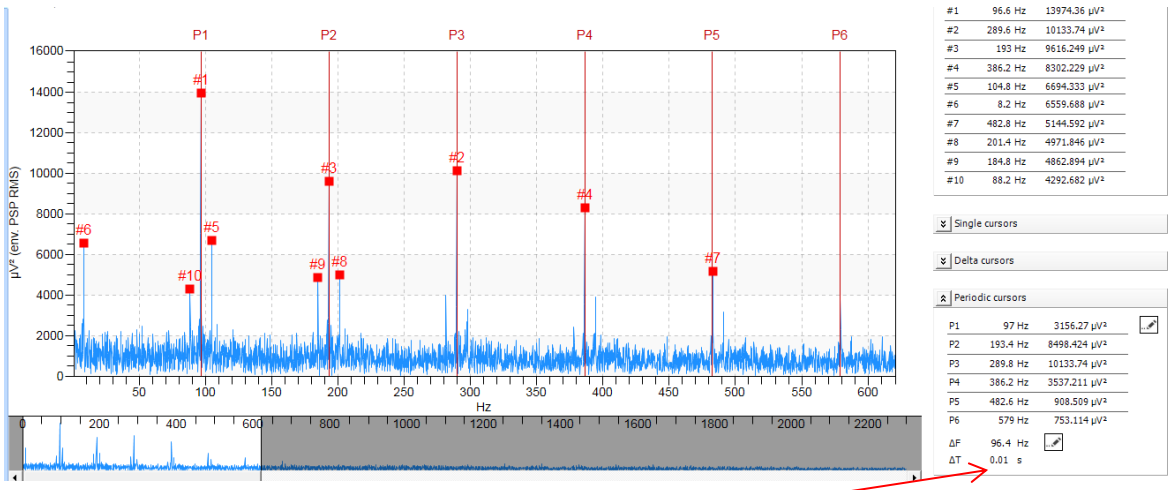
In this presentation we have identified the potential to run these biogas conversion facilities in a more cost-effective manner by putting Ultrasound condition monitoring to work. We all must recognize that the path to efficiency and profitability is paved by Reliability. SDT's field service team has demonstrated just how easy and effective it is to employ simple ultrasound analysis to predict high-cost failures well in advance. By increasing reliability and decreasing unplanned expenditures ultrasound is helping make biogas conversion an economically viable alternative fuel source.

# Horizontal Mixer Jack Shaft

**Author:** SDT Ultrasound Solutions

On July 18, 2019, during Cody's SDT routes he recorded a repeating ticking in the drive side bearing on the intermittent shaft for the horizontal mixer.




The ticks were found to repeat at 96.4 Hz.

Below you will find the data collected and calculated.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | | | | | | | |
| 14 | FPM | Roll Diameter (in) | | RPM | UAS Frequency | | Frequency Factor |
| 15 | 413 | 3.1875 | | 494.9157007 | 96.4 | | 0.194780646 |

Using a tachometer, we found the shaft to spin at roughly

Shaft Diameter

RPM = (FPM*12)/(D*pi)

Obtained from above

FF = UASF/RPM

Bearing being used is a Sealmaster RPM-303-2. Sealmaster provides their vibration geometry.

**Table No. 17** Vibration Geometry Information

| SHAFT SIZE | UNIT NO. | INSERT NO. | FACTOR FOR ROLLER SPIN (BSF) O | FACTOR FOR INNER ROLLER PASS (BPFI) I | FACTOR FOR OUTER ROLLER PASS (BPFO) B | FACTOR FOR FUND. TRAIN (SHAFT ROT.) (FTF 1) F | FACTOR FOR FUND. TRAIN (HSG. ROT.) (FTF 2) G | NUMBER OF ROLLERS/ROW Z |
|---|---|---|---|---|---|---|---|---|
| 1 3/16 | 103 | RCI-103 | 0.12580 | 0.17823 | 0.13844 | 0.00729 | 0.00938 | 19 |
| 1 1/4 | 104 | RCI-104 | 0.12580 | 0.17823 | 0.13844 | 0.00729 | 0.00938 | 19 |
| 1 3/8 | 106 | RCI-106 | 0.11732 | 0.18917 | 0.14416 | 0.00721 | 0.00946 | 20 |
| 1 7/16 | 107 | RCI-107 | 0.11732 | 0.18917 | 0.14416 | 0.00721 | 0.00946 | 20 |
| 1 1/2 | 108 | RCI-108 | 0.11320 | 0.17101 | 0.12899 | 0.00717 | 0.00950 | 18 |
| 1 5/8 | 110 | RCI-110 | 0.11320 | 0.17101 | 0.12899 | 0.00717 | 0.00950 | 18 |
| 1 11/16 | 111 | RCI-111 | 0.11320 | 0.17101 | 0.12899 | 0.00717 | 0.00950 | 18 |
| 1 3/4 | 112 | RCI-112 | 0.10828 | 0.16264 | 0.12069 | 0.00710 | 0.00957 | 17 |
| 1 15/16 | 115 | RCI-115 | 0.10828 | 0.16264 | 0.12069 | 0.00710 | 0.00957 | 17 |
| 2 | 200 | RCI-200 | 0.10828 | 0.16264 | 0.12069 | 0.00710 | 0.00957 | 17 |
| 2 3/16 | 203 | RCI-203 | 0.10828 | 0.17921 | 0.13745 | 0.00724 | 0.00943 | 19 |
| 2 1/4 | 204 | RCI-204 | 0.12160 | 0.19584 | 0.15416 | 0.00734 | 0.00933 | 21 |
| 2 7/16 | 207 | RCI-207 | 0.13446 | 0.19584 | 0.15416 | 0.00734 | 0.00933 | 21 |
| 2 1/2 | 208 | RCI-208 | 0.13446 | 0.19584 | 0.15416 | 0.00734 | 0.00933 | 21 |
| 2 11/16 | 211 | RCI-211 | 0.15781 | 0.22018 | 0.17982 | 0.00749 | 0.00917 | 24 |
| 2 3/4 | 212 | RCI-212 | 0.15781 | 0.22018 | 0.17982 | 0.00749 | 0.00917 | 24 |
| 2 15/16 | 215 | RCI-215 | 0.15781 | 0.22018 | 0.17982 | 0.00749 | 0.00917 | 24 |
| 3 | 300 | RCI-300 | 0.15781 | 0.22018 | 0.17982 | 0.00749 | 0.00917 | 24 |
| 3 3/16 | 303 | RCI-303 | 0.17061 | 0.23678 | 0.19656 | 0.00756 | 0.00911 | 26 |
| 3 7/16 | 307 | RCI-307 | 0.17061 | 0.23678 | 0.19656 | 0.00756 | 0.00911 | 26 |
| 3 1/2 | 308 | RCI-308 | 0.17061 | 0.23678 | 0.19656 | 0.00756 | 0.00911 | 26 |
| 3 15/16 | 315 | RCI-315 | 0.16448 | 0.23758 | 0.19576 | 0.00753 | 0.00914 | 26 |
| 4 | 400 | RCI-400 | 0.16448 | 0.23758 | 0.19576 | 0.00753 | 0.00914 | 26 |
| 4 7/16 | 407 | RCI-407 | 0.16005 | 0.22885 | 0.18781 | 0.00751 | 0.00915 | 25 |
| 4 1/2 | 408 | RCI-408 | 0.16005 | 0.22885 | 0.18781 | 0.00751 | 0.00915 | 25 |
| 4 15/16 | 415 | RCI-415 | 0.15868 | 0.22922 | 0.18745 | 0.0075 | 0.00917 | 25 |
| 5 | 500 | RCI-500 | 0.15868 | 0.22922 | 0.18745 | 0.0075 | 0.00917 | 25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | | | | | | | |
| 14 | FPM | Roll Diameter (in) | | RPM | UAS Frequency | | Frequency Factor |
| 15 | 413 | 3.1875 | | 494.9157007 | 96.4 | | 0.194780646 |

Due to uncertainty in the tac, it was determined there was an issue within the out race of the bearing.

Below is a picture of the outer race of the bearing when taken out and inspected.

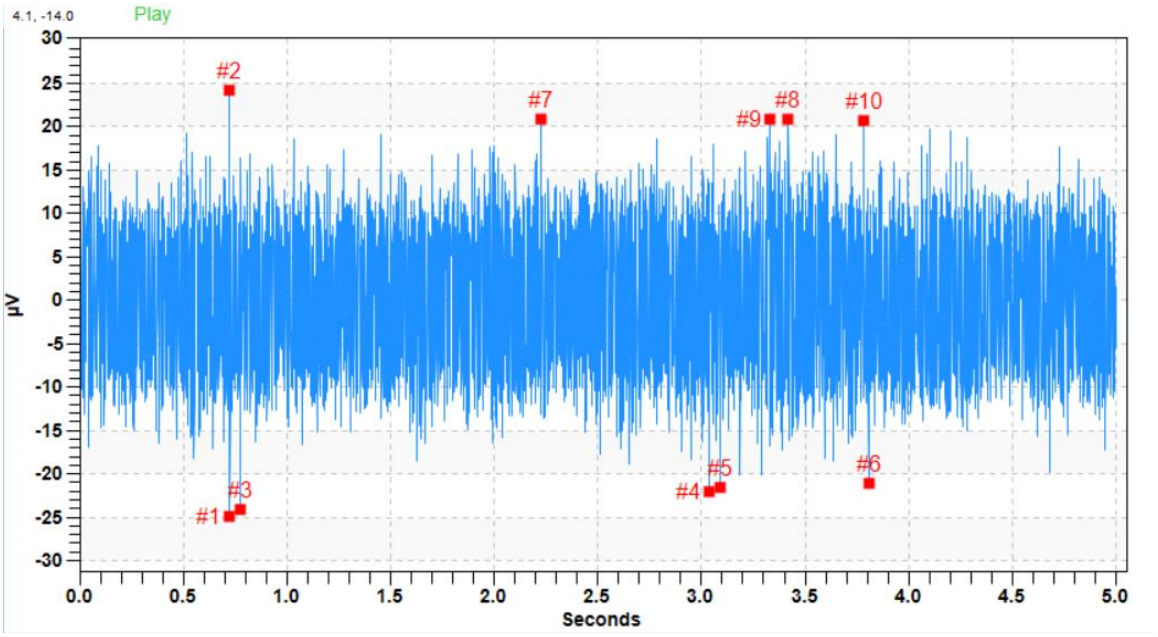
Grooves are worn into the outer race, and this is what the ultrasound was detecting as each rolling element contacted it. Eventually this would lead to a failure of the bearing.

# Grid Couplings

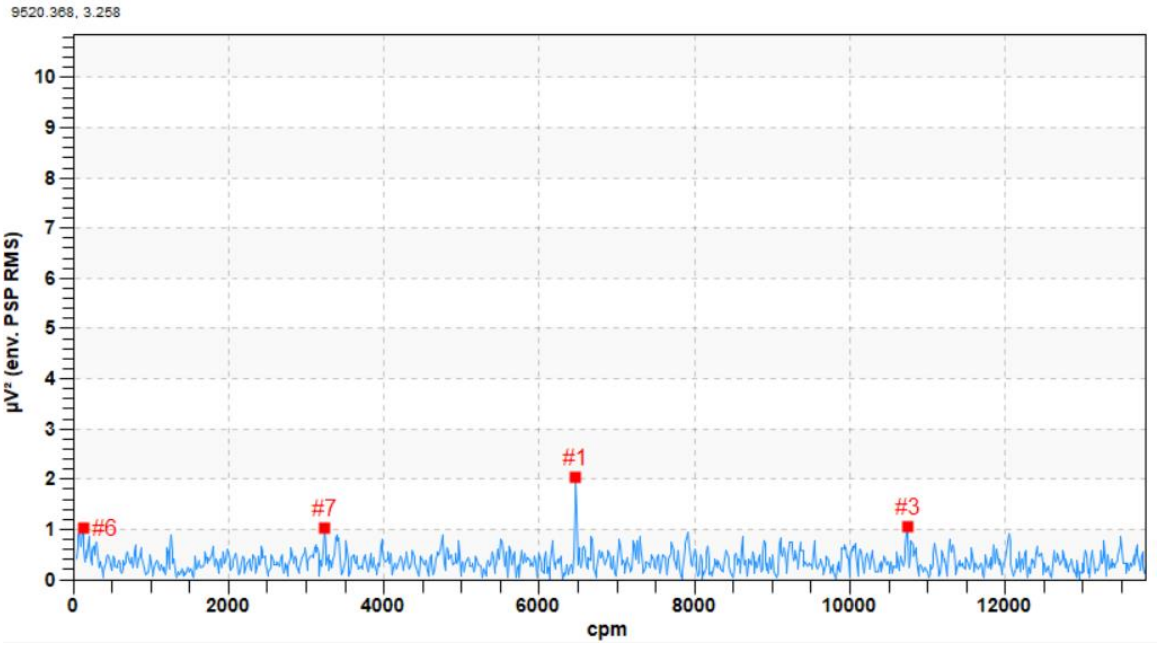
**Author:** Robert Dent
**Email address:** robert.dent@sdtultrasound.com

Canroof Canada uses airborne ultrasound to check the health of their couplings every month. A 5 second reading provides enough data to identify lubrication and functional issues.

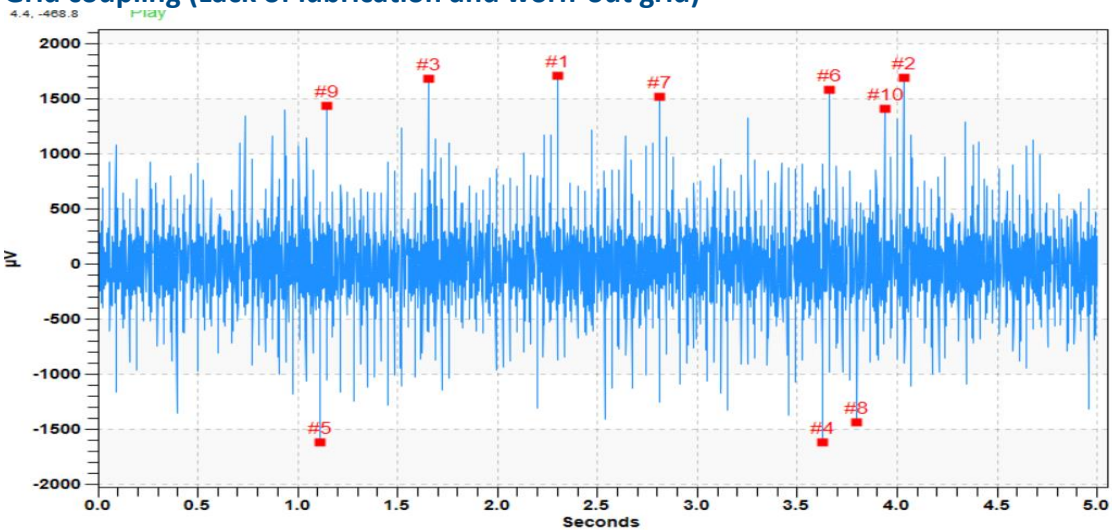
## Grid coupling with no problems



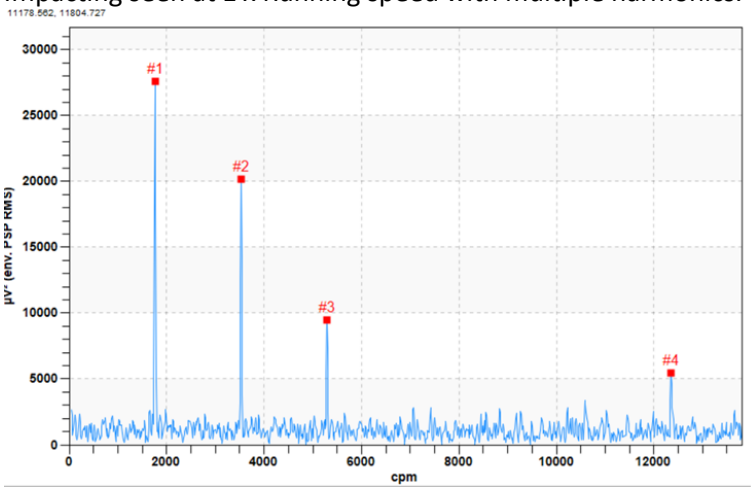

No real impacting – very low energy being generated.



## Grid coupling (Lack of lubrication and worn-out grid)




Impacting seen at 1 x Running speed with multiple harmonics.




Highest Peaks

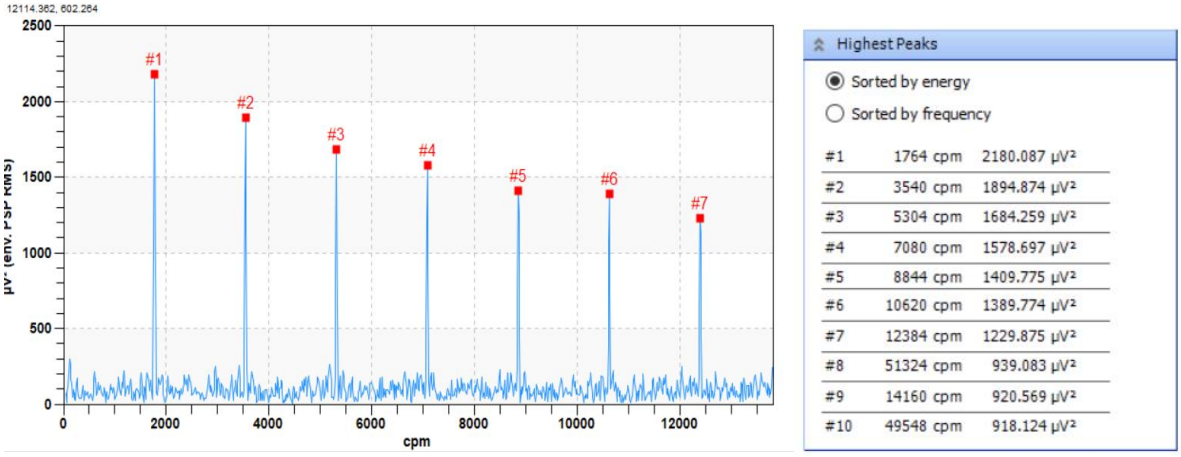
Sorted by energy

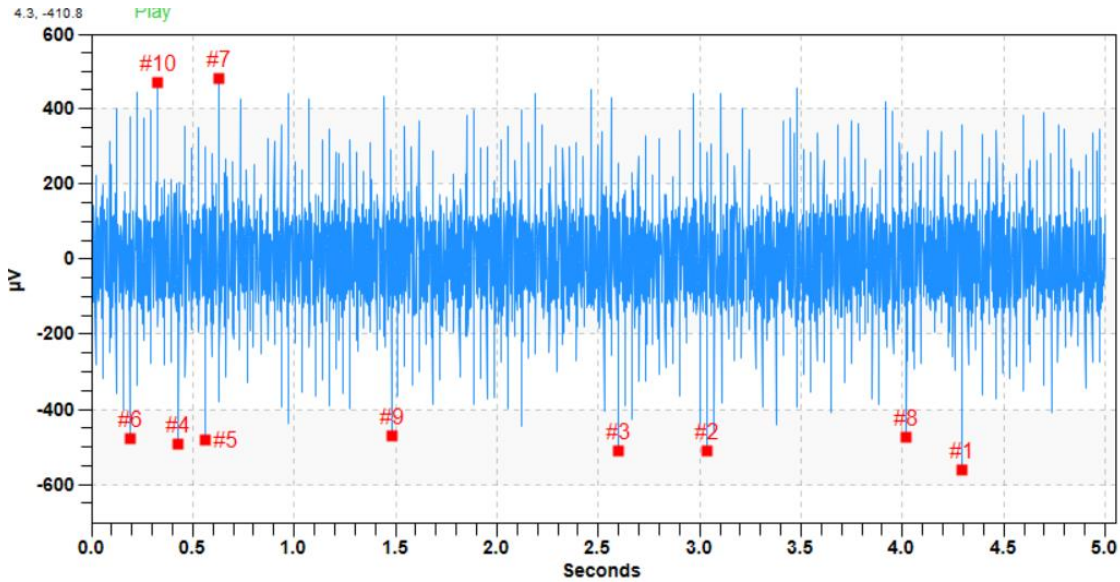
Sorted by frequency

| | | |
|---|---|---|
| #1 | 1764 cpm | 27594.68 µV² |
| #2 | 3528 cpm | 20181.11 µV² |
| #3 | 5292 cpm | 9445.919 µV² |
| #4 | 12348 cpm | 5474.875 µV² |
| #5 | 14112 cpm | 6176.597 µV² |
| #6 | 15876 cpm | 5461.881 µV² |
| #7 | 17640 cpm | 5071.651 µV² |
| #8 | 30000 cpm | 5922.473 µV² |
| #9 | 31764 cpm | 6173.367 µV² |
| #10 | 33528 cpm | 5433.415 µV² |

## Grid coupling (broken grid)

*Impacting seen at 1 x Running speed with multiple harmonics*




# Greenfield Ethanol Failure Cause Analysis

**Authors:** Tristan Rienstra and Jonathan D.
**Email address:** tristan.rienstra@sdtultrasound.com

## Continuously Monitored using Vibration & Ultrasound Analysis

This BF-9401 Area Pulling Fan plays an integral role in Greenfield Ethanol's manufacturing process. It is a critical component to their Thermal Oxidizer Equipment. If this fan goes down, production is severely hindered, and possibly even stopped all together.


**Vigilant System Permanent Install on Critical Fan Bearing**

## Understanding the Asset

The asset is a New York Blower with a 250hp motor that rotates 1780 rpm. The fan rotates at 1168 rpm 24/7, all day, every day. The fan shaft is mounted with two SKF 22232 bearings, they're lubricated with oil.

The last time the fans bearings were replaced was October 22, 2012.

## Vibration & Ultrasound Analysis, September 2022

Lead Vibration Analyst, Jonathan Dion takes routine vibration measurements on this plant's critical equipment. Back in 2018, a defect was detected on the pulley side of the fan (SKF 22232). It has since been evolving. Using the acceleration envelope filter in Peakvue, it can be seen clearly.

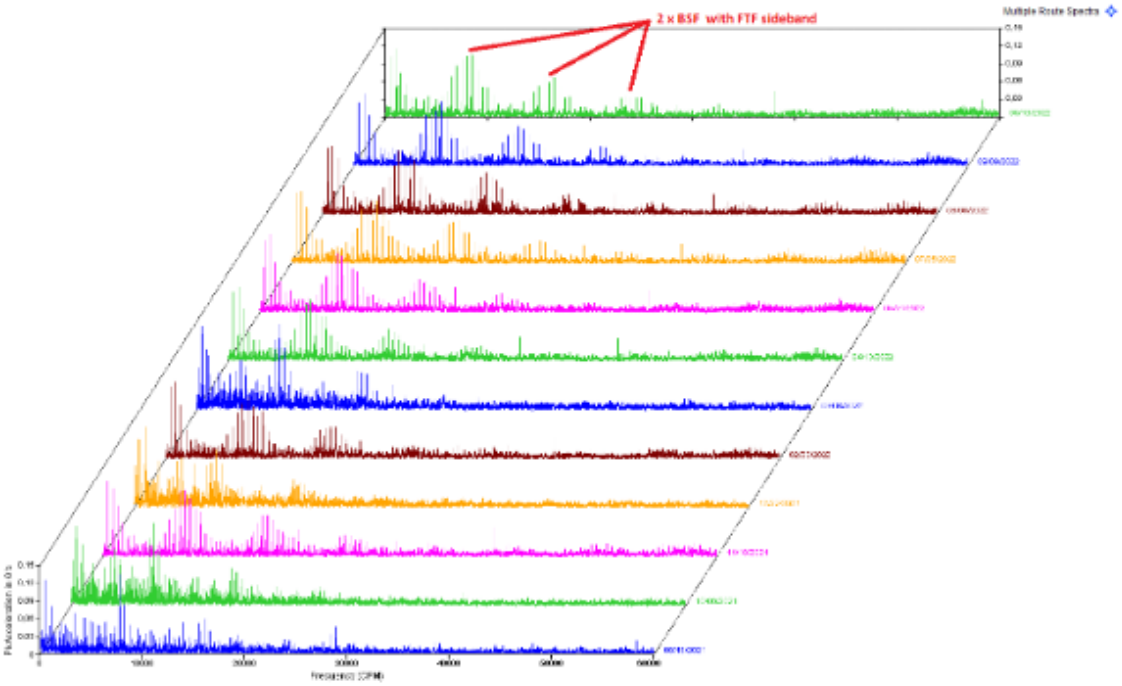



**Figure 1 – Envelope Spectrum (Peakvue)**

The following ultrasound readings were taken on September 9, 2022, helping confirm the findings from the Vibration readings.

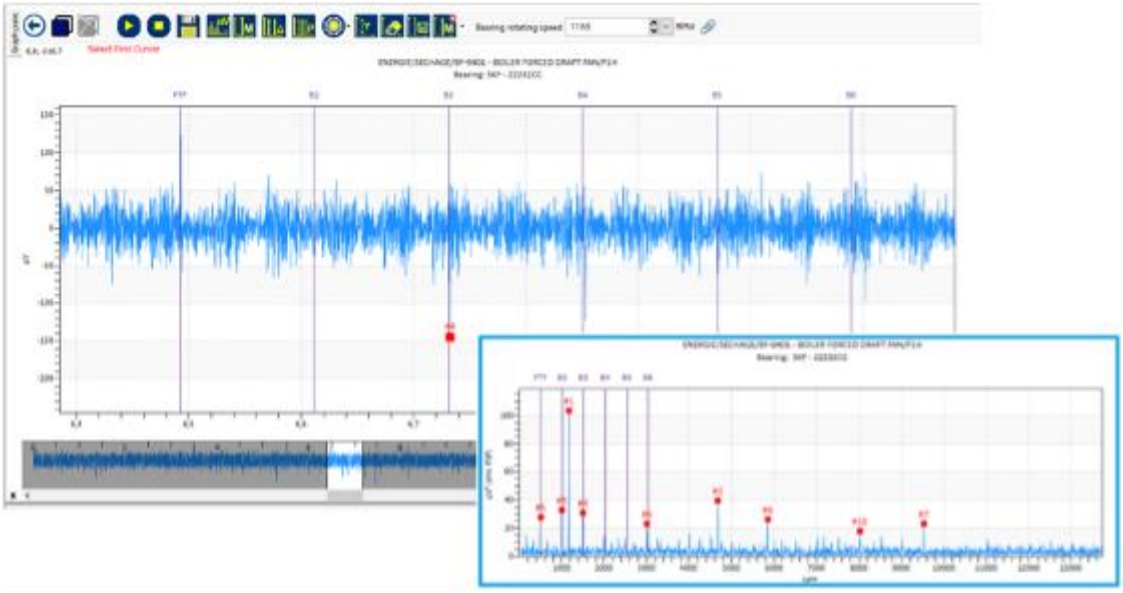


**Figure 2 – Ultrasound Readings (UAS3)**

## Vibration & Ultrasound Analysis, November 2022, Vigilant System

With no plan to replace the bearings until the large-scale planned shutdown in September 2023, the best course of action decided by the reliability team was to install a Vigilant System to continuously monitor the condition of the fans bearings, and hopefully see the assets life extended until the planned shutdown.

*The Vigilant System is an 8-Channel Online Condition Monitoring Solution that combines the versatility of ultrasound and the analytics of vibration. Vigilant comes standard with its own embedded software that any member of the reliability team can access using the correct network credentials.*

*The Vigilant provides reliability teams with a means to continuously monitor critical assets that are heavily guarded, or in this case as they near their end of life.*


**Vigilant System**

See how the Vigilant was configured below:

- M2H horizontal drive motor
- F1H : fan side drive Horizontal
- F1A : fan side Axial drive
- F2H : fan opposite drive side Horizontal

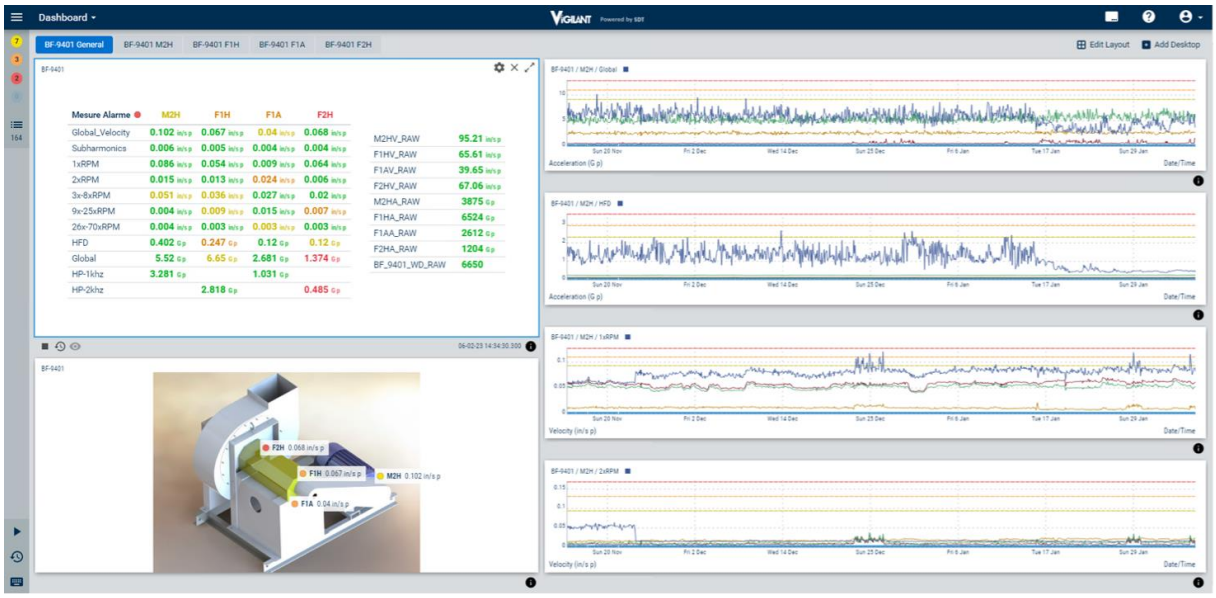


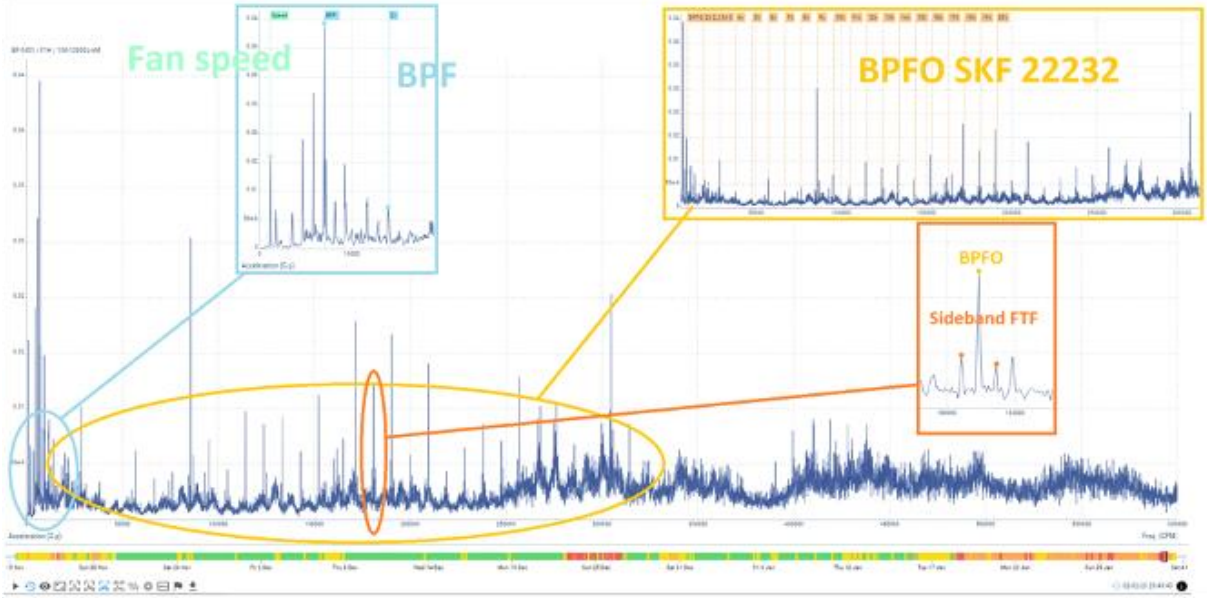

**Figure 3 – Vibration Sensor Configuration & Dashboard (Vigilant Embedded Software)**

## Vibration & Ultrasound Analysis, February 2023, Vigilant System

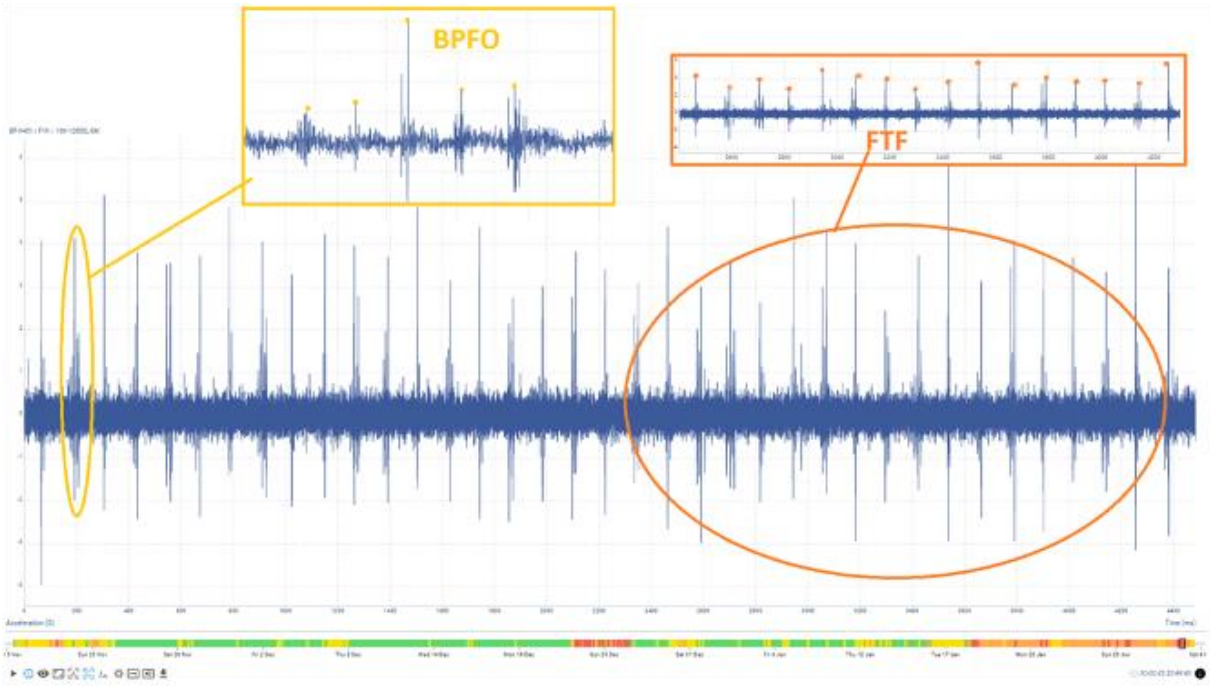
The reliability team's focus was monitoring data collected by the F1H Accelerometer. Monitoring technicians split their windows into 4, all with different lines of resolution as to see rapid changes as well as changes over a long period of time.


**Figure 4 – Vigilant Window Configuration**

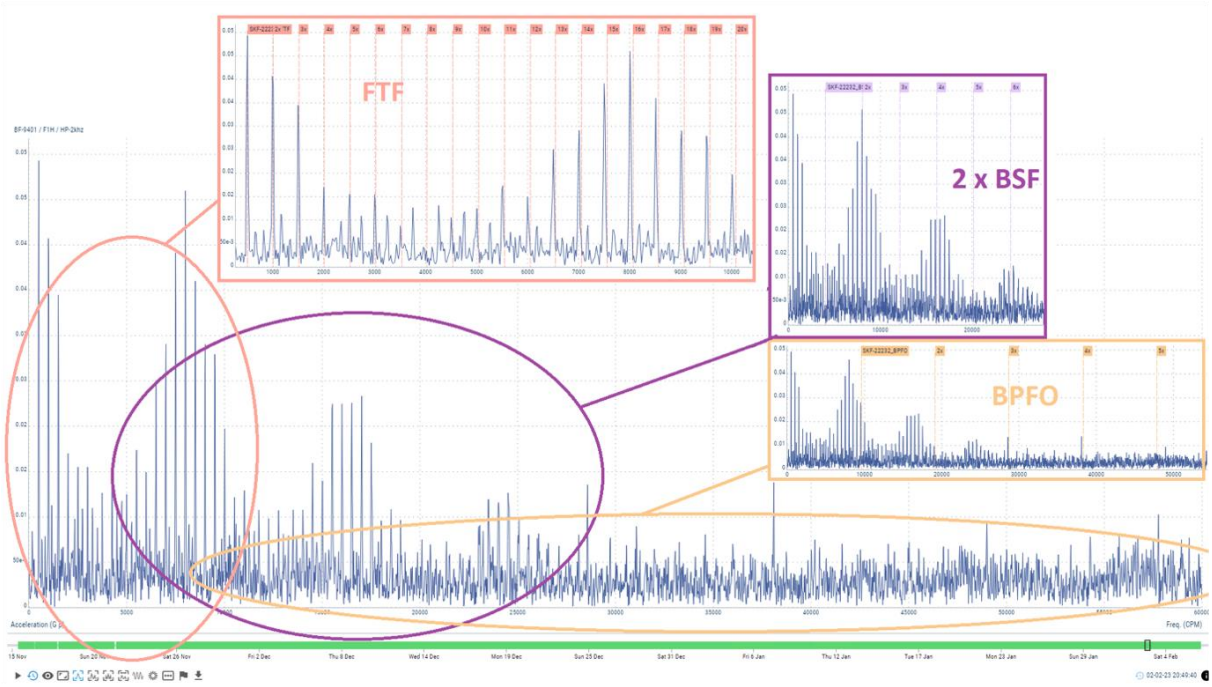
## A Closer Look at Each of the 4 Windows



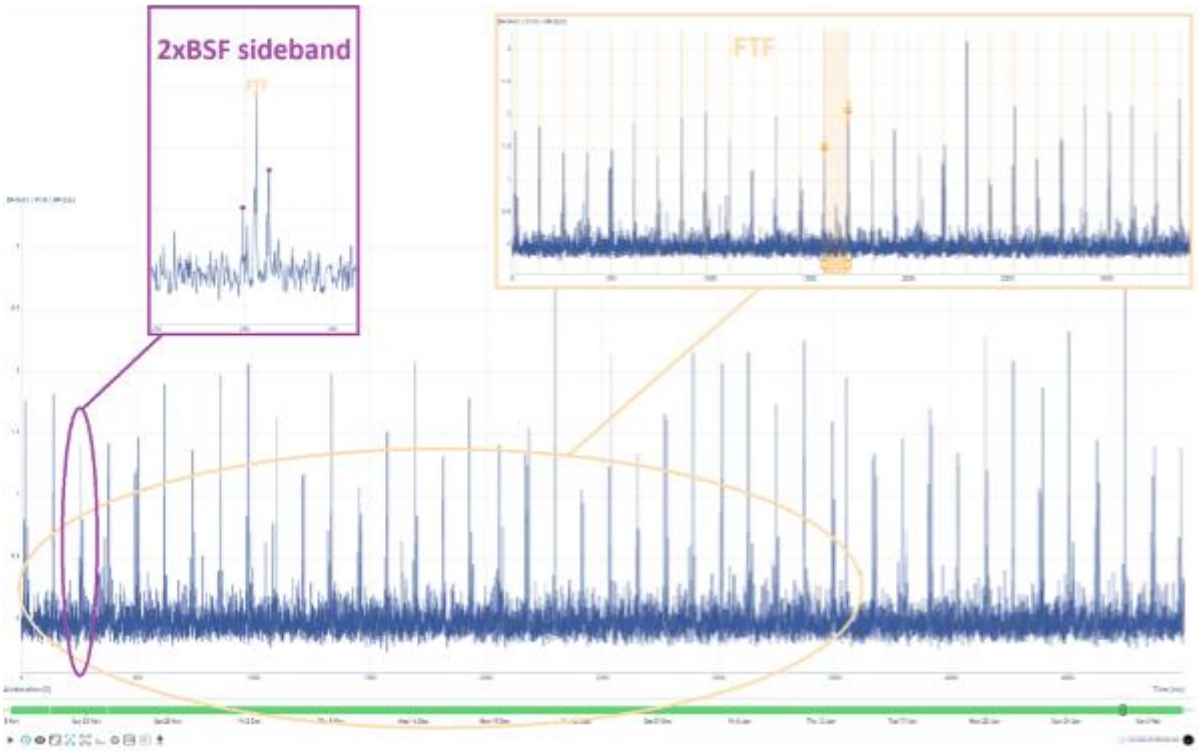

**Window 1 - Max. Frequency 10000hz, Lines 12800, Averages 6 – February 2, 2023**




**Window 2 – Time Waveform – Duration: 4.485 seconds – Points: 114817 – February 2, 2023**




**Window 3 – Envelope Spectrum – High-Pass Freq. 2000hz, Max. Freq. 1000hz, Lines 3200, 1 Average – February 2, 2023**




**Window 4 – Envelope Time Waveform – High-Pass Freq. 2000hz, Duration: 5.05 seconds – Points: 12800 – February 2, 2023**

## Concluding Thoughts

With the Vigilant system in place, constantly monitoring the condition of the fans faulty bearing, the maintenance and reliability team at Greenfield Ethanol can safely extend the life of this fan, possibly even until the next scheduled shutdown in September 2023.

But just in case, alarm management was set up with the plants DCS to trigger email alerts if the condition of the fans bearings decreases to dangerous levels.

# Critical Centrifuge Bearing Monitoring

**Authors:** Tristan Rienstra
**Email address:** tristan.rienstra@sdtultrasound.com

A centrifuge uses centrifugal forces, generated at high RPMs to separate solids and liquids. At Greenfield Ethanol, they use centrifuges in their manufacturing processes. They are critical to their operations.

This centrifuge in question rotates at 5250RPM, and it has a suspected bad bearing. The following Figure 1 & 2 depicts the bearing & the asset.

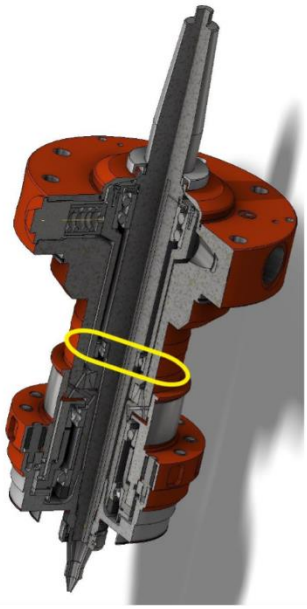


**Figure 1 - Centrifuge - Greenfield Ethanol**
**Figure 2 - Centrifuge Diagram - Bad Bearing in Question**

Jonathan Dion, of Greenfield Ethanol previously reported monitoring a critical fan with a bad bearing up until his plants next scheduled shutdown.

He successfully managed to extend that fans lifespan for a full calendar year by keeping it under a watchful eye with his Vigilant System: an 8-Channel permanent condition monitoring solution, capable of both ultrasound and vibration analysis.

A similar situation arose at his plant. He discovered a bad bearing on a centrifuge using his SDT Ultrasound Data Collector. The fault was not yet visible with his vibration analysis tools. No cause for concern yet, the bearing had a lot of life left, but it was in the early stages of failure. Still, no reason to use unplanned downtime to replace the bearing. The plan is to replace the bearing during the next scheduled shutdown. Please see the DIPF curve in Figure 3.

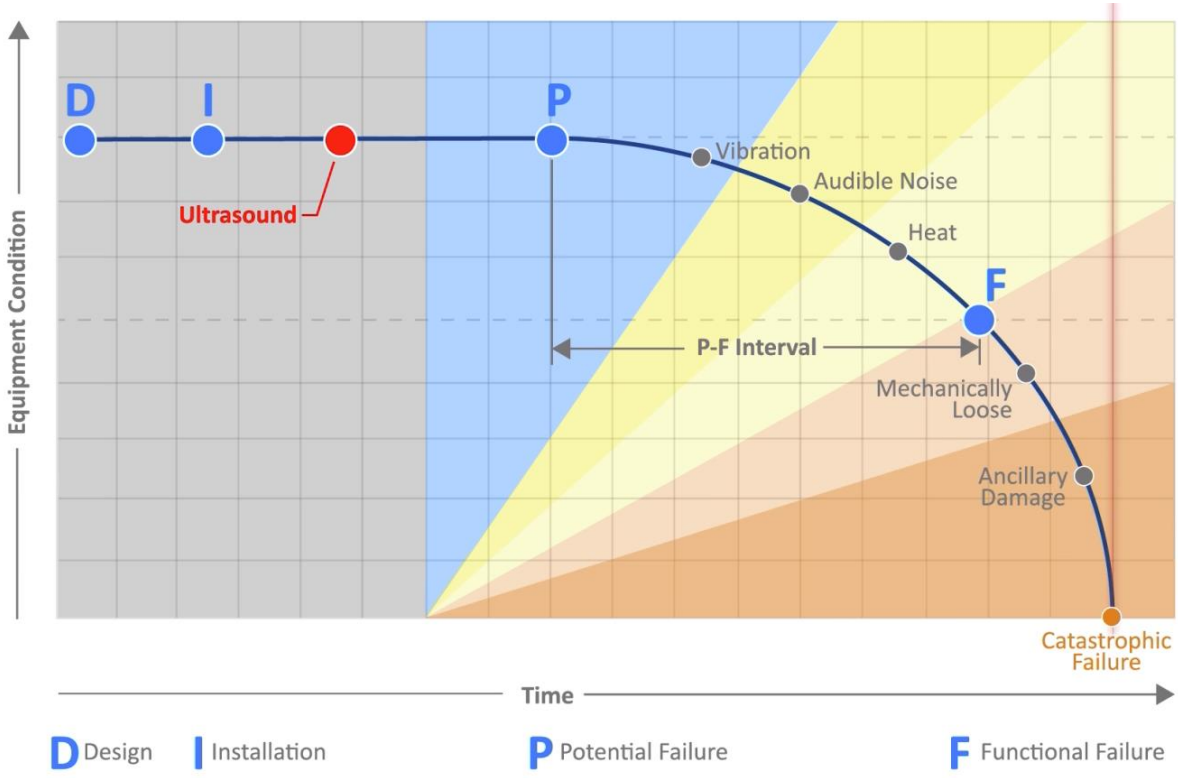



**Figure 3 - DIPF Curve**

So, Jonathan did what any savvy reliability engineer would; used his Vigilant System (as per figure below) to establish permanent monitoring on this critical bearing, as operations and production continued. Jonathan used both ultrasound and vibration to monitor its condition.

For the next few months, the bearings condition continued to slowly deteriorate in the ultrasound spectra. It was eventually visible and well defined in the vibration spectra and demodulated spectrum, as seen in the data in Figure 4 & 5.

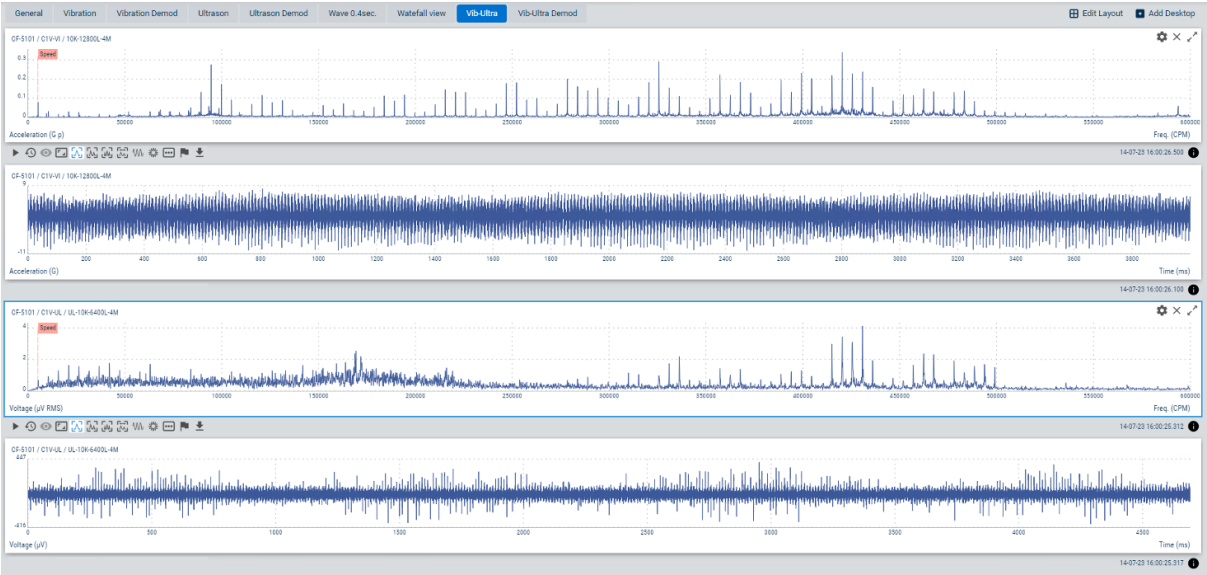



**Figure 4 - Vigilant Dashboard - Ultrasound & Vibration Spectra**

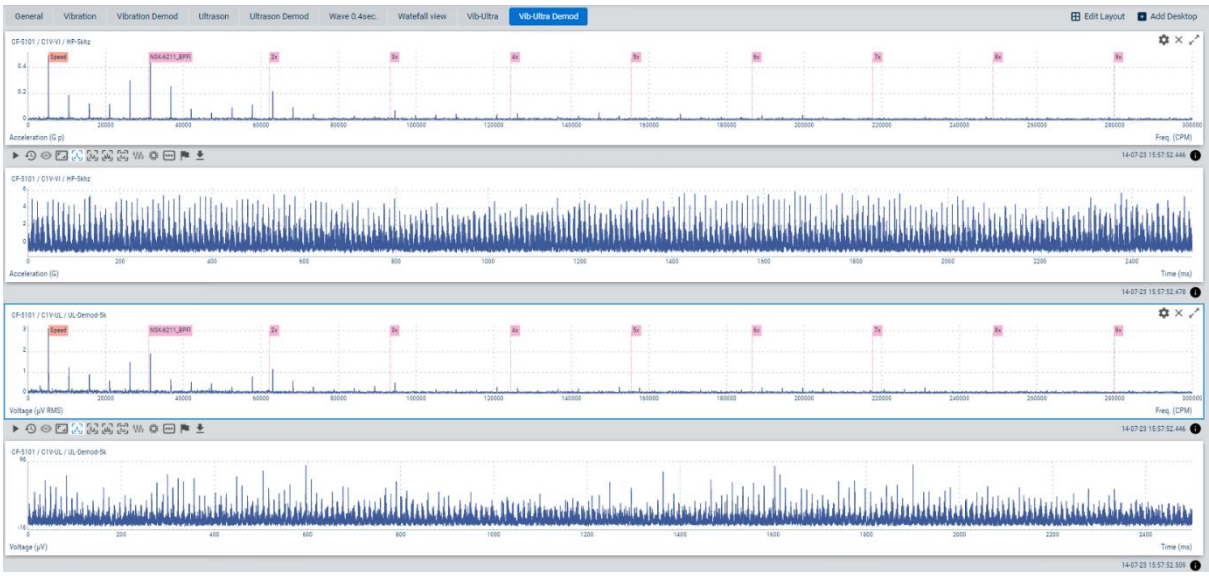



**Figure 5 - Vigilant Dashboard - Ultrasound & Vibration Spectra Demodulated**

The severity of the problem has clearly increased since it was first discovered with ultrasound. It is now visible in the vibration spectra, showing a ball pass frequency outer race defect with 1x rpm sidebands.

# Mining industry

## Hydro-Cyclone Surveillance, Antapaccay Mine, Preventing Sanding & Blockages

**Authors:** Allan Rienstra and Gus Velasquez
**Email addresses:** allan.rienstra@sdtultrasound.com and gus.velasquez@sdtultrasound.com

This is a Hydro-Cyclone. It separates things. Solids from liquids, solids from solids, or even liquids from gases. The principle is simple enough. A slurry enters the inlet pipe.

Centrifugal force pulls large stuff to the sides and gravity lets them fall through the exit pipe. The vortex in the middle lifts smaller, lighter stuff through the top exit pipe.

Mines use hydro-cyclones in nests to separate sand particles from liquids in a slurry. If the sand particles become too large the cyclone clogs. A clogged cyclone is a safety risk, and results in asset damage and lost production.

The major components of each centrifuge within the nest can be seen depicted in Figure 1. Key components include:

- Feed Inlet (Where the slurry of pulp enters the centrifuge)
- Fluted Vortex Finder (Where the vortex occurs)
- Apex Nozzle (Where concentrated solids exit the vortex)
- Overflow (Where diluted solids exit the vortex)

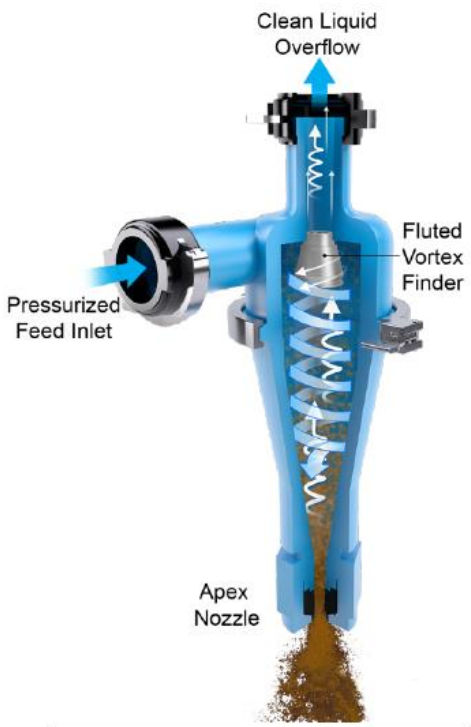



Figure 1: Hydro-Cyclone Components

The Antapaccay Mine in Peru uses a group of 6 Centrifuge Hydro-Cyclones as part of their mineral separation process.

When hydro-cyclones are grouped together like this, they are called nests.

A consistent reliability issue Antapaccay Mine faces with their nests is sanding and blockages leading to excessive wear on the centrifuges & their components, as well as stoppages to production.

Sanding is caused by the increased size of granular particles.

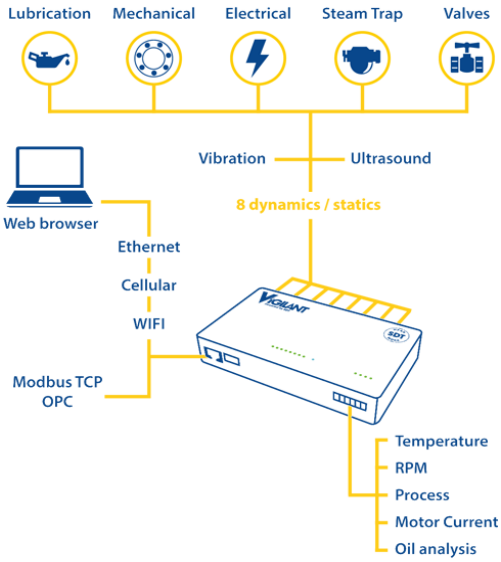
Blockages occur when particle size increases even further. This can lead to pressure spikes which can lead to safety concerns for operators, loss of production and equipment damage.

Detect “sanding” and “blockages” in hydro-cyclones.

Determining wear of internal rubber coatings on exit pipe.

## A Permanent Monitoring Solution to Prevent Sanding & Blockages

The Vigilant System from SDT Ultrasound Solutions is a multi-channel online condition monitoring solution that combines ultrasound and vibration sensors for permanent monitoring of critical assets. The Vigilant answers the necessary demand to have advanced warning of critical asset failure in remote, or hard/dangerous to access areas.




The Vigilant is designed to provide reliability teams with continuous feedback about the health of their factory's most critical assets. It combines data from the two most relevant asset condition monitoring disciplines (Ultrasound & Vibration) to provide advanced insight about potential machine failures.

## Mineral Separation Process & Inspection

The process begins when pulp enters through the feed inlet. The cycloning then begins taking place in the feed chamber. The heavier particles move to the outer walls, and the apex. This is known as underflow. The lighter particles stay near the center of the cone and are carried by the vortex, which is called overflow.

The inspection process for this reliability issue was very simple with the help of a permanent monitoring system. SDT techs first attached a RS2T sensor to each of the 6 hydro-cyclones. We then used the ultrasonic signals produced during the cycloning process to determine if one of the following was occurring:

- Small particles (normal condition)
- Large particles (sanding condition)

- Without Flow (clogging condition)

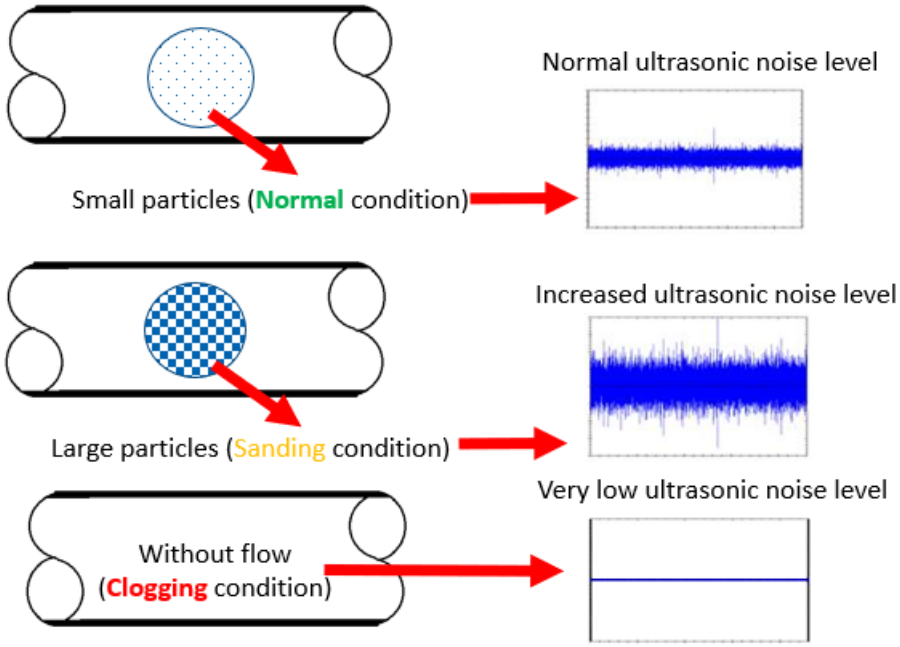



Figure 2: Normal, Sanding, Clogging Condition & their Ultrasound Signals

These can be further illustrated in Figure 2.

Ultrasound is easily able to identify these failure modes as friction & impacting can be monitored closely and trended with SDT's resonant sensors and advanced software.

Even when the hydro-cyclones are functioning as they should, there is lots of ultrasound produced from friction between minerals & against pipe walls. These ultrasound levels just increase when there is sanding occurring.

We conducted preliminary tests to ensure the installation & permanent monitoring would work. The results can be seen in Figure 3 below.

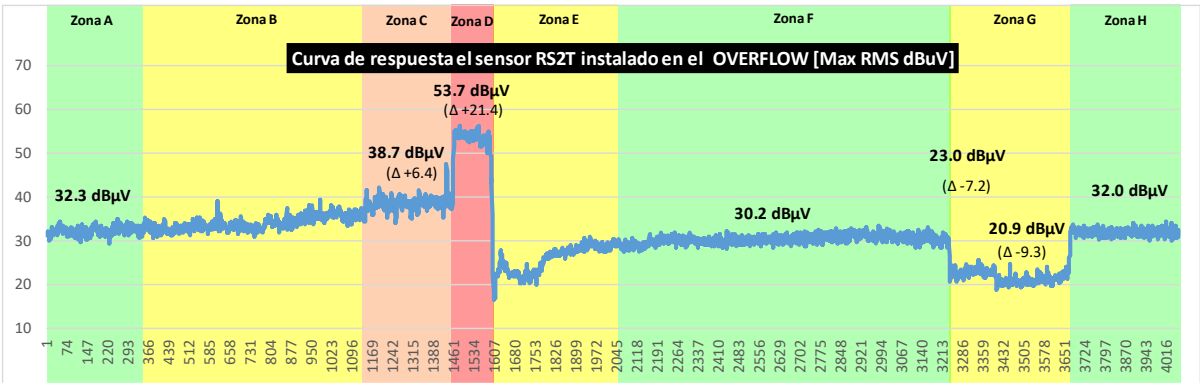



Figure 3: Preliminary Test Data

We tested our sensors & permanent condition monitoring solution against the different granularities of minerals that would most likely be passing through this hydro-cyclone.

- Zone A indicates normal condition
- Zone B, C, D indicates sanding as it is intentionally induced gradually
- Between Zone D & E – Clogging occurred, the Emergency Stop was triggered
- Zone E – Process was restarted after the clog was removed
- Zone F – Normalized operation was achieved again
- Zone G – Flow was intentionally decreased
- Zone H – Normalized Operation was achieved again

In conclusion, we were able to determine that ultrasound was able to detect both sanding and clogging conditions in this mine's hydro-cyclone nests. We were able to determine whether or not the hydro cyclones were functioning as they should non-invasively. Installation was not difficult and monitoring the asset from the maintenance and reliability control room proved easy with the Vigilant's ability to relay condition monitoring through ethernet or cellular networks.

# Power Plant

## Identifying Condenser Tube Leaks with an SDT270 Ultrasound Detector

**Author:** Allan Rienstra
**Email address:** allan.rienstra@sdtultrasound.com

### Introduction

Heat exchangers come in many shapes, sizes, and configurations. Their purpose; to efficiently transfer heat energy from one medium to another while keeping those media separate.

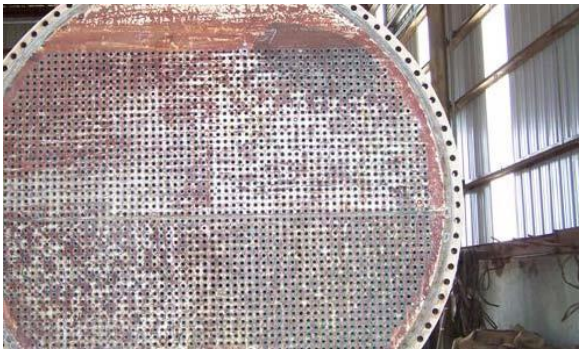


**Figure 1 - Tube and Shell Condenser**

Sometimes called "surface condensers", these installations are used in a variety of industrial applications. We find them in refineries, water and wastewater treatment facilities, food processing, and power generation to name just a few.

Shell and tube heat exchangers consist of a bundle of steel tubes entombed in a shell. For the installation to perform effectively both bundle and shell must be leak free.

Two fluids of different temperature flow freely through and around the tubes. Separated by only the thinnest of steel, the transfer of heat energy is completed without the mingling of a single molecule.

Heat exchangers function under extreme high pressures and temperatures; conditions which, over time, contribute to failure modes that impact the installation's integrity. A common cause of failure is corrosion. The corresponding effect is tube leaks.

In fact, the bundles consist of thousands of tubes, which provides excess capacity to accommodate leaks. Corroded and leaking tubes only need be plugged to effectively remove them from active duty. The exchanger can continue to function so long as a sufficient number of functional tubes remain. The leaking ones are by-passed.

**Figure 2 - Scaling on turbine blades**

There are systems in place to notify operators of the increasing presence of tube leaks. Tube corrosion can be attributed to increasing levels of contaminants like sulfates, organic acids, and chlorides.

One method used to identify contamination is to measure condensate samples for cation conductivity. Cation conductivity measures the electrolytic conductivity of a water sample and reports it in micro-Siemens per centimeter (uS/cm).

Silica and sodium levels are monitored constantly. When they exceed acceptable levels (measured in parts per billion = PPB) it's time for action. If not, silica deposits on the tube walls and creates scaling.

Corroded leaking tubes allow the two separated media to merge. Contamination of highly pure steam and water transfers downstream to other system components.

Formations on turbine blades, pump vanes and valves diminish their efficiency, creates imbalance, and forces drive components to work harder just to maintain output (Figure 2).

Increased vibration levels accelerate component deterioration. Originally, tube leaks were caused by corrosion. Add in the juddering and jarring from vibration and new leaks appear in the form of cracked tubes.

## Two Action Paths to Consider

Results engineers have two paths of action when silica and sodium level are high. With either choice, the station is forced to run at a lower output capacity for the duration of the maintenance.

Simple action is non-intrusive and fast. It involves valving off one side of the condenser and flushing the system. Acceptable sodium and silica levels are quickly restored, and the generator unit is back to full capacity fast.

In human terms, it's a detox. A detox is temporary. It treats the symptoms but doesn't address the problem. In the human example, bad diet and lifestyle is the culprit. In the condenser example its leaking tubes.

**Figure 3 - Leaking tubes are identified and plugged**

Flushing the tubes has environmental consequences to consider. Old water is disposed of, and new water brought in. The unit runs at reduced power, burning more coal, while producing less megawatts.

The leaks remain. Levels of sodium and silica will rise again. Another flush will be necessary soon.

The other action choice is to identify the leaking tubes and plug them; effectively removing the leakers from service. This is the better solution because it treats the cause. But it too carries downside.

Looking for leaks can be unpredictably more time consuming than a system flush. Depending on the tools used for leak detection, you can be looking at a few hours, a day, or even longer. This needs to be communicated clearly so enough time is budgeted to do the job right.

Safety is an issue always. Inspectors are exposed to confined spaces and high levels of heat and humidity. The condenser is at or near operating temperature. They must work in teams; never alone. Personal hydration is paramount.

Bill Phipps is Production Manager at the AB Brown Power Plant in Mt. Vernon, Indiana. Located on the northern bank of the Ohio River, AB Brown is a four-unit, 700 MW power generating facility.

Two of the units are coal fired and the other two are gas. The coal units depend on leak-free condensers to operate efficiently. Water from the cooling tower passes through the inside of the

tubes. Steam exhausted by the turbine passes over the tubes and is transformed back into condensate as ultrapure water. The water is returned to the boiler and converted back to steam.

The steam side of the tubes maintains 27 inHg (inches of mercury) vacuum. Any tube leak allows the water from the cooling tower to pass through and foul the ultrapure water with sodium and silica. Condenser tube leaks increase the silica and sodium counts in the boiler water and steam. Once the silica and sodium in the boiler water reach 750 PPB, they are forced to lower pressure on the Unit and lose Megawatt production.

## January 2015 – Silica and Sodium is Rising

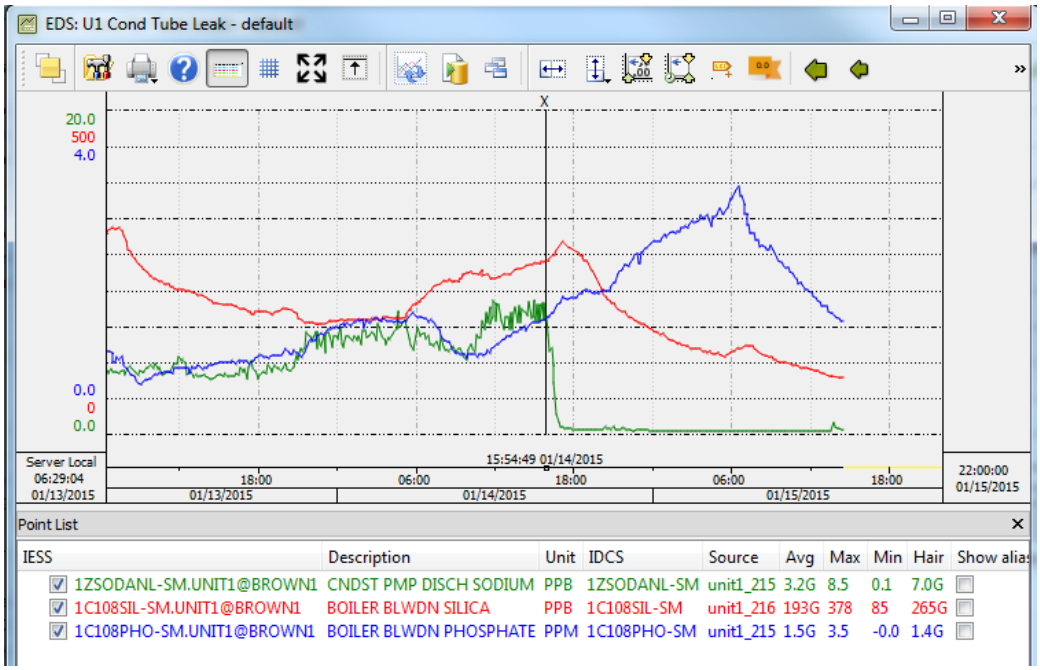



**Figure 4 – Rising sodium and silica leaks in Unit 1 indicate small tube leaks. Condenser flushed on January 14, 2015, restored normal levels for now.**

Figure 4 shows a typical graph trending higher silica and sodium levels in the cooling tower water on Unit 1. The presence of contaminants is below the 750 PPB threshold, but it puts Phipps' team on notice. On January 14, 2015, his team isolated and drained half of the condenser (Unit 1, 216) with the leak. The green line is the sodium and it immediately dropped; however, it takes a while for the silica levels to respond. The red line shows the gradual drop in silica. These levels will gradually rise again unless the tube leaks are found and isolated.

On January 10, 2015, sensors indicated high levels of sodium and silica in Unit 2. With valves they isolated and drained half of the condenser with the leak. See Figure 5.

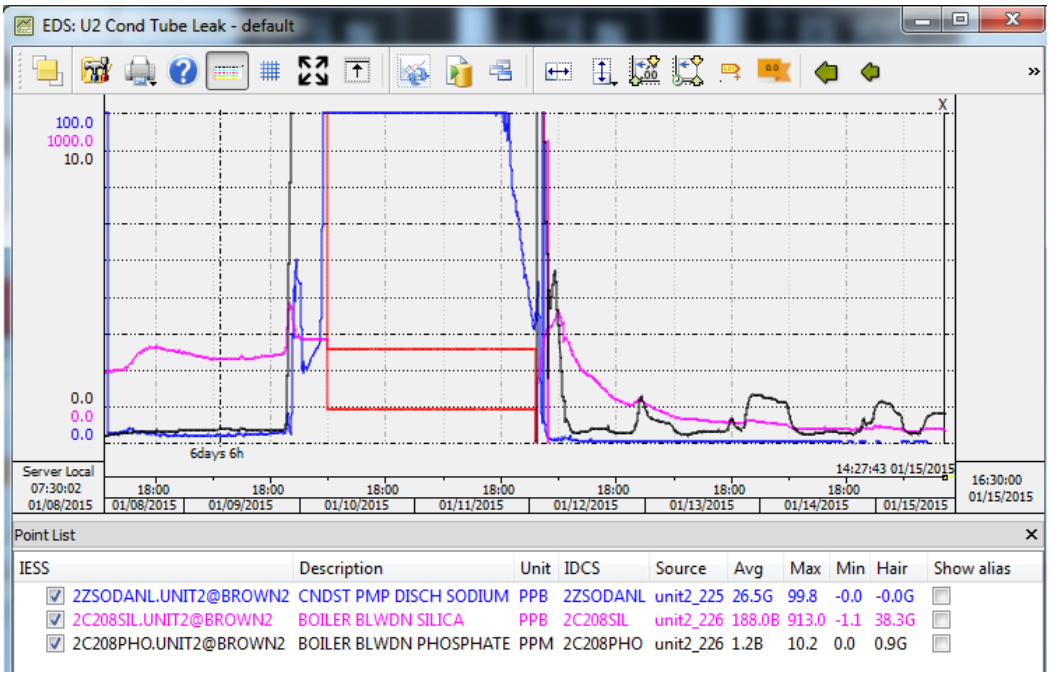



**Figure 5 - Significant tube leak on Unit 2 caused reduction in output. Unit was shut down on January 10th and 11th for dye test. Leaks were found and isolated. Silica levels restored to normal by January 13th and 14th.**

We knew we had a tube leak in Unit 2's condenser, in fact, during a planned outage they did a dye hydro on it to locate the tube leak. This graph of Unit 2 shows the difference in the silica and the sodium when we have a tube leak. Disregard the area between January 9 and 12 as this was the area that the Unit was offline, and the condenser tube side was filled with water and dye. Just look at the difference in the "pink" (Silica) amplitude before and after.

Phipps and his team are experienced at battling condenser tube leaks. "We usually helium leak test for Condenser Tube Leaks." says Phipps. The water side (inside) of the tubes are drained – the outside of the tubes (shell) is under vacuum. The helium detector inlet is inserted into the vacuum pump exhaust. Helium is sprayed around on the water side of the tubes. We have a box fabricated that allows us to narrow the area of a condenser tube leak down so that we shoot areas of the tube sheet instead of shooting each individual tube. Once the general area is located, then individual tubes have helium shot in them.

We had helium leak checked this half of the condenser 3 times but determined that the leak was so small we could not find it. This requires half of the condenser to be taken out of service to check for leaks. This has a negative effect on the heat rate, as well as during the summer months – Generator Output due to the backpressure created on the low-pressure turbine. We have the equipment and trained personnel to perform the Helium leak check. Since none of us had ever "heard" of a condenser tube leak using the Ultrasound equipment, and when the leak increased to a point that we thought we could locate it, the half of the condenser was again isolated.

A helium leak check was then performed, and the two leaking tubes were identified using Helium. Allan Rienstra had instructed the Results Engineer and Maintenance crew that if they could find the tube leak using helium, he then wanted them to use the SDT270 unit to "listen" to what a tube leak sounded like. When performing a Helium Leak Check the time involved is at least a day per condenser half. We hoped to reduce that time using ultrasound.

Once the two tubes were identified – the Results Engineer took the SDT270 Unit into the Condenser. He started in an area where the helium had not identified a leak. He did not use the precision tip but

just “scanned” the area. He said he heard nothing in the areas where the helium had not detected a leak, however, when he waived the SDT270’s airborne sensor in the area where the tube leaks were known to exist, he started hearing noise. As he continued scanning over the tubes that were leaking, he could hear a “psssst” then nothing as he moved away from the tube. He then put the precision tip on and started checking each individual tube in about a 5 tube by 5 tube area. He said when he checked the leaking tubes – he actually had to turn the sensitivity down on the SDT Unit.

In all, he scanned approximately 18 000 tubes in 30 minutes with the SDT270 compared to a whole day with Helium Tracer Gas. The SDT270 Unit narrowed the leak(s) down to a small area.

It is his opinion that we should use the SDT Unit for finding Condenser Tube leaks in that:

1. He believes smaller leaks can be identified with the SDT270 Unit where they cannot be detected with helium.
2. He knows that he can find the leaks faster with the SDT270 Unit using the scanning method first.
3. It will be cheaper in that Helium Gas will not have to be purchased.
4. It will also return the Unit to full load capacity faster by significantly reducing the time that it takes to find leaks.

He may still use the helium to verify the leak, but the SDT Unit will be the first tool used. His confidence in the ultrasound has grown with each inspection. He states, “If you can’t find it with the SDT270 Unit, you will not find it with the helium.”

There was a time when Phipps used a contractor to helium leak check condensers. This came with an average cost of about $10 000 per visit so they purchased the helium leak check equipment and trained their own operators.

The ultrasound equipment from SDT is more than justified in this cost savings alone. And since investing in ultrasound, they added additional attachments and purchased a software upgrade for the SDT270. “We will expand the program in hopes of identifying air leaks, valves leaking through, bearing lubrication and other issues that are in the capability of the SDT Unit,” states Phipps.

## April 2015 – Furthering Their Confidence in SDT

In May, I revisited Bill Phipps to check on his progress. He was pleased to share his new success. On April 13, 2015, another leak was reported.

Silica levels spiked in the cooling tower blowdown water at 3:15 pm. Looking at the graphic below, the control room was alerted when blowdown silica spiked to 1 000 ppb (parts per billion).

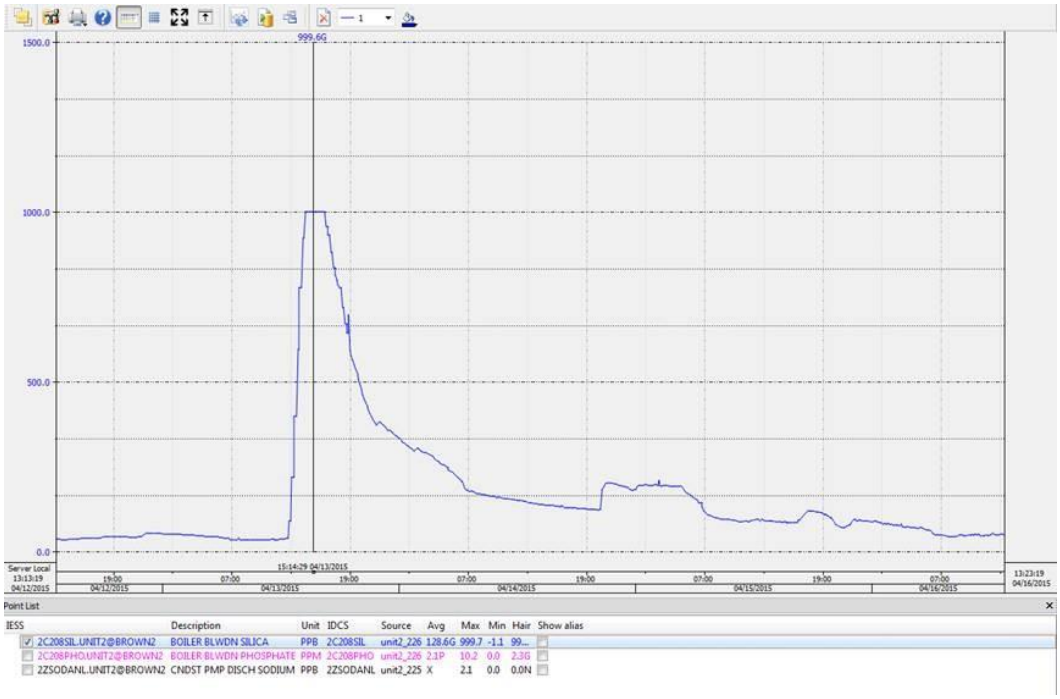



**Figure 8 - Silica levels spiked on 04/15 indicating new and significant leaks on Unit 2 226.**

This graphic conveniently points out the source of the spike too. Unit 2 226 tells them which side of the condenser to valve out. The turbine can keep running, albeit at reduced capacity, while the ultrasound team heads in to find the leak.

The SDT270 ultrasound equipment was used to rapidly identify the tubes and the area. The leak was massive and required plugging of 39 tubes. As a secondary check, and to follow procedure, the leaking tubes were then verified with Helium.

As Phipps' team continues to have this level of success with ultrasound, he expects they will fully eliminate the helium verification altogether.

## Summary

Most reliability departments recognize the significant versatility of Ultrasound as an asset condition management technology. For those pursuing world-class reliability standards, implementing ultrasound testing for all its virtues is a necessity.

# Compressed air leaks and screw pumps inspection in a Cameroonian power plant

**Author:** Gauthier Ghislain and André Malemka
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Dibamba Power Development Company is a heavy fuel oil power plant, the first independent power producer in Cameroon. Operating in the power generation sector in Cameroon and part of the Globeleq Group, the company's vision is to participate in Africa's growth through the development and operation of power plants.

The Yassa-Dibamba heavy fuel oil power plant requires compressed air at two pressure levels: 30 bar for the engine start-up air compressors and 7 bar for the auxiliary instrumentation. To produce the instrumentation air, the plant has 3 air compressors running more than 5 000 hours per year with very short stand-by times.

In order to optimize its costs and to guarantee the contractual availability of its machines, the company thought of applying proactive solutions to allow them to anticipate the different failures of their machines and better plan the necessary contingency actions.

Using their new SDT340 ultrasound detector and its flexible sensor, they began to search for air leaks to improve their efficiency, as one of the compressors is currently out of service.

This research led them to identify several air leakage sources, some of which could be directly corrected, while others required further action.

To date, the effects are convincing. In spite of the actions that are still in latency, maintenance technicians are already able to observe instantaneous effects, namely the reduction of the number of hours of operation of these remaining compressors up to 30%. This translates into a reduction of more than 4 hours per day, per compressor, over the last two weeks. And this despite the absence of one of the compressors. The impact will be quantifiable with the costs related to energy consumption and maintenance based on operating hours and therefore annual material consumption.

The compressed air leakage searches allowed them to reduce the stress on their start-up air compressors and therefore the costs related to their operation, to name but a few. The LEAKReporter application has been a plus in helping management understand the impact of these inspections from a financial point of view with very easy to visualize analyses.

Studies are underway to define the periodicity for regular inspection rounds to maintain or even improve these conditions.


The heavy fuel oil, to speak only of it, requires a rather complex treatment process that solicits several units, the majority of which have screw pumps that, before 2019, were the main sources of maintenance of the company, with an average of 200 million CFA (Central African franc) francs spent per year. This does not include downtime due to failures and even overtime generated during on-call maintenance teams.

The reliability of the installations depends on the state of the important number of auxiliary systems (pumps, centrifugal separators, compressors and others) contributing to the production of the 8 groups that the power station counts, each of which can produce 11MW (installed power).

In the case of these screw pumps, they have set up inspection routines which, coupled with the establishment of reference values, have enabled them to monitor failure states in order to recommend corrective/proactive actions in time. This has enabled them to considerably reduce their maintenance costs by up to 80% on screw pumps.

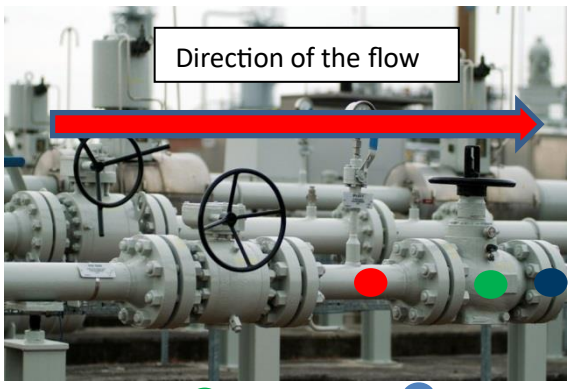
# Maintenance of hydraulic equipment and components: ultrasound, the winning solution

**Author:** Patrice Dannepond

## The challenges of maintaining hydraulic equipment and components

Of all the installations on a production site, hydraulic equipment and components certainly represent a major challenge in terms of availability.
It is also a safety issue, particularly for French nuclear power plants, which use SDT ultrasound detectors to monitor all their industrial valves, as well as safety valves in the oil and gas refining (TOTAL) and petrochemical (SANOFI, ARKEMA, BASF...) sectors.
In the organization of preventive maintenance on an industrial site involving hydraulic pumps, some companies would not be able to produce without a water supply. In France, the basic chemicals, yarn/synthetic fiber, paper and cardboard, metallurgy, parachemistry and pharmaceutical industries alone account for two-thirds of industrial water consumption. And the stakes are just as high in pumping stations for drinking water networks.

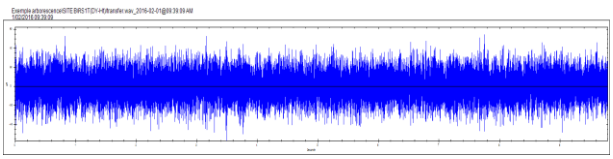
With an SDT detector, valve testing involves placing a contact sensor at three points: upstream, on the seat and downstream of the valve. Diagnosis is quick and immediate, based on a comparison of the 3 measurements. A rise in pressure on the valve seat indicates that the valve is leaking. This is confirmed by listening: the operator actually hears the leak.
Data management is simplified by storing measurements and processing them in the Ultranalysis® Suite 3 software, with reports, alarms, missed measurement points and rounds. An ATEX version is available for hazardous environments.



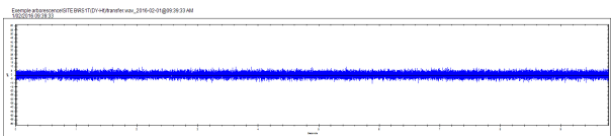

Inspection of a pressure reducer on a natural gas installation.

Upstream measurement Seat measurement Downstream measurement

The customer's assessment after dismantling the regulator



Upstream measurement: 21 dBµV

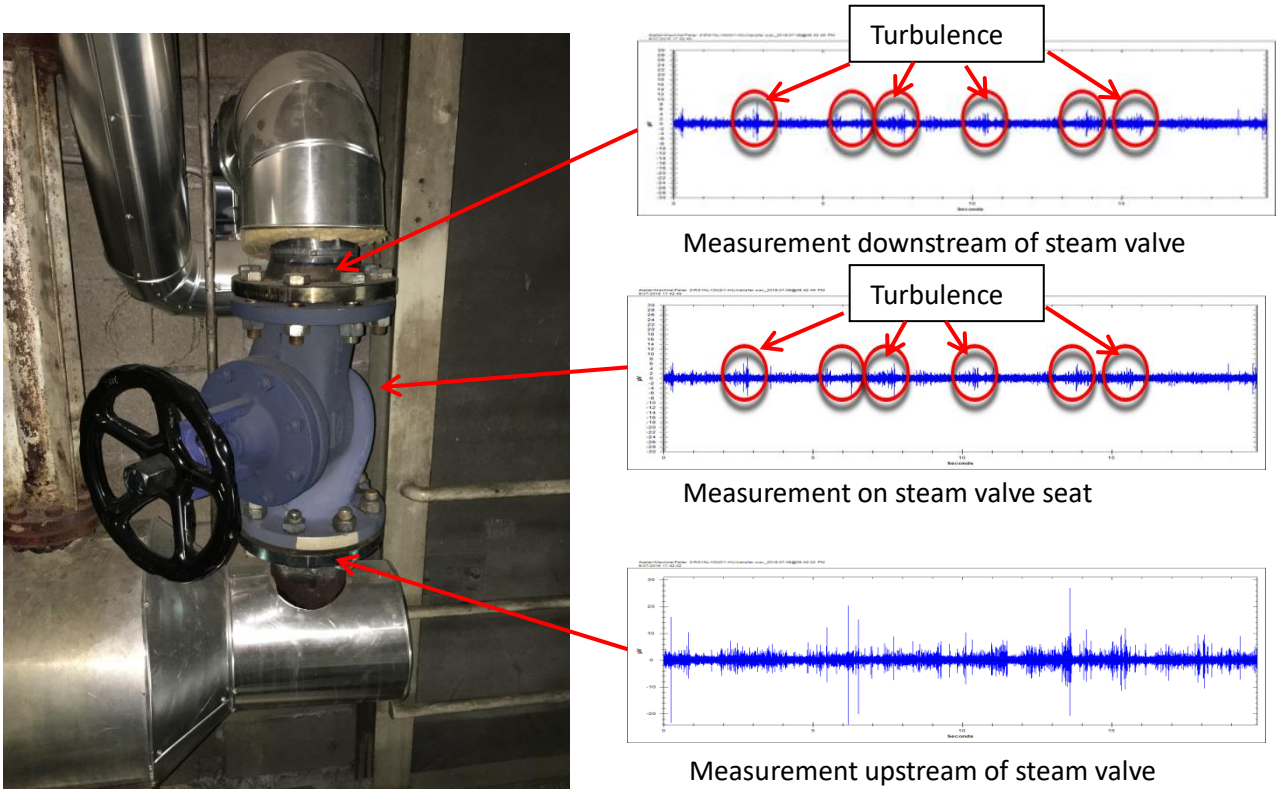


Seat measurement: 10dBµV, where turbulence and a slight whistling sound can be heard

In this example, the customer is a natural gas supplier and distributor. The company's maintenance department only visually inspected its valves and regulators. When they dismantled this equipment,

they could never be sure that they were dismantling a component that could be considered a leak. This on-site demonstration highlighted the effectiveness of ultrasound measurement in finding a defective component quickly and efficiently.

Below is a second example of a leak test on a steam valve in a boiler room at a cardboard plant.




Turbulence on the steam valve seat and downstream of the piping (highlighted on the spectra above), demonstrates that this component is leaking. This enabled the Maintenance Manager to confirm the failure of this component, which could cause a problem in the boiler room process.

# Wind Farm

## Monitoring Ontario's Wind Farms

**Author:** Tristan Rienstra
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Wind farmers power Ontario with clean, renewable energy and if they are forewarned of critical component failure, then they can expect many years of useful, trouble-free life from their assets. But wind turbines are complex assets consisting of both slow and high-speed components which presents unique challenges for condition monitoring technicians. These challenges are overcome with advanced technologies and safety training.

One such challenge is the height where data must be collected. The average height of wind turbines in the United States is 280' (85.3m). This poses significant accessibility and safety concerns for condition monitoring technicians.

Another challenge reliability technicians must overcome is the logistical nightmare when failing or failed components need maintaining or replacement.

Both require expensive heavy-duty machinery with trained operators for multiple down days. Therefore, planning these interventions weeks or months ahead of time is the best way to minimize cost overruns, or mitigate them altogether.

The third challenge condition monitoring technicians face is the differing rotational speeds of their wind turbine's components. Vibration analysis works well for monitoring assets that rotate fast, such as the drive end and non-drive end bearings on a main generator. Where vibration falters is on the turbines slow rotating components. The main bearing on a wind turbine turns much slower than the generator's bearings. Slow-speed bearings don't create enough vibration for it to be an effective monitoring tool. To monitor slow-rotating assets, condition monitoring technicians put their trust in ultrasound technology.

### Accessibility

The most glaring accessibility challenge faced is the height at condition monitoring technicians must perform their data collection. Before even ascending a wind turbine, technicians must complete a mandatory eight plus hours Working at Heights safety training course.

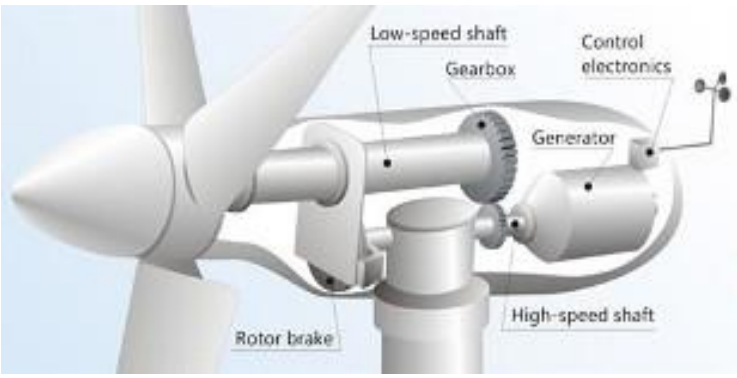
Whenever working at extreme heights, the element of employee safety requires consideration. This is especially true for technicians working on turbines without lifts. Technicians climbing 50-100 meters up a ladder have the extra element of fatigue amplifying their safety concerns, especially when this ascent is made multiple times in a single day. Additionally, ascending and descending wind turbines all day uses up a technician's valuable time. When time becomes scarce it often borrows common sense for companionship.

A permanent condition monitoring solution that streams data to a wind farm's maintenance headquarters is ideal for extreme heights. It reduces the need for frequent trips up and down wind

turbines, and improves the overall efficiency of the maintenance and reliability department's operation.

## Inside the Nacelle

Choosing the right condition monitoring technology enables maintenance and reliability technicians to perform their job better and more efficiently. A look inside the nacelle depicts a wind turbine's critical components. The main bearing connects the turbine blades to the rest of the mechanism. This main turbine shaft turns around 10-20 rotations per minute, depending on wind speeds. The turbine's gearbox, and the generator drive end, and non-drive end turn much faster than the slow-speed main shaft.




## Success Story

SDT Ultrasound Solutions representatives Robert Dent, Mark Nanni, and Matt Jeffrey recently installed the first Vigilant System on a 90-meter-tall wind turbine in Southwestern Ontario.

Vigilant is a permanent condition monitoring solution with both ultrasound and vibration analysis capabilities. Each Vigilant pod is capable of managing inputs from eight data sources continuously (no multi-plexing).

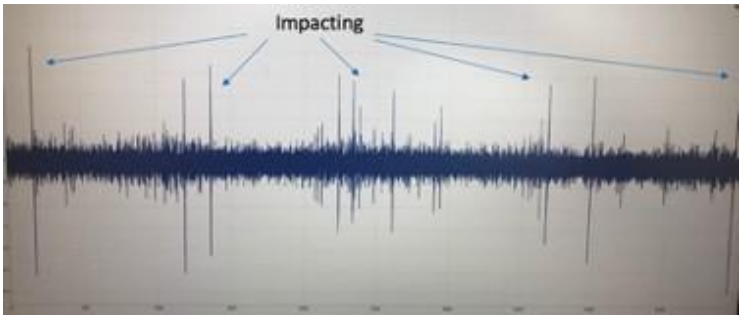
Condition monitoring data streams live, via WIFI, ethernet or cellular, to its onboard trending and analysis application. Reliability teams are fed a constant diet of information about the health of their remote and critical assets. Complex analysis tools normally reserved for expensive, high-end vibration software are readily available to analysts of any skill level. And because the application is web-based, there's no tricky licensing setups to hassle over. Simply login with your favorite browser and start analyzing!

Vibration analysis was already being utilized to permanently monitor the turbines critical components. Vigilant was deployed to monitor seven key data collection points using ultrasound. One data collection point was on the slow-speed main bearing, four were on the gearbox, and one data collection point was put on both the drive- end and non-drive-end of the turbine's generator.

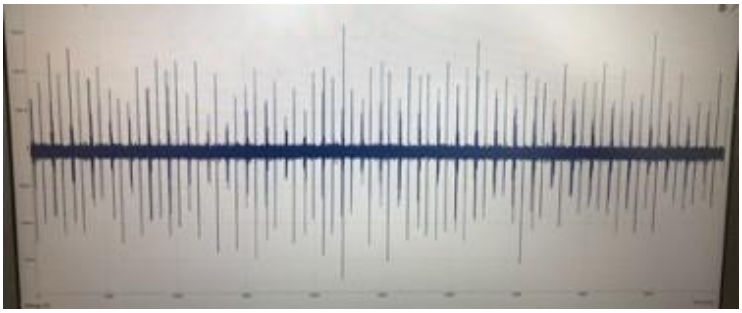
Ultrasound is optimal for monitoring the slow-speed main bearing of the turbine, which turns 91X slower than the bearings on the main generator. Receptive to micro-sonic changes in low energy events caused by friction and impacts, ultrasound warns us when changes to safe, normal operating parameters reveal imminent failure. With Vigilant installed, all key data collection points now benefit from a more complete analysis with smart data from both ultrasound and vibration.

SDT Personnel were able to complete the installation very quickly. In under two hours condition monitoring data was streaming from the Vigilant System 90 meters in the air, to the wind farm's maintenance office.

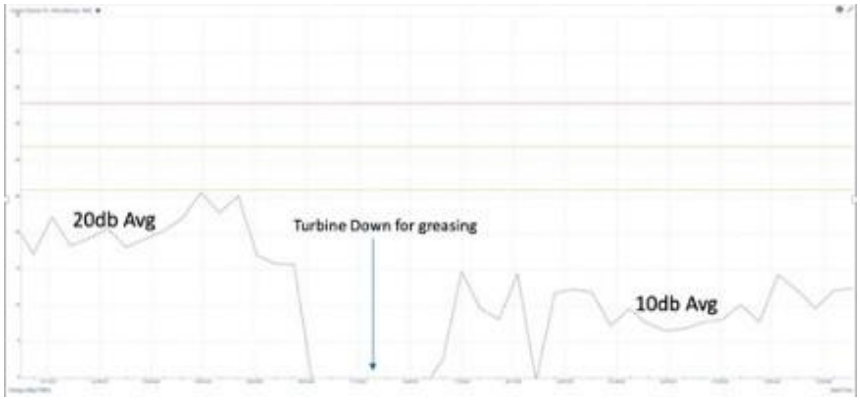
## Analysis




Planetary Bearing - As expected from the initial vibration data, ultrasound reading confirmed the presence of impacting.



Slow-Speed Main Bearing - The initial ultrasound reading on the main bearing came back higher than expected with lots of impacting. SDT's recommendation was to lubricate the bearing. Ultrasound decibel levels dropped afterwards, indicating a reduction in both friction and impacting as seen in the figure below.




**Slow-Speed Main Bearing, Before and After Greasing**

**SRB | 230/800YMDWEW919GC6**

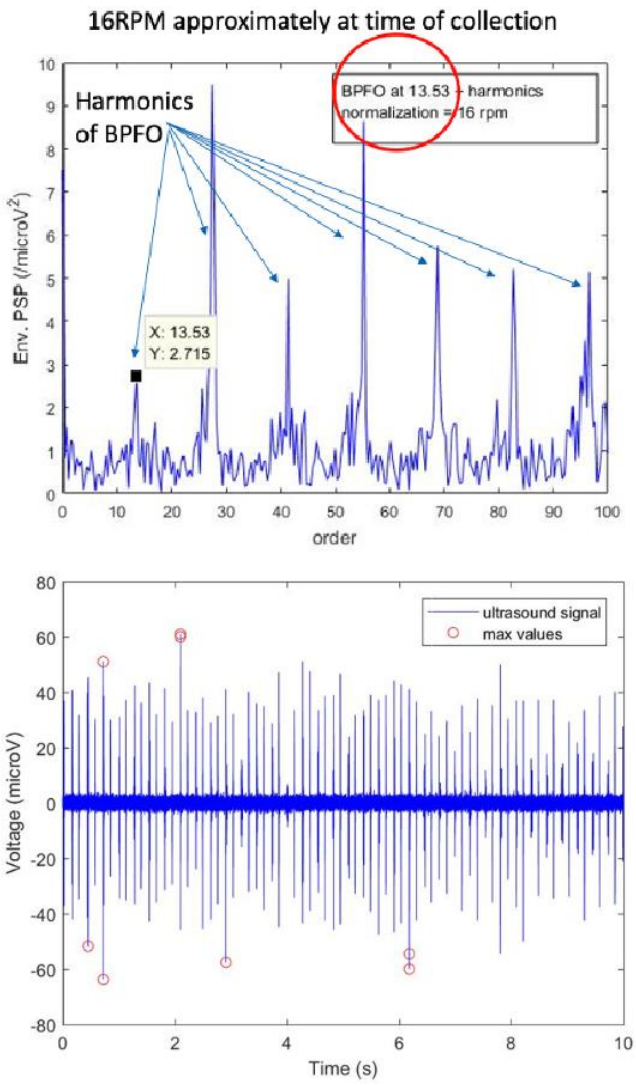
Operating Speed (rpm)

16

Calculate

View the technical paper:
Bearing Dynamics and Sound

| Element | Value | Comments |
|---|---|---|
| BPFI - Ball or Roller Pass Frequency - Inner | 16.362 | |
| BPFO - Ball or Roller Pass Frequency - Outer | 13.638 | |
| BSF - Ball or Roller Spin Frequency | 5.411 | |
| FTFI - Fundamental Train Frequency - Inner Rotation | 0.455 | |
| FTFO - Fundamental Train Frequency - Outer Rotation | 0.545 | |
| **Frequencies Resulting From Component Irregularities** | **Hz** | |
| f0 or f1 - Eccentricity or Out-Of-Round Rotating Member | 0.267 | rps |




Additional analysis was conducted on the main bearing. Repetitive impacts were discovered at a BPFO of approximately 13.5x running speed, consistent with an outer race defect. SDT's recommendation was to closely monitor the condition of the main bearing. The defect will eventually result in the main bearing needing to be replaced.

The wind turbine maintenance technicians benefitted from installing the Vigilant System by gaining 7 permanent ultrasound data collection points on the critical components of their wind turbine. Using their new data, they were able to confirm a suspected defect on the planetary bearing which was originally detected using vibration analysis.

Additionally, they found a new defect on the main bearing that went undetected by the vibration sensors already in place. After applying some grease to the main bearing, the technicians noticed a significant drop in friction levels. They will continue to monitor the main bearing closely moving forward.

# Cement Industry

## Diagnosing Bearing Failure with LUBExpert Static & Vibration Analysis

**Author:** Tristan Rienstra, Torki Ibrahim and Khaled Salman Almarwany
**Email address:** tristan.rienstra@sdtultrasound.com

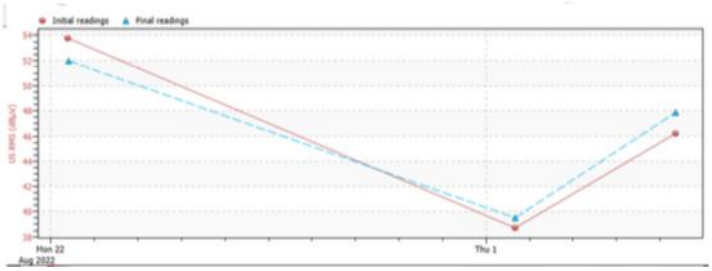
Torki works as a senior lubrication engineer at a cement manufacturer. He recently completed his Live Online Level One Ultrasound Certification with SDT Ultrasound Solutions and has since been applying what he learned during the course to his job as a lubrication engineer.

Torki was kind enough to share this lubrication case study with us. He co-authored it with his co-worker, vibration analyst, Khaled Salman Almarwany.

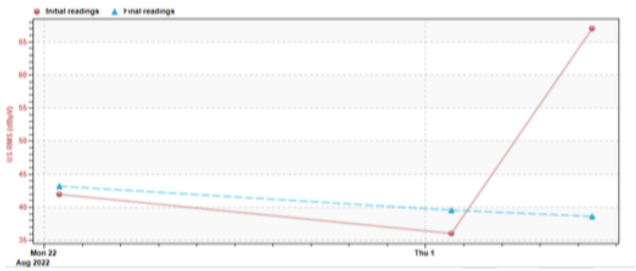
The initial task was simple. Lubricate the drive-end and non-drive-end bearings of a cooling fan using a LUBExpert Static.

Previously, the lubrication team at this cement manufacturer greased their bearings on a time-based schedule, rather than condition based. The calendar schedule called for 50 grams of grease every two weeks, regardless of the needs of the bearing.

Since switching to the ultrasonic condition-based method for greasing their bearings, Torki and his fellow lubrication technicians noticed a steep decline in grease consumed. Where it used to be 50 grams every two weeks for both the drive-end & non-drive-end bearings, it dropped to 16 grams for the drive-end and 14.4 grams for the non-drive-end during the most recent successful lubrication task, which can be seen in the following two figures.

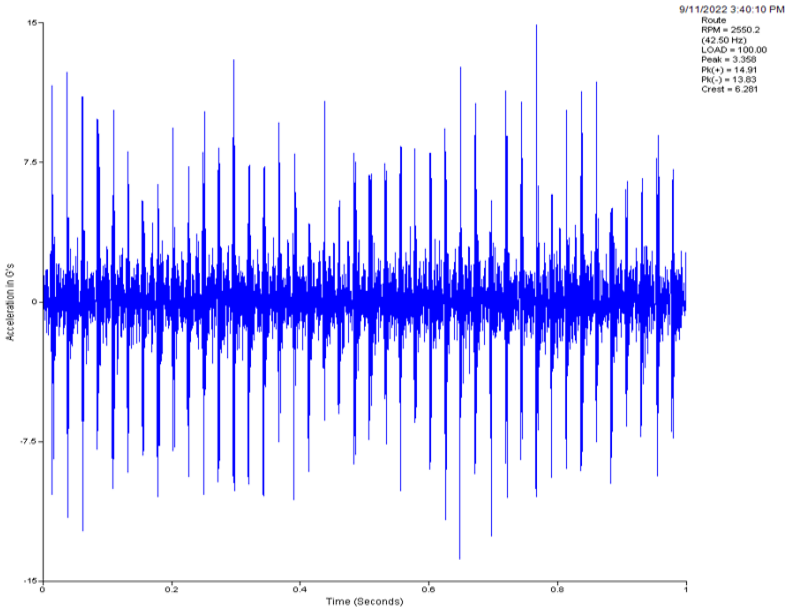



**Drive End – September 5**

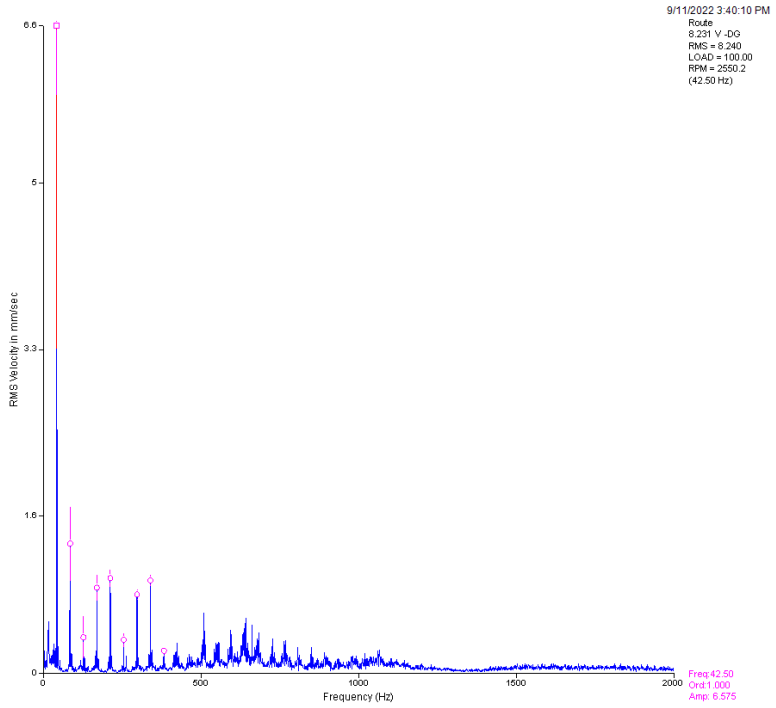



**Non-Drive-End – September 5**

As seen above, lubricating the drive-end bearing increased friction, indicating over-lubrication or a suspected bearing failure. Lubricating the non-drive-end bearing drastically reduced friction indicates a lubrication success. However, the LUBExpert still issued a suspected bearing failure warning on the non-drive-end bearing. This additional analysis from the LUBExpert was backed up by the vibration analysis performed by Khaled, which indicated mechanical looseness, as seen in the harmonics of the impacts in the vibration spectra below.

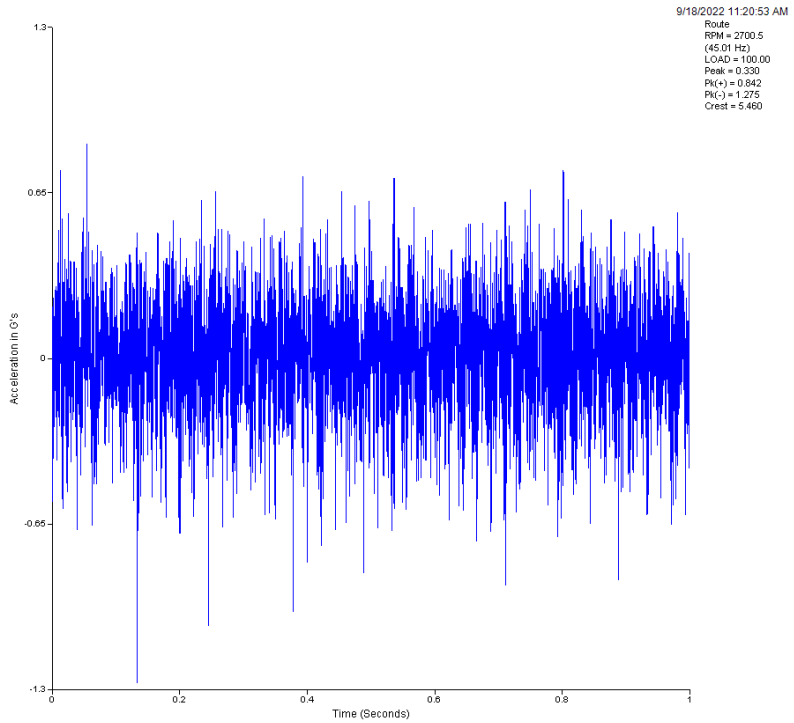



**Waveform – September 11**

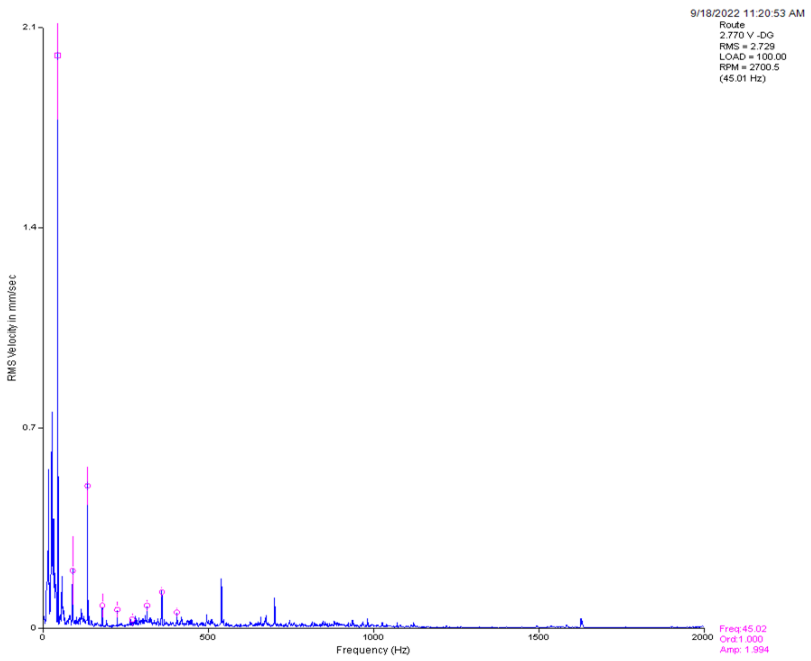



**Vibration Spectra – September 11**

As seen in the vibration data, the bearings were in a failed state due to mechanical looseness and required replacement. They were replaced during the next shutdown, and new vibration measurements were taken on the machine. As seen below, the overall RMS went from 8.2 to 2.7 after the bearings were replaced.

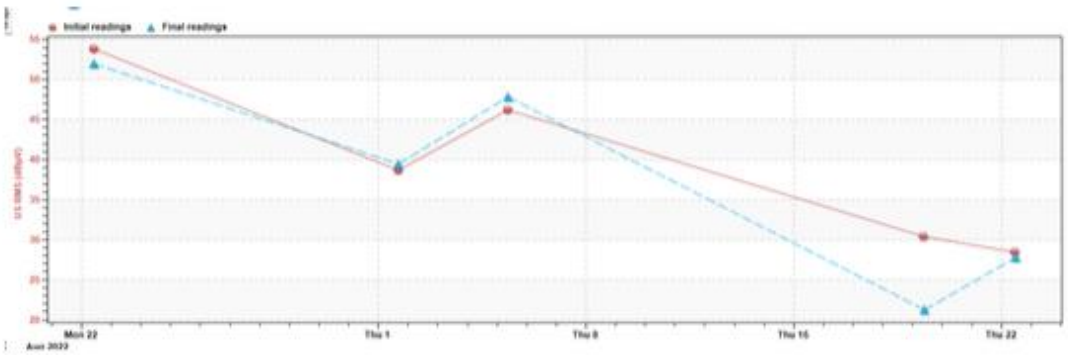



**Waveform – September 18**

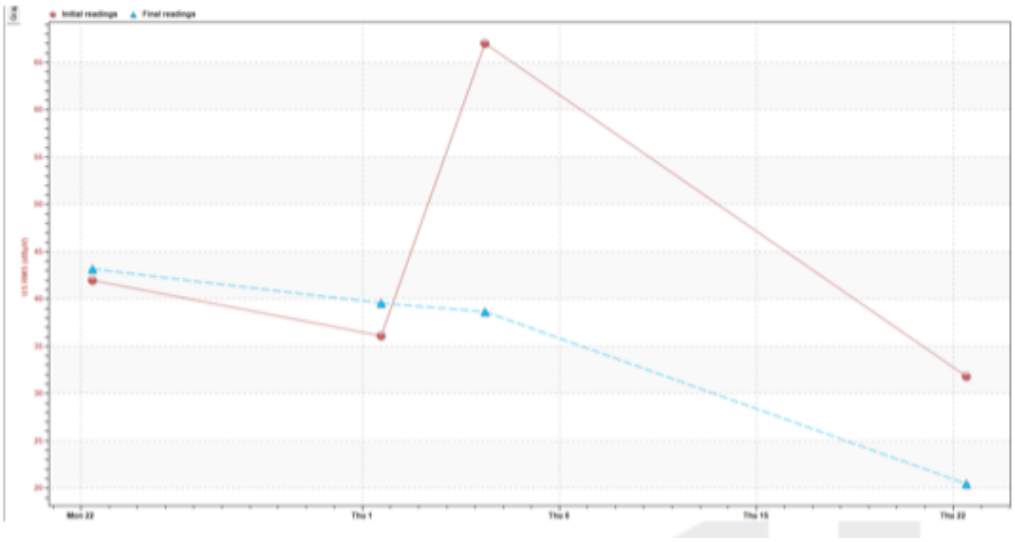



**Vibration Spectra – September 18**

After the bearings were installed on September 18, they were lubricated successfully 4 days later on September 22 using the LUBExpert Static. The data can be seen below!




**Drive-End – September 22**




**Non-Drive-End – September 22**

This case demonstrates the effectiveness of combining LUBExpert, and lubrication reliability, with the vibration team, and their mechanical condition monitoring efforts! The lubrication team can communicate their results with the vibration team, and vice versa.

Cross-referencing both sets of data leads to a more complete picture of bearing health. It allowed the lubrication and vibration team at this cement manufacturer to replace both compromised bearings before they failed, avoiding unplanned downtime. Both departments were also able to collaborate on the installation of the new bearings, preventing any installation failures.

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