Under the patronage of **H.E. Dr. Abdullah Belhaif Al Nuaimi -** Minister of Infrastructure Development

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Enhancing Maintenance Through Big Data Management

Vibration Condition Monitoring and DATA Management in a Modern Waste Recovery Park

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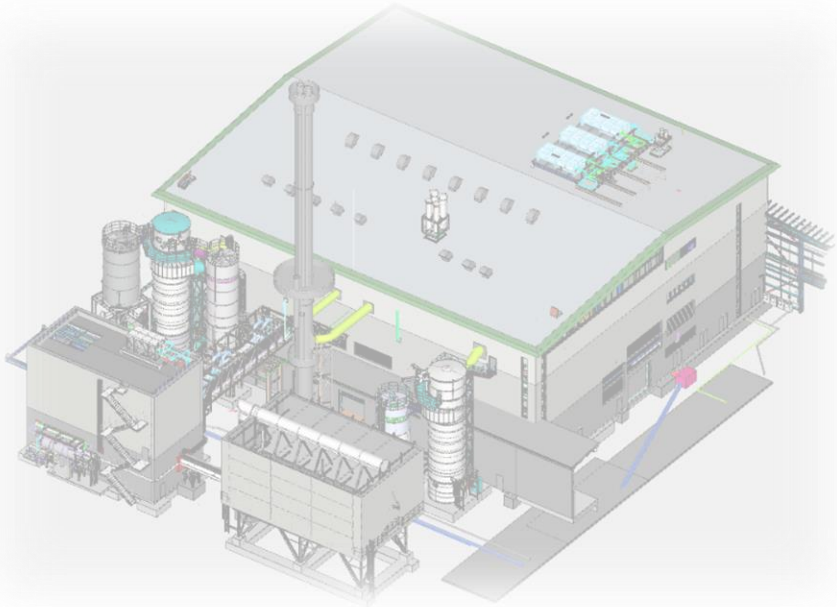
Overview

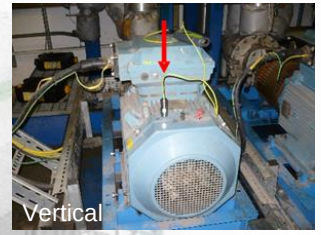
A large state-of-the-art waste recovery plant in the United Kingdom combines waste recycling with renewable energy generation.

- The plant has over 250 machines with rotating parts (motors, pumps and fans) that require constant monitoring.
- Rotating Equipment Verification Limited (REV) have carried out baseline measurements of the equipment, set up a management scheme and provided training to the employees of the waste recovery park so that they can continue carrying out periodic monitoring.
- The potential of identifying faults before they cause failures and therefore, potentially a complete plant shutdown, leads to massive savings for the waste recovery site operator.



Methodology

- The baseline measurements incorporated a significant amount of data, culminating in the output from the measurement software which had up to thirteen graphs per measurement location, including:
  - ISO spectra,
  - g-spectra,
  - separate spectra for displacement, unbalance, misalignment and looseness,
  - time waveform,
  - trend lines for ISO,
  - Bearing Damage Units
  - g-level trend lines
- Multiplied by three measurement directions per machine and by all machines, this gives an unmanageable amount of data.
- Expert knowledge was required to carry out data selection and export only data that was relevant to the vibration pattern of the machine.



The Site & Plant

- Mechanical waste recycling facility;
- Anaerobic digestor with Combined Heat & Power (CHP) generators – power from biodegradable waste;
- Advanced Thermal Treatment (ATT) facility with 8MW generator – power from non-recyclable and non-compostable waste
  - Large Turbine & Generator
  - Mechanical sorting facility with conveyors, sorting drums, etc – powered by motors;
  - Boiler house and plant room with dozens of critical equipment (pumps, motors and fans);
  - Overall over 250 machines with rotating parts – most of them critical for the operation of the plant

Vibration Data Acquisition

- ✓ *Fast and non-destructive technique*
- ✓ *'Continuous' condition monitoring*
- ✓ *Finding fault before failure*
- ✓ *Using signal analysis to diagnose looseness, misalignment, bearing defects, etc.*
- ✓ *Plotting trend-lines to monitor wear and tear of equipment*
- ✓ *Pre-Emptive maintenance*

What can go wrong?

Analysis

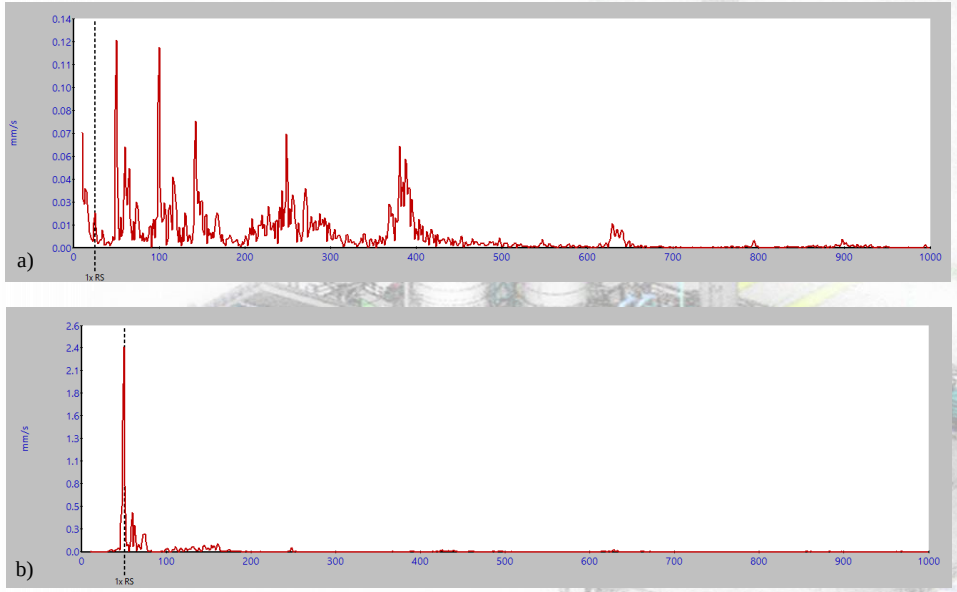


Figure 1 - Two spectral graphs of machines in <u>good</u> condition displaying:

a) low amplitude noise floor across the frequencies
b) single peak at rotational speed without harmonics

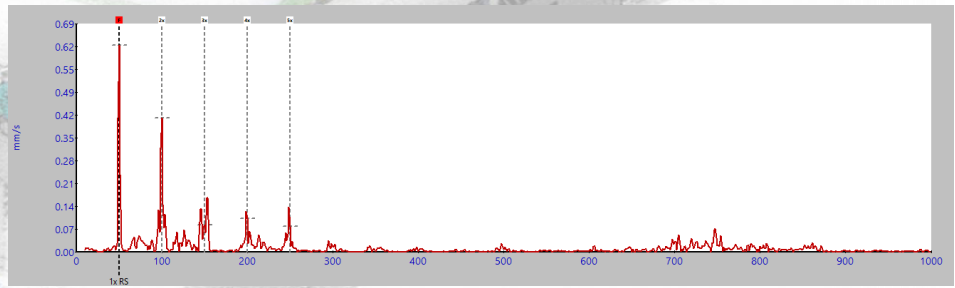
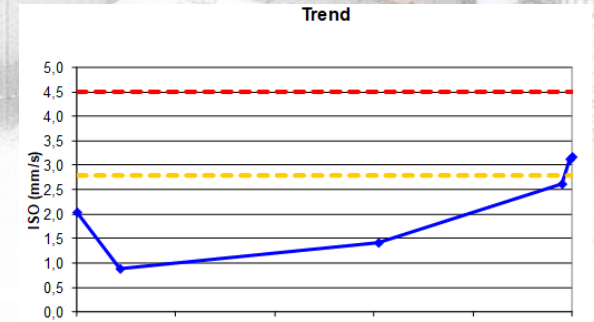


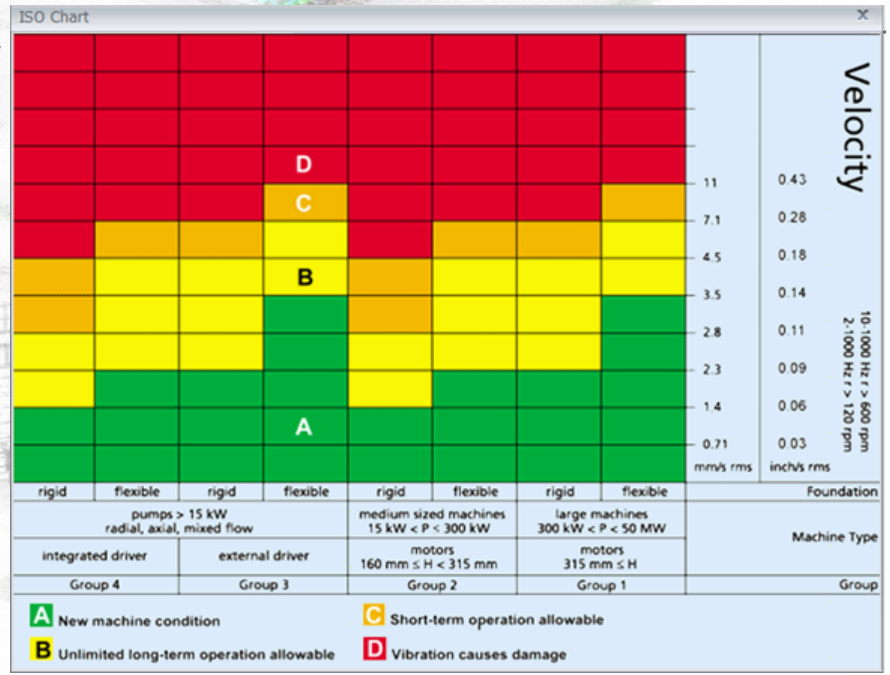
Figure 2 - Spectrum of a pump motor vibration with clearly visible harmonics.

Analysis

Faults can be detected using a combination of the following methods:

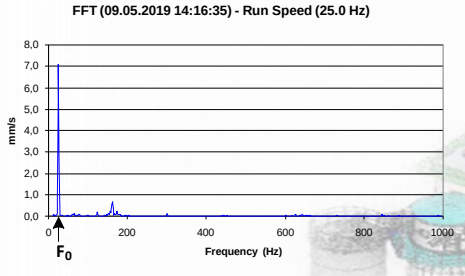
- ✓ *Comparison of overall levels to industrial standards (ISO 10816-3);*
- ✓ *Comparison with previous measurements (trend line analysis);*
- ✓ *Spectrum analysis;*
- ✓ *Time waveform analysis;*
- ✓ *Phase analysis.*



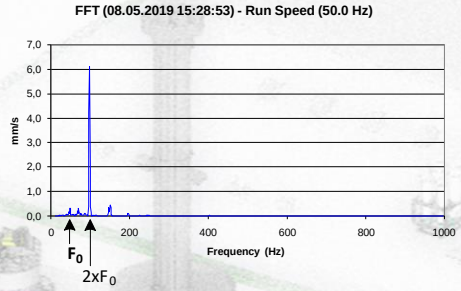


Analysis

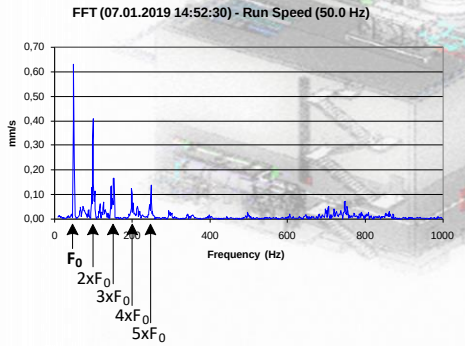
a) imbalance



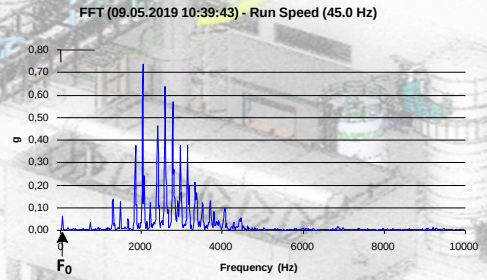
b) misalignment



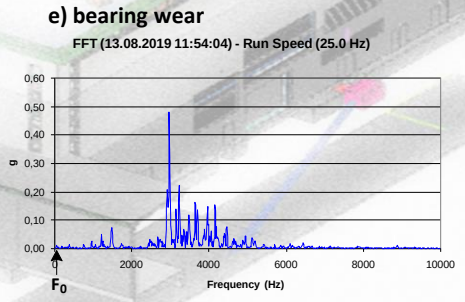
c) looseness



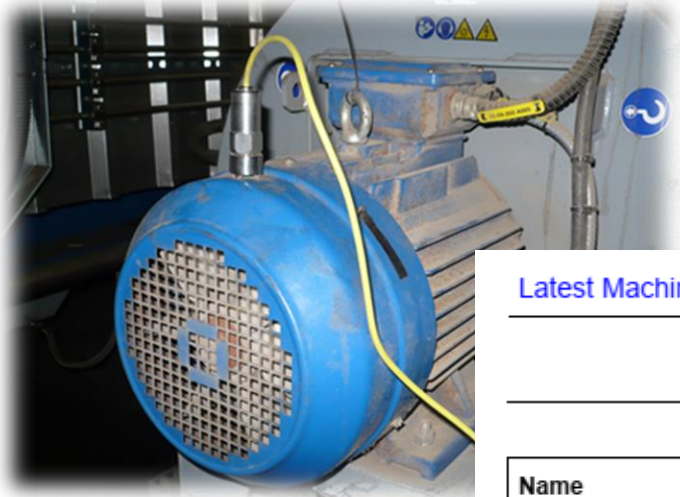
d) fan blade pass



e) bearing wear



Data Output - Summary



Latest Machine Status

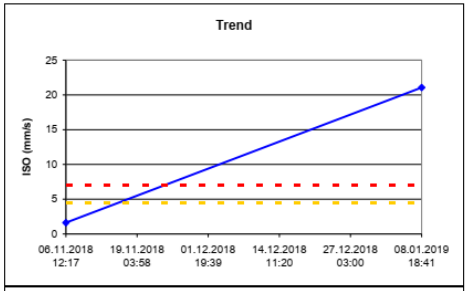
Vibration Points

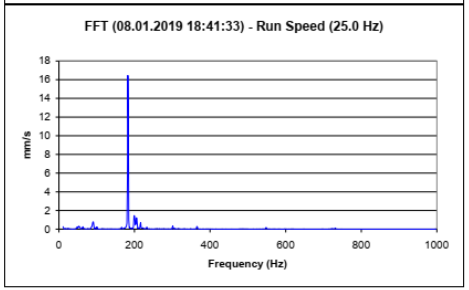
Ext Diesel Pump A # +11-PB-001A-ES

Name	Date/Time	Status	ISO (mm/s)	Brg. Noise (BDU)	Total (g)
Vertical	08.01.2019 18:41:09	WARNING	6.839	56	2.0
Axial	08.01.2019 18:41:33	CRITICAL	21.055	24	2.5
Transverse	08.01.2019 18:42:32	CRITICAL	10.574	60	3.0

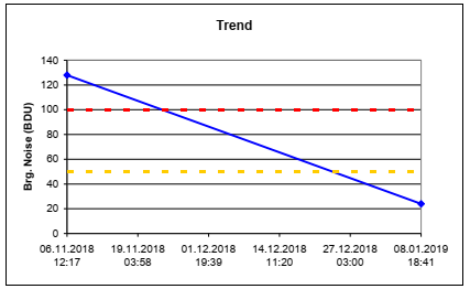
Data Output – Single Point

ISO (mm/s)

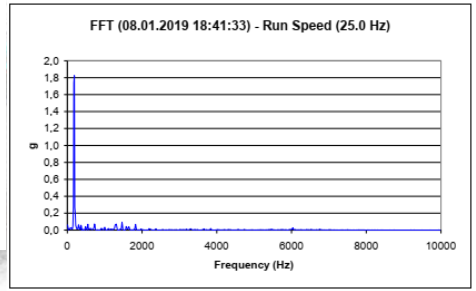




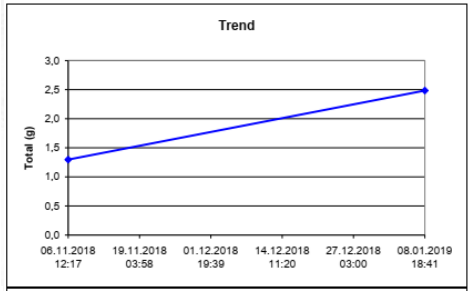
Brg. Noise (BDU)

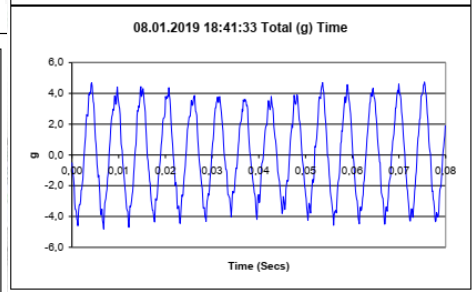


Total (g)

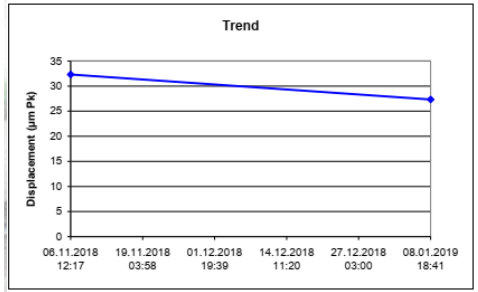


Total (g)



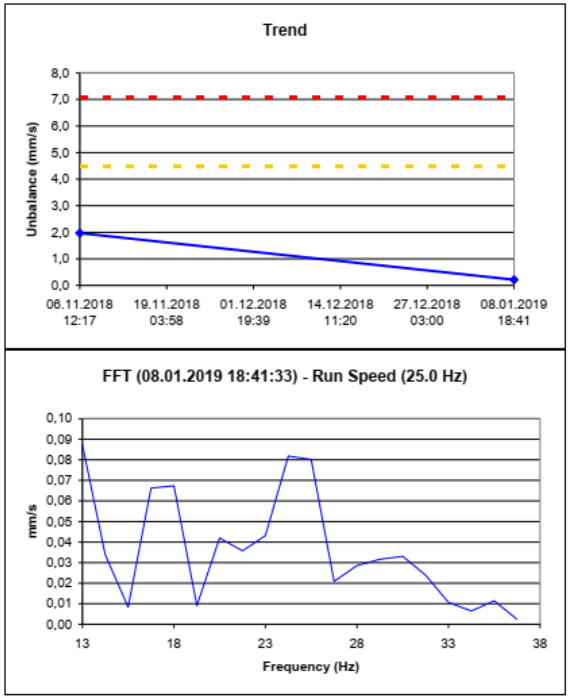


Displacement (µm Pk)

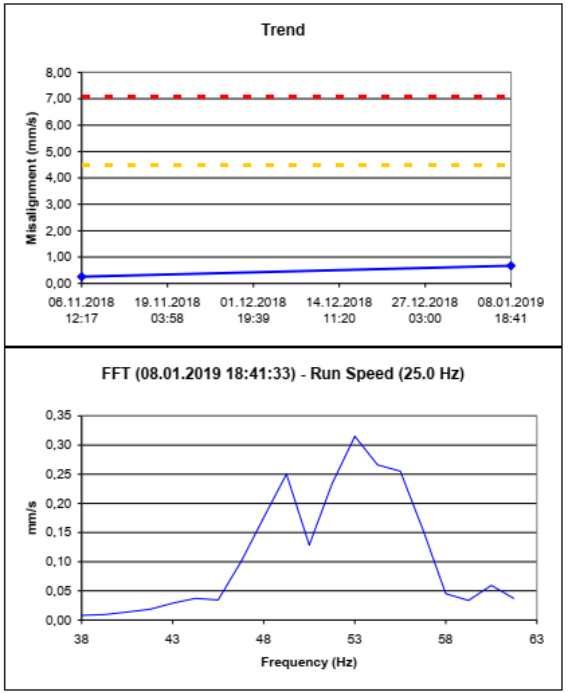


Data Output – Single Point (continued)

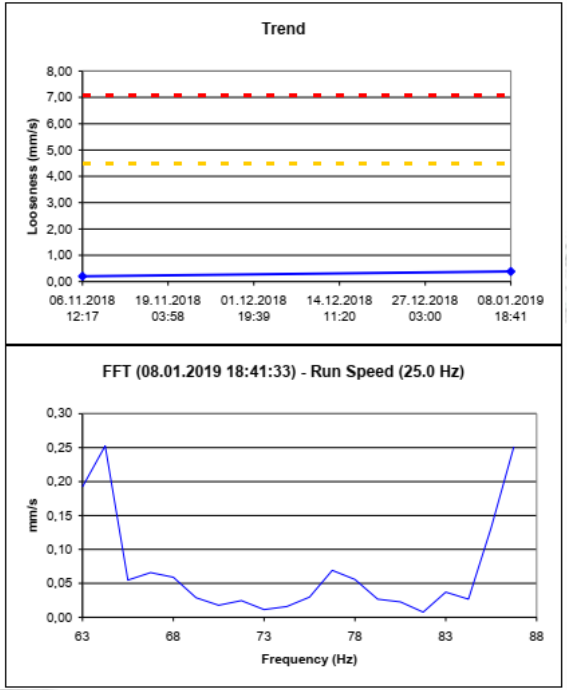
Unbalance (mm/s)



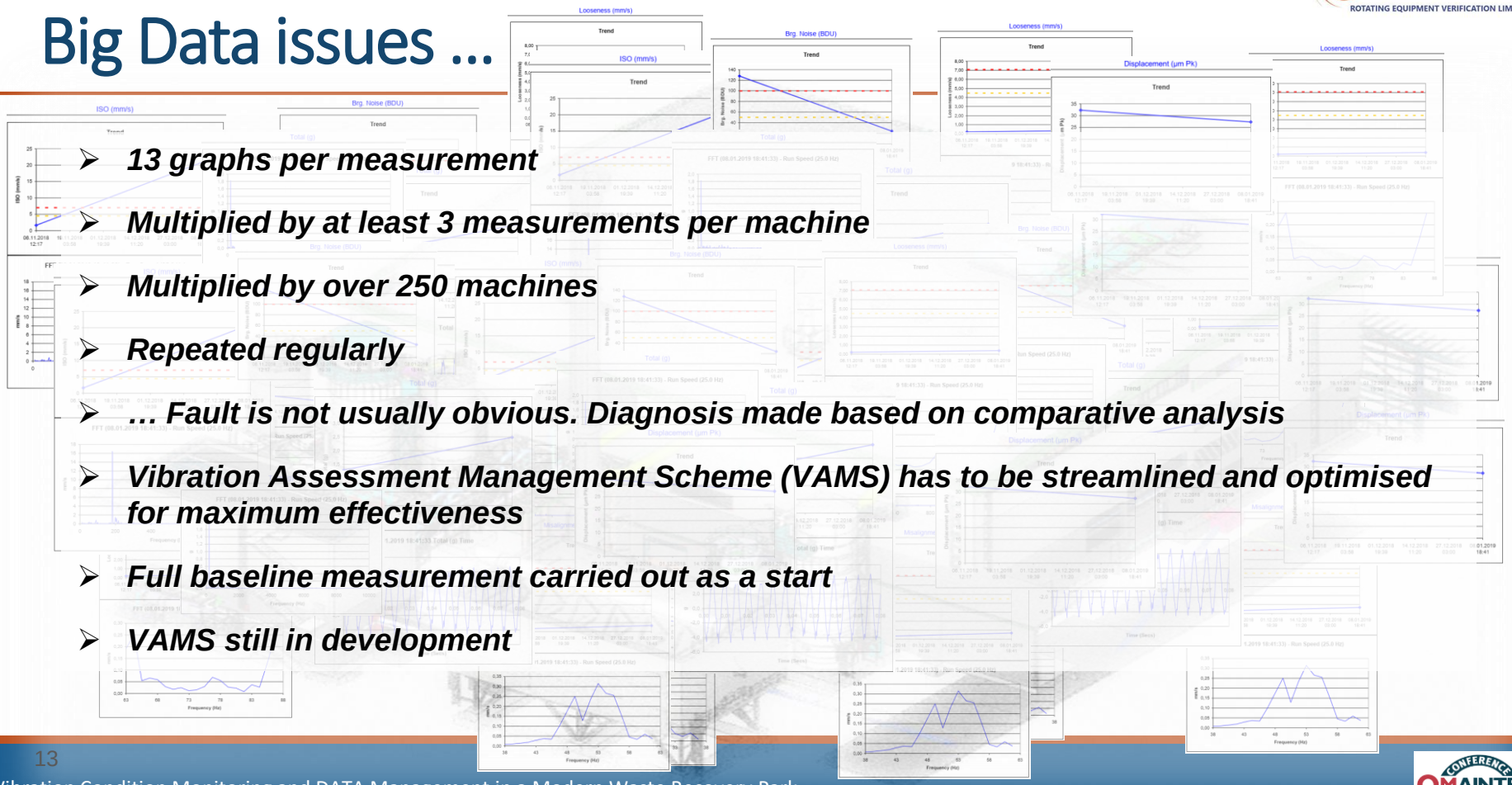
Misalignment (mm/s)



Looseness (mm/s)



Big Data issues …



- ***13 graphs per measurement***
- ***Multiplied by at least 3 measurements per machine***
- ***Multiplied by over 250 machines***
- ***Repeated regularly***
- ***… Fault is not usually obvious. Diagnosis made based on comparative analysis***
- ***Vibration Assessment Management Scheme (VAMS) has to be streamlined and optimised for maximum effectiveness***
- ***Full baseline measurement carried out as a start***
- ***VAMS still in development***

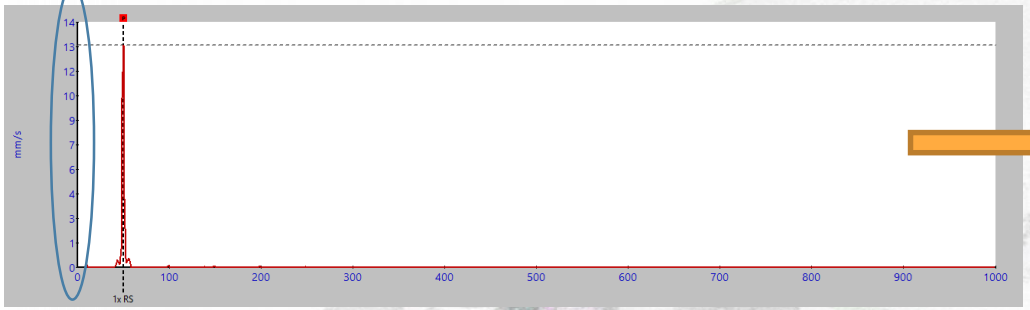
Baseline Measurements

Throughout the baseline measurement process, 261 machines were identified and catalogued. 179 were measured. The following is the outcome of the analysis:

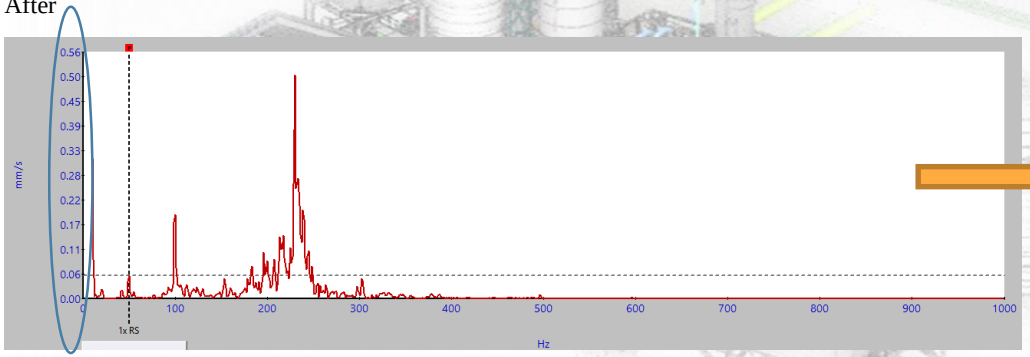
- 147 were deemed in good condition. A recommendation to continue periodic monitoring and observe trend lines was given.
- 24 machines had vibration levels that indicated some condition problem. A warning label was given and it was recommended that either measurement is repeated at different locations (e.g. pump or bearing), trend lines are observed or that the unit should be serviced at the earliest opportunity.
- 8 machines had high vibration levels indicating likely failure was imminent. A critical warning level was given and a recommendation to investigate further and / or service unit was advised.

Baseline Measurement Intervention

Before



After



Example of Data Output

Identification	Machine	Serial Number	RPM	Highest ISO (mm/s)	Highest bearing noise (BDU)	Status	Comments	Recommendation
Redacted	Conv. motor	Redacted		21.3	37	Warning	Extremely high ISO levels indicates significant unbalance	Service at earliest convenience
	Conv. motor			-	-	-	Out of reach. Not measured	-
	Conv. motor			2.8	2	OK	Good condition	Observe trend lines
	Brush motor		1461	4.1	53	OK	Good condition	Observe trend lines
	Conv. motor		1460	4.4	6	OK	Good condition	Observe trend lines
	Sort drum motor			-	-	-	Out of reach. Not measured	-
	Sort drum motor			-	-	-	Out of reach. Not measured	-
	Conv. motor		1455	3.8	14	OK	Good condition	Observe trend lines
	Brush motor		1500	15.8	9	Warning	High ISO levels are characteristic for brush motors, however, condition of motor should be checked	Observe trend lines / service at earliest convenience
	Conv. motor			3.0	9	OK	Good condition	Observe trend lines
	Brush motor		1320	3.2	30	OK	Good condition	Observe trend lines
	Conv. motor		1455	3.6	29	OK	Good condition	Observe trend lines
	Conv. motor		2028	5.9	9	OK	Good condition	Observe trend lines
	Conv. motor		2478	4.5	72	OK	Good condition	Observe trend lines
	Conv. motor		1278	12.2	3	Warning	Significant vibration peak at 230 Hz, possibly unrelated to the motor condition	Observe trend lines and compare spectra after next measurement
	Conv. motor		1460	2.6	12	OK	Good condition	Observe trend lines
	Rolling bar motor			-	-	-	Out of reach. Not measured	-
	Conv. motor		2328	9.9	3	Warning	High ISO values indicate likely unbalance	Observe trend lines / service at earliest convenience
	Conv. motor		2928	5.7	19	OK	Good condition	Observe trend lines
	Conv. motor		1800	3.1	3	OK	Good condition	Observe trend lines
	Eddie current motor		1800	23.7	12	Critical	Extremely high ISO level and rich harmonic content in spectra indicate likely significant looseness	Service
	Conv. motor			3.7	9	OK	Good condition	Observe trend lines
	Sorting drum motor			-	-	-	Out of reach, not measured	-
	Sorting drum motor			-	-	-	Out of reach. Not measured	-
	Ballistic separator motor		1473	5.4	21	OK	Good condition	Observe trend lines
	Conv. motor			-	-	-	Out of reach. Not measured	-
	Brush motor			8.9	65	Warning	High ISO levels are characteristic for brush motors, however, condition of motor should be checked	Observe trend lines / service at earliest convenience
	Brush motor			13.0	3	Warning	High ISO levels are characteristic for brush motors, however, condition of motor should be checked	Observe trend lines / service at earliest convenience
	Conv. motor			-	-	-	Out of reach. Not measured	-
	Ballistic separator motor			3.4	15	OK	Good condition	Observe trend lines
	Conv. motor			-	-	-	Out of reach. Not measured	-
	Brush motor			-	-	-	Out of reach. Not measured	-
	Conv. motor			4.0	19	OK	Good condition	Observe trend lines
	Wind shifter motor		1455	3.1	5	OK	Good condition	Observe trend lines
	Wind shifter motor		1455	2.3	11	OK	Good condition	Observe trend lines
	Conv. motor			5.7	21	OK	Good condition	Observe trend lines
	Conv. motor		1455	2.5	3	OK	Good condition	Observe trend lines
	Conv. motor		1480	4.0	9	OK	Good condition	Observe trend lines

Redacted	Conv. motor	Redacted	2328	9.9	3	Warning	High ISO values indicate likely unbalance	Observe trend lines / service at earliest convenience
	Conv. motor		2928	5.7	19	OK	Good condition	Observe trend lines
	Conv. motor		1800	3.1	3	OK	Good condition	Observe trend lines
	Eddie current motor		1800	23.7	12	Critical	Extremely high ISO level and rich harmonic content in spectra indicate likely significant looseness	Service
	Conv. motor			3.7	9	OK	Good condition	Observe trend lines
	Sorting drum motor			-	-	-	Out of reach, not measured	-

Conclusions

- The baseline monitoring lasted for approximately 10 working days with one engineer carrying out the measurements.
- In line with the scheme, plant operators will take over and carry out periodic measurement of all plant, preferably on a one-month - three-month basis.
- The baseline measurements already showed problems in some key areas, thus potentially saving on unnecessary shutdowns.
- Plant operators were trained to carry out monitoring, manage the database and interpret the results. During a practical training session, they already found a bearing problem on another thermal oil pump.
- This confirmed the importance of periodic monitoring.
- Upon learning the measurement procedure and data analysis basics, the operators themselves commented that this scheme will bring great savings to the plant.

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