

A Common Sense Discourse on Misalignment-related Vibration



Stan Riddle

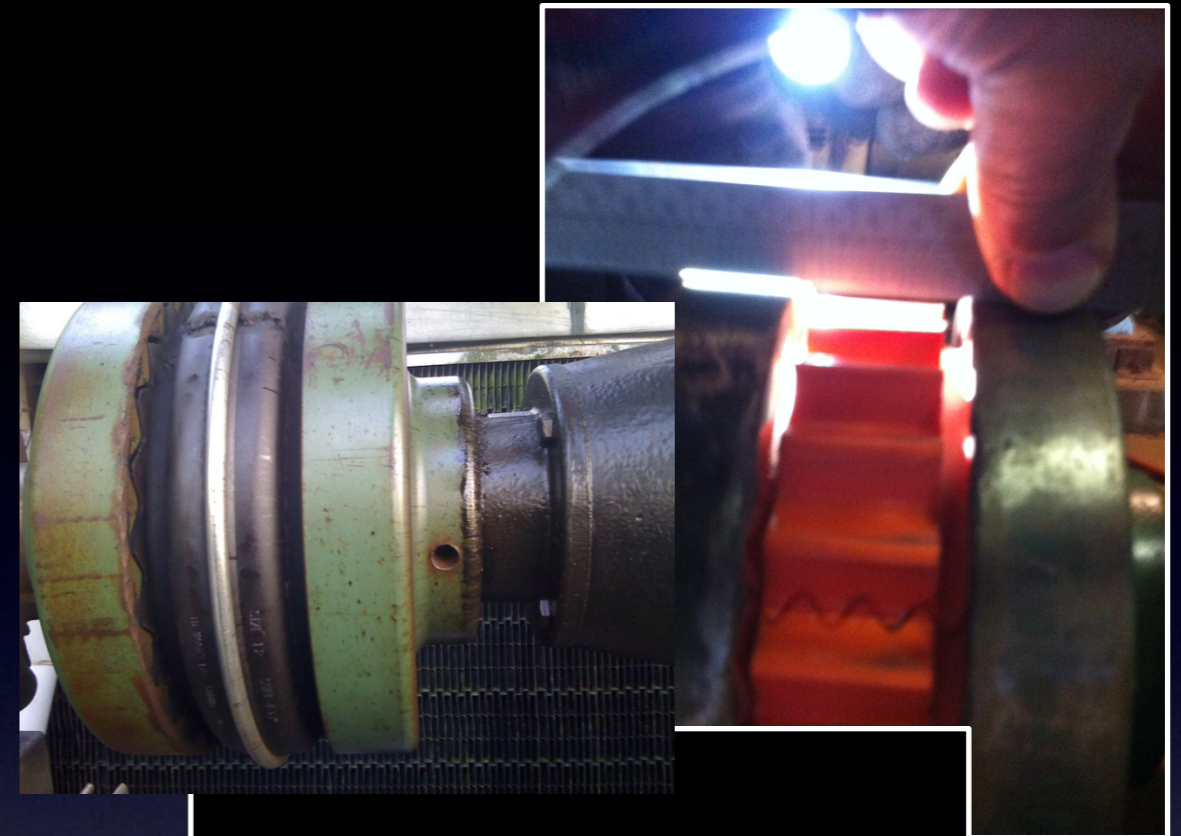


This will be a discussion:

- I am merely the facilitator
- I want to hear your thoughts as well
- There is a wealth of knowledge in this room

A common misconception...

- If it's a pump, and it's coupled, and it vibrates, it must be misaligned.
- If it's a fan, and it vibrates, it must be out of balance.
- Really?



What Is “Good” Alignment?

This coupling was aligned to within the coupling manufacturer’s tolerances!



Rpm	mils / 1"	mils
3600	0.5	2.0
1800	0.7	4.0
1200	1.0	6.0
900	1.5	8.0
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OK

TABLE 2 – MAXIMUM RPM AND ALLOWABLE MISALIGNMENT
(Dimensions in Inches)

Sleeve Size	Maximum RPM	Types JE, JN, JES, JNS, E & N			*Type H & HS		
		Parallel	Angular	G ₁	Parallel	Angular	G ₁
3	9200	.010	.035	1.188	.....	.....	.....
4	7600	.010	.043	1.500	.....	.....	.....
5	6000	.010	.050	1.938	.....	.....	.....
6	6000	.015	.070	2.375 (1)	.010	.016	2.375
7	4500	.020	.094	2.563	.012	.020	2.563
8	4500	.020	.094	2.938	.015	.025	2.938
9	3750	.025	.109	3.500	.017	.028	3.500
10	3600	.025	.128	4.063	.020	.032	4.063
11	3600	.032	.151	4.875	.022	.037	4.875
12	2800	.032	.175	5.688	.025	.042	5.688
13	2400	.040	.195	6.625	.030	.050	6.625
14	2200	.045	.242	7.750	.035	.060	7.750
16	1500	.062	.330	10.250	.....	.....	.....

Note: Values shown above apply if the actual torque transmitted is more than 1/4 the coupling rating. For lesser torque, reduce the above values by 1/2.
* Type H and HS sleeves should not be used as direct replacements for EPDM or Neoprene sleeves.
(1) Value when using 6J flanges is 2.125.

TOLERANCES FOR SHAFT ALIGNMENT (±)

RPM	GAP (mils/10°)		OFFSET (mils)		SPACER SHAFT (mils/in.)	
	Excellent	Acceptable	Excellent	Acceptable	Excellent	Acceptable
600	10.0	15.0	5.0	9.0	1.8	3.0
900	7.0	10.0	3.0	6.0	1.2	2.0
1200	5.0	8.0	2.5	4.0	0.9	1.5
1800	3.0	5.0	2.0	3.0	0.8	1.0
3600	2.0	3.0	1.0	1.5	0.3	0.5
7200	1.0	2.0	0.5	1.0	0.15	0.25

All RPM: Maximum Soft Foot Reading 2.0 mils. (1 mil = .001")
Note: Use OEM or in-house tolerances if available.

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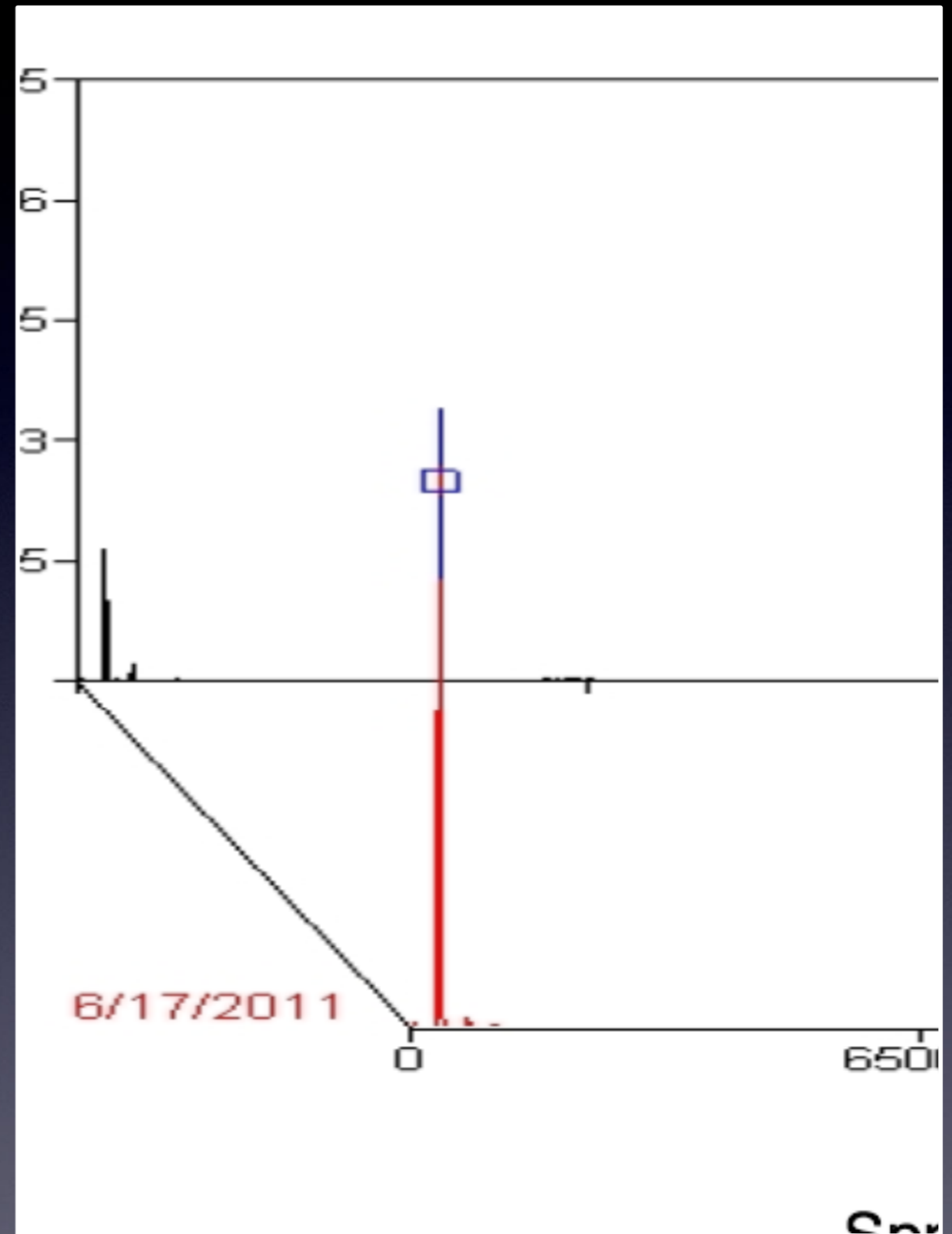
There’s a big difference in coupling tolerances and shaft alignment tolerances!

Misalignment's Effects on Machinery Life

- Decreased coupling life.
- Increased radial and axial loads on bearings, seals, gears, etc.
- Increased vibration and heat.
- Decreased Mean Time Between Failures.
- More downtime for maintenance.
- Lost production.

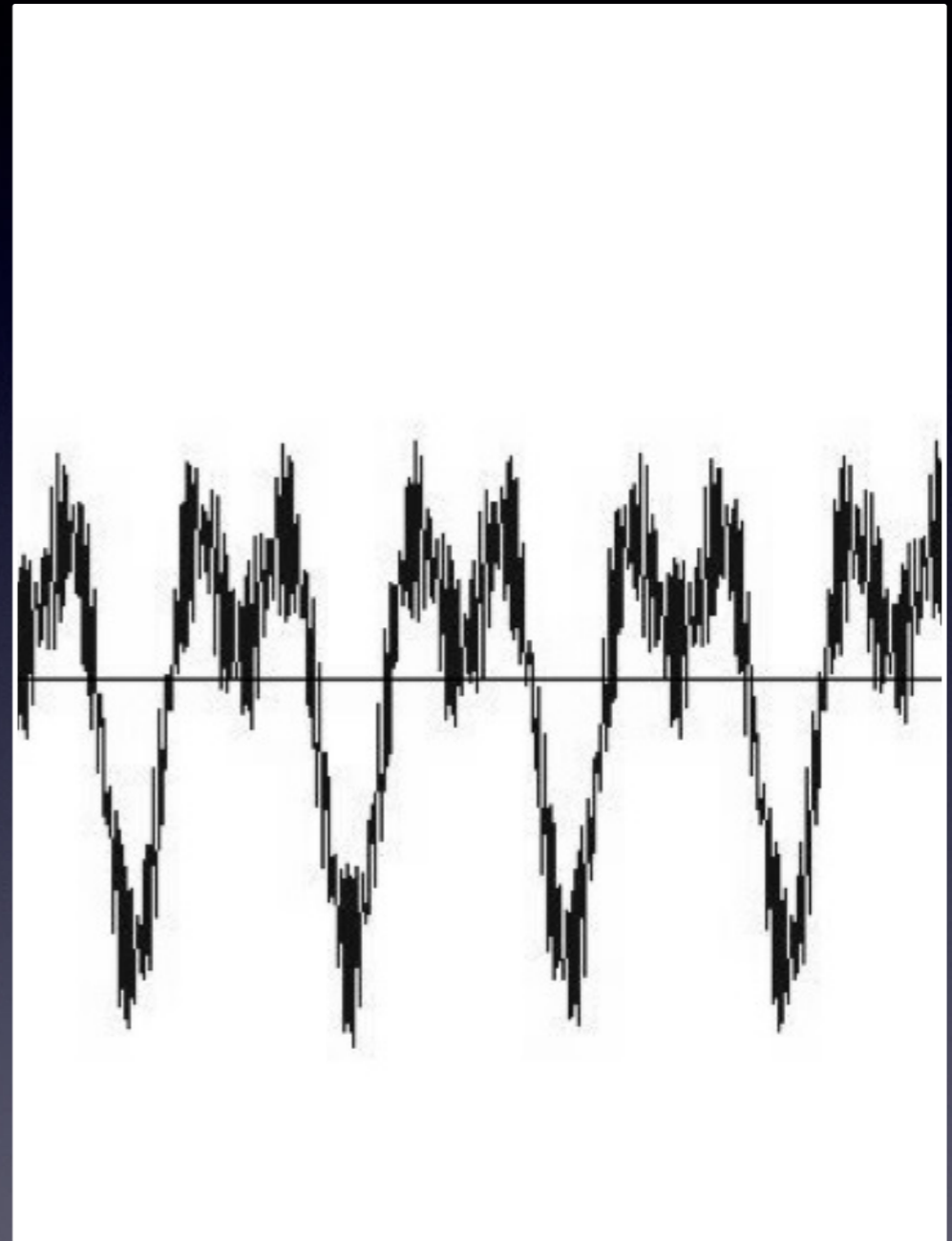
What does misalignment look like in FFT?

- But not always...



What does misalignment look like in TWF?

- But not always...





What does misalignment look like in
ODS?

- Sometimes it is almost pure 1x.
- Or 1x with a little 2x.
- Or 1, 2, and 3x.
- Or 1,2,3 and 6x.
- Or jaw pass frequency.
- Or gmf of the gear coupling
- And, sometimes the radial is highest. Sometimes, the axial response is highest.

And sometimes, the amplitude can be fairly low, and still be a problem.

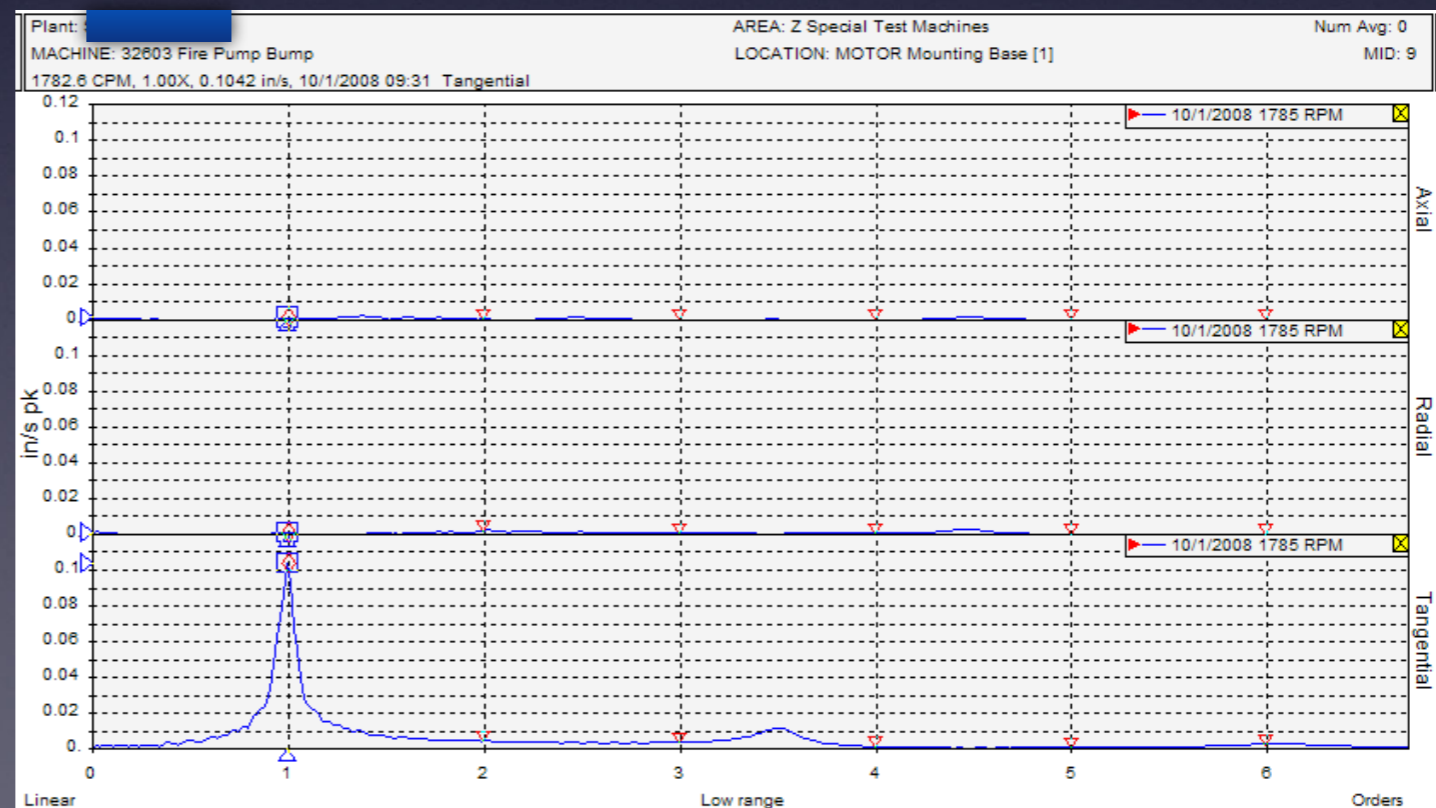
What Can Affect the Signature Characteristics and Amplitude of Vibration Due to Misalignment?

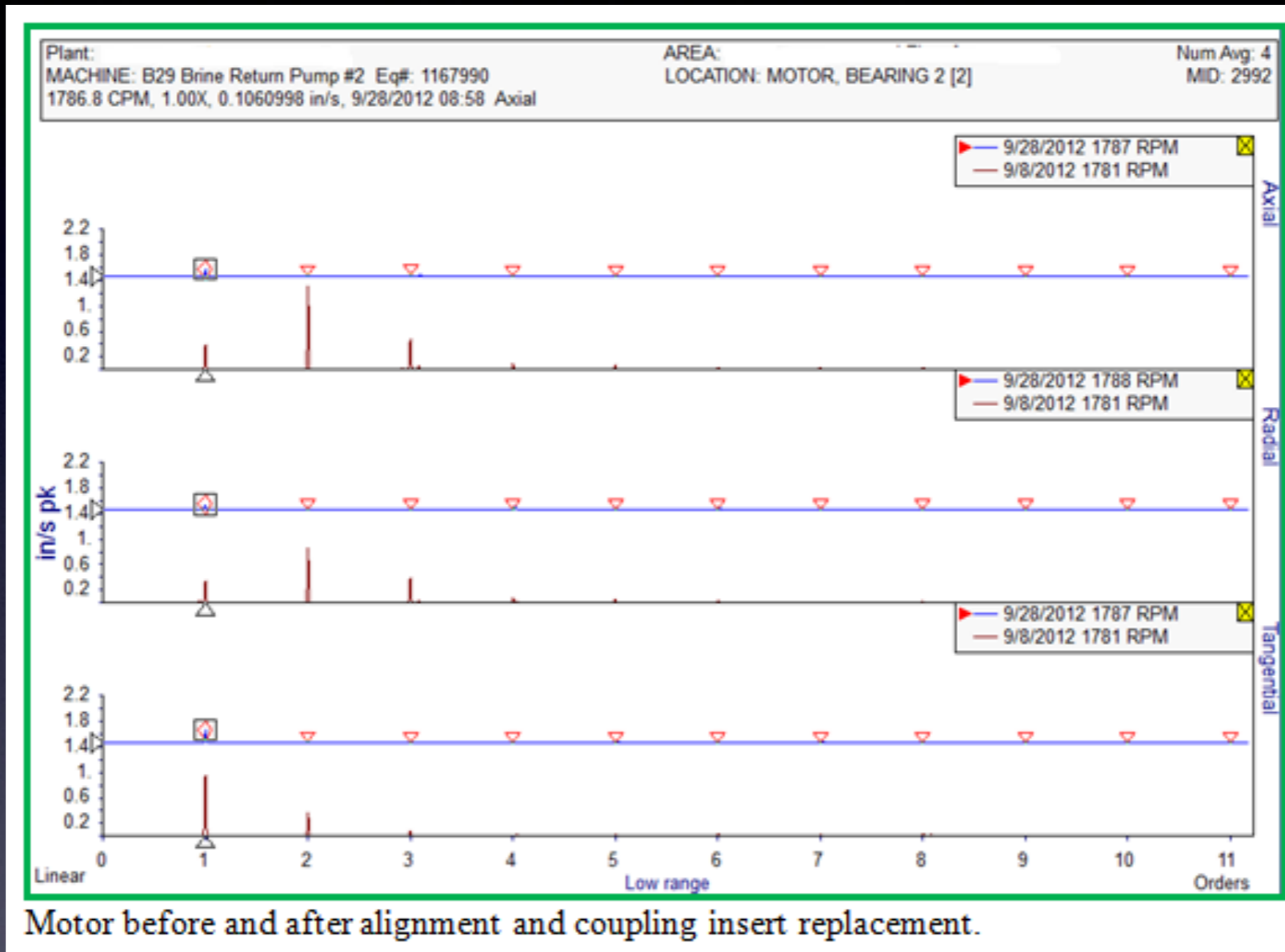
- The type of misalignment
- The degree of misalignment
- The direction(s) of misalignment
- Coupling type
- Coupling stiffness
- System response and damping
- Quality of installation
- Base, piping, isolators, etc...
- Lubrication, or the lack thereof, of the coupling
- ?

And to make it even more confusing, misalignment seldom has a linear response. Twice as much misalignment seldom means twice as much vibration.

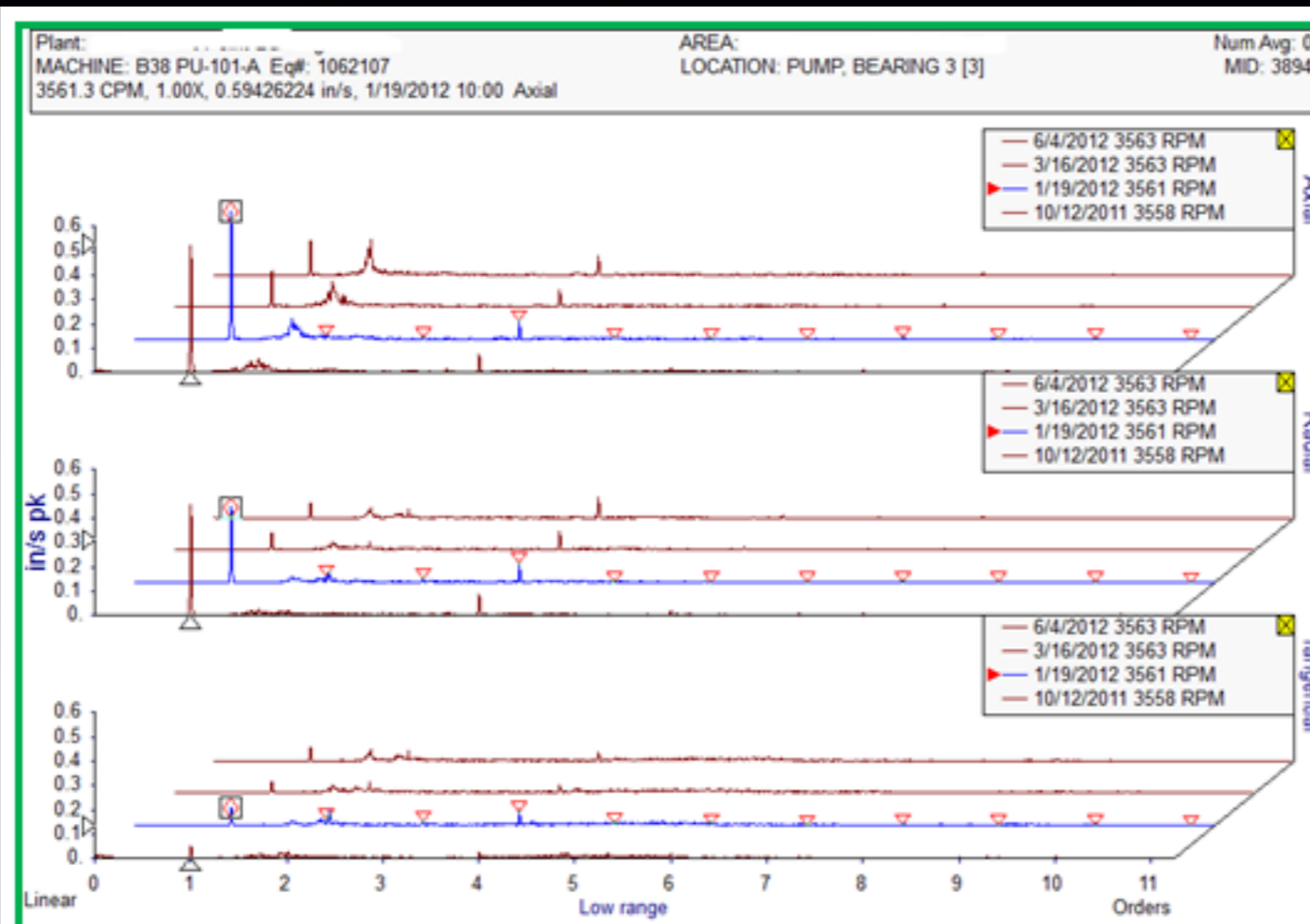
What other machinery phenomena can exhibit the same types of vibration?

- Imbalance?
- Bent shaft?
- Bearing clearance issues, especially on sleeve bearings?
- Coupling installation errors?
- Improper axial spacing?
- Resonance?



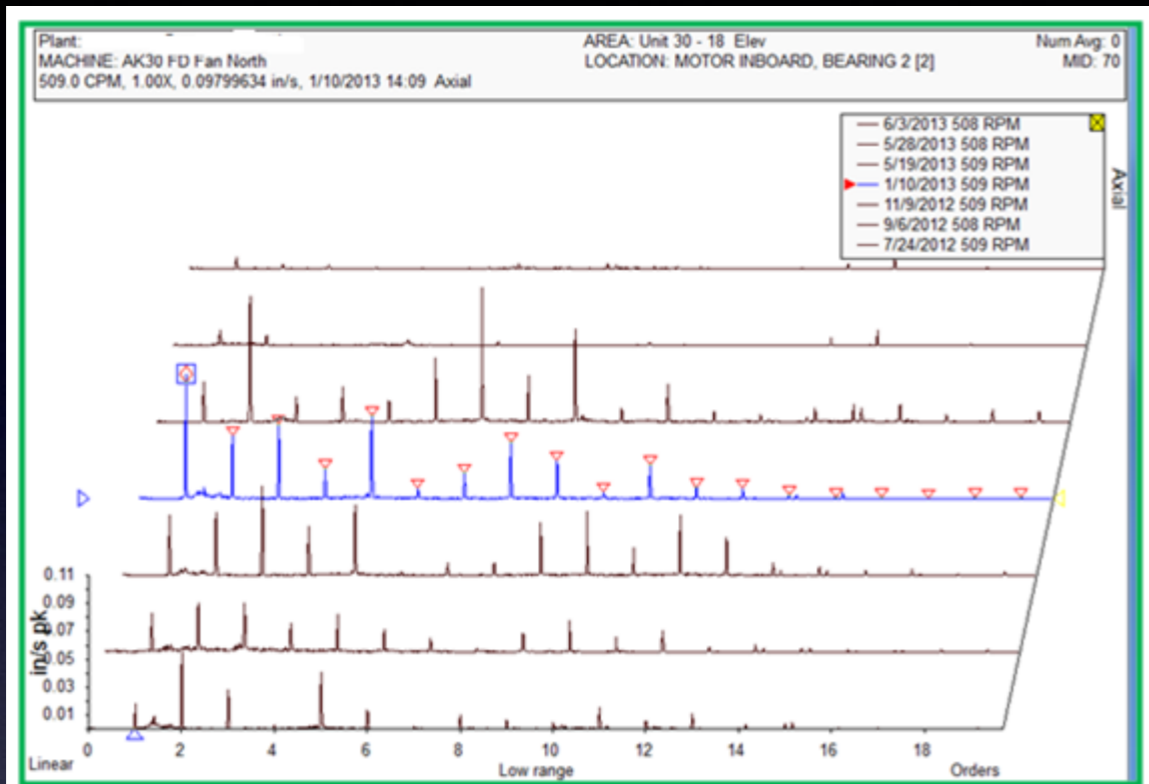


Not misalignment, but a deteriorated coupling insert.

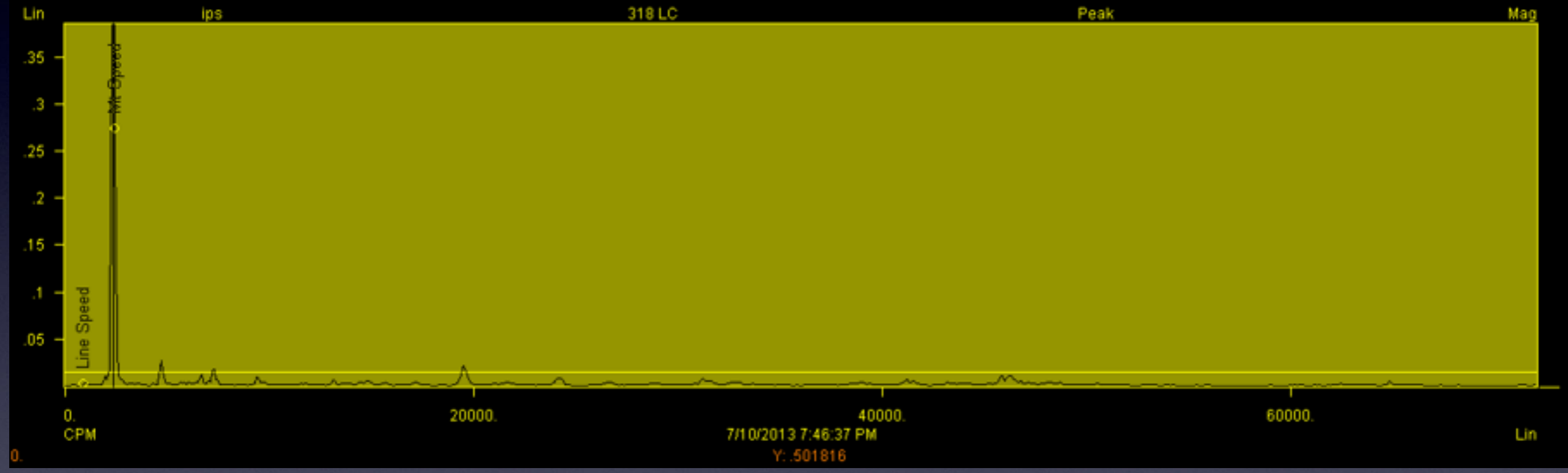
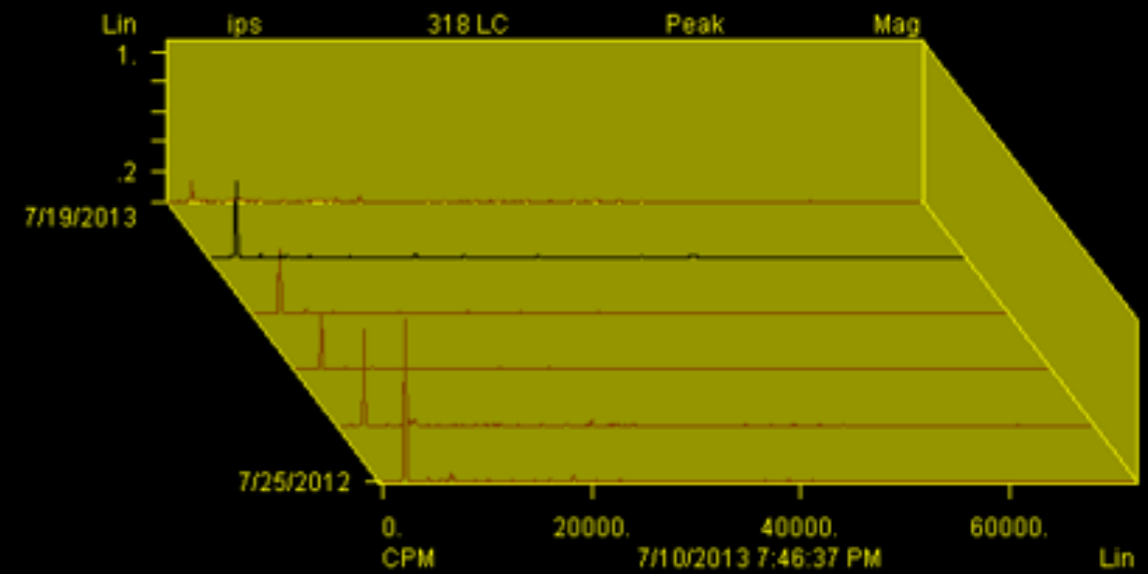
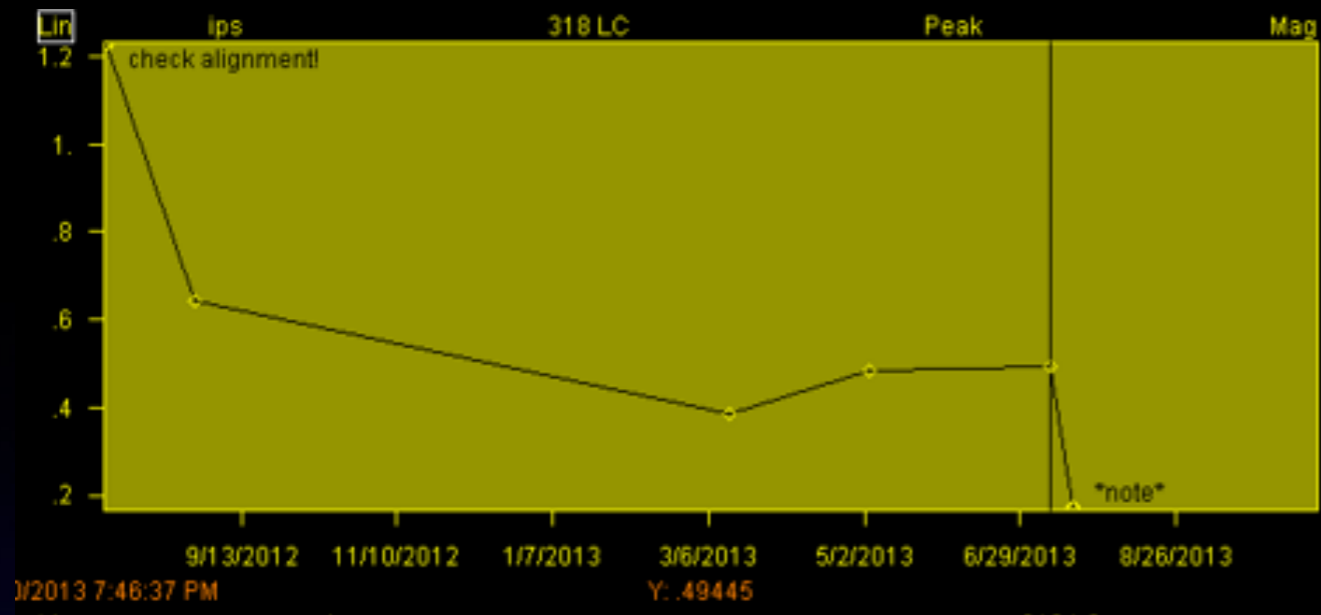


Pump with coupling unbalance fault 1X axial elevated. Unit was found to be significantly out of alignment >50 Mil parallel and 1mil/in angle. Correction did not correct the vibration response. Unit was trim balanced using the motor cooling fan. High axial is due to coupling unbalance and not angular misalignment.

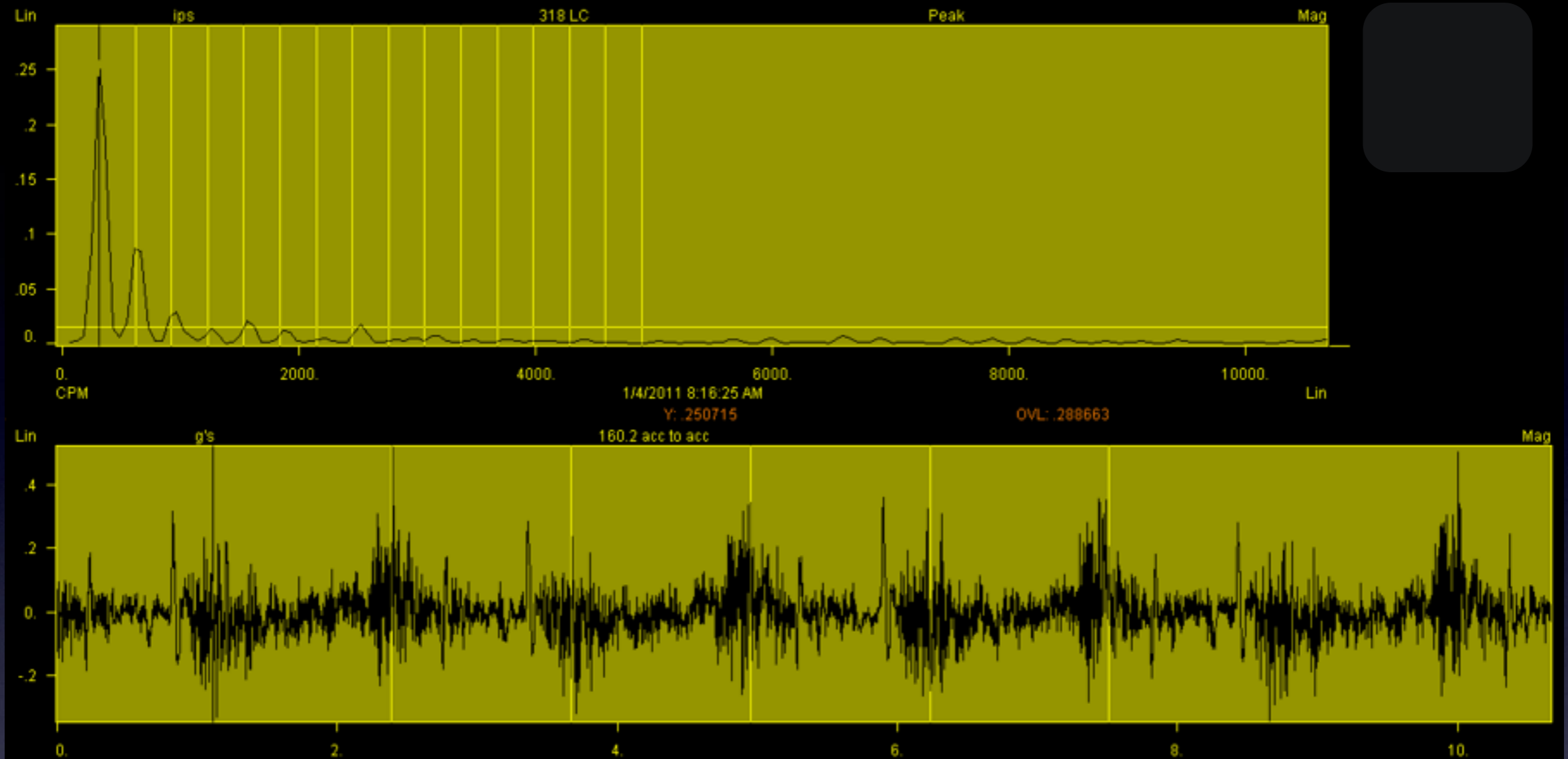
Coupling imbalance.



Misdiagnosed as misalignment

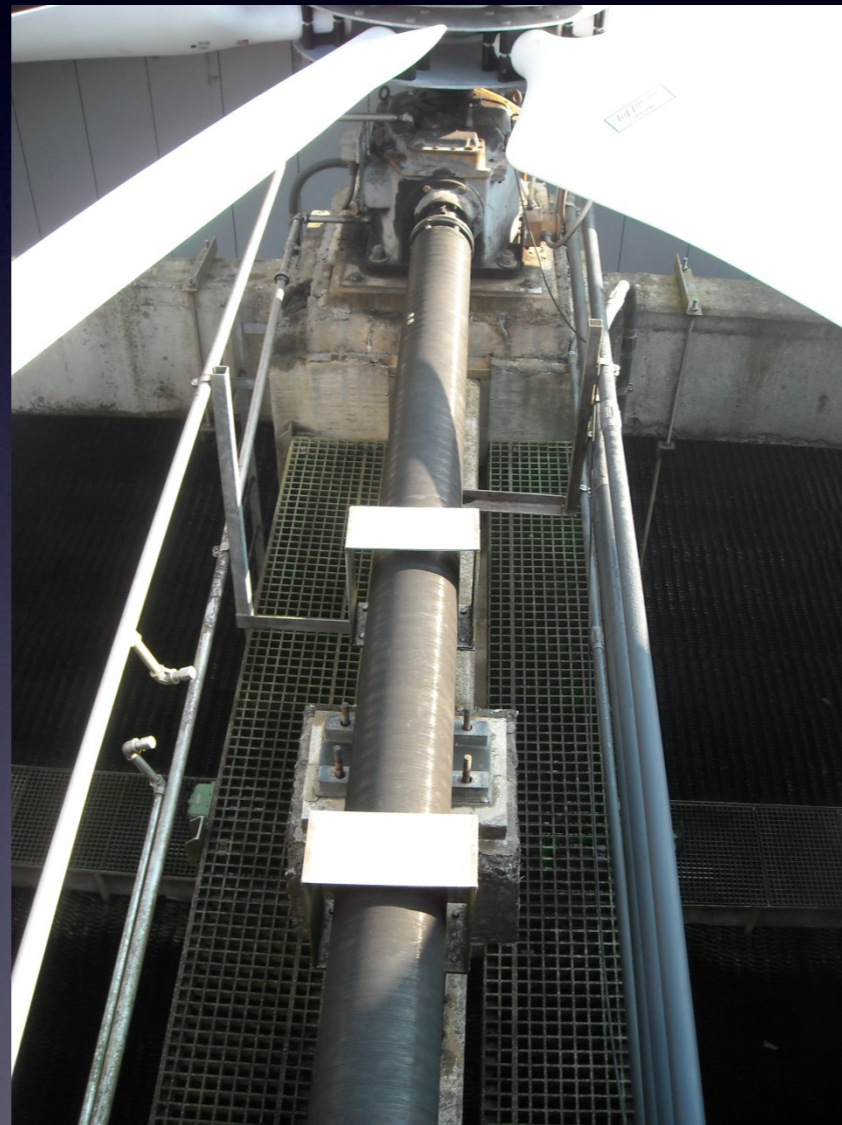


A Bolt Bound Motor. Is this an alignment problem?



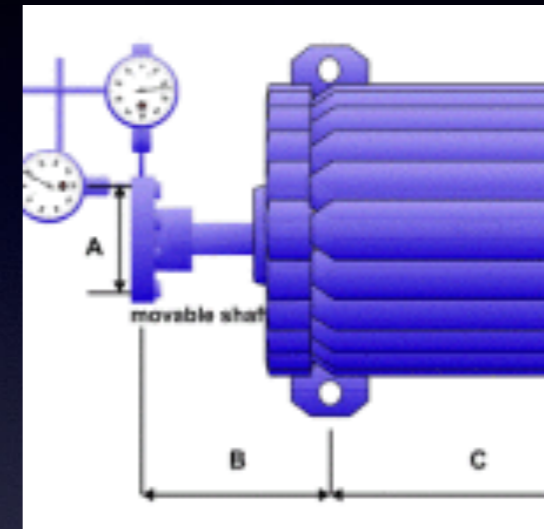
Bent shaft on a paper machine, caused by improper operation.

So, with all these variables, how can you determine misalignment?

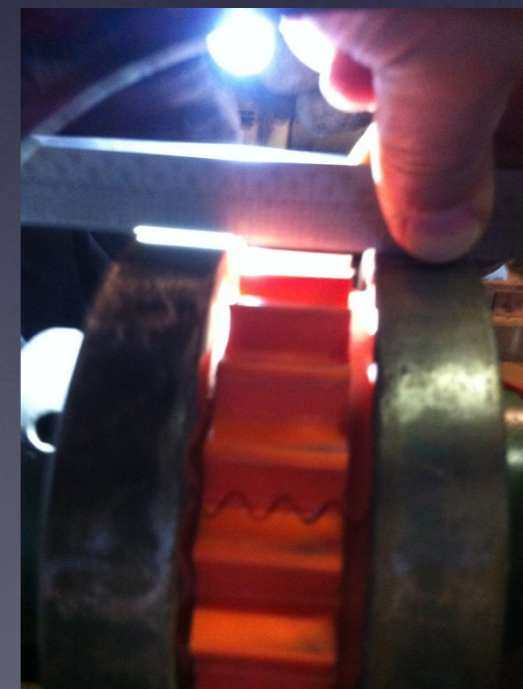


- Mechanical checks for misalignment
- Observation
- The vibration signature
- Phase analysis
- Discussion with mechanics and operators
- Looking for what isn't misalignment

Mechanical Checks for Misalignment



This is probably the best way to determine misalignment.

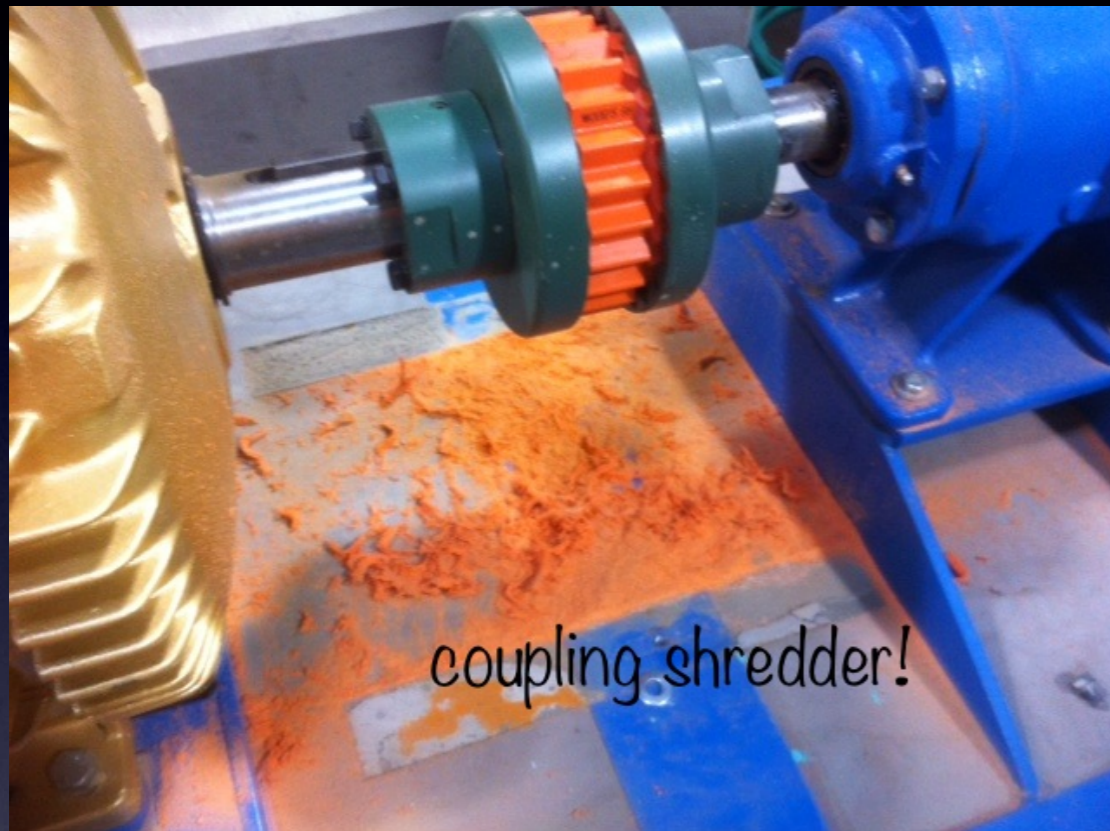


Precision alignment checks should be included as part of the PM process.

Are they done at your facility?

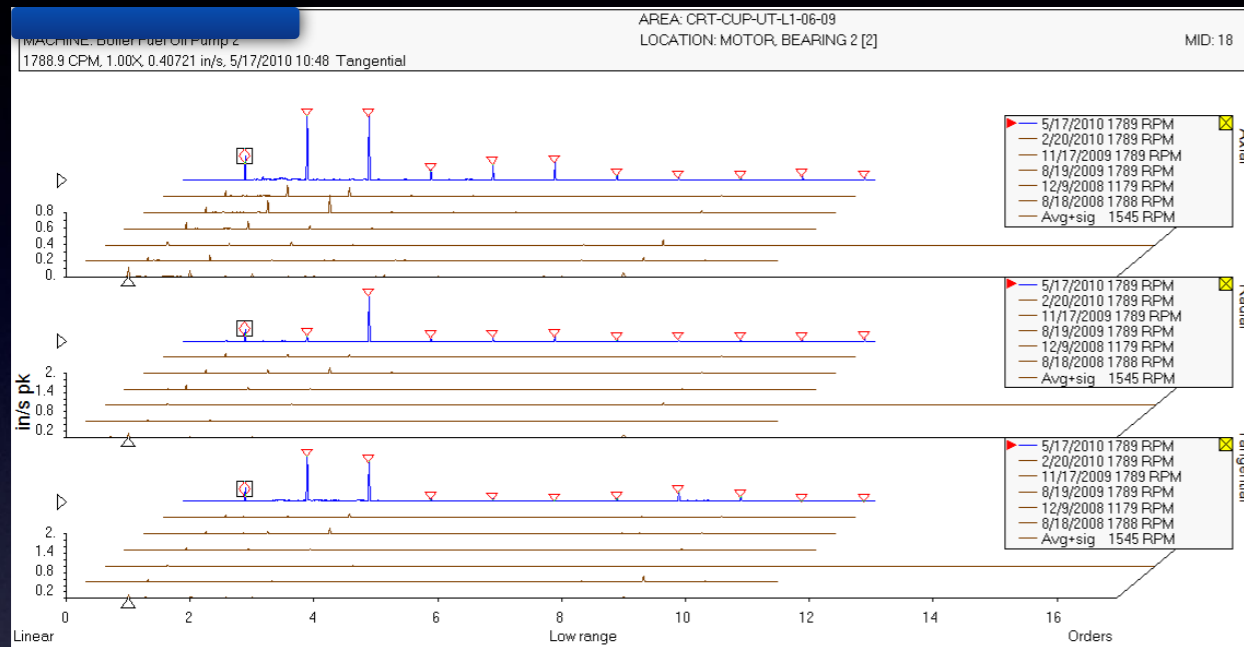


Observation



- What do YOU look for?
- For me, collecting vibration data is an excellent time to observe.

The Vibration Signature



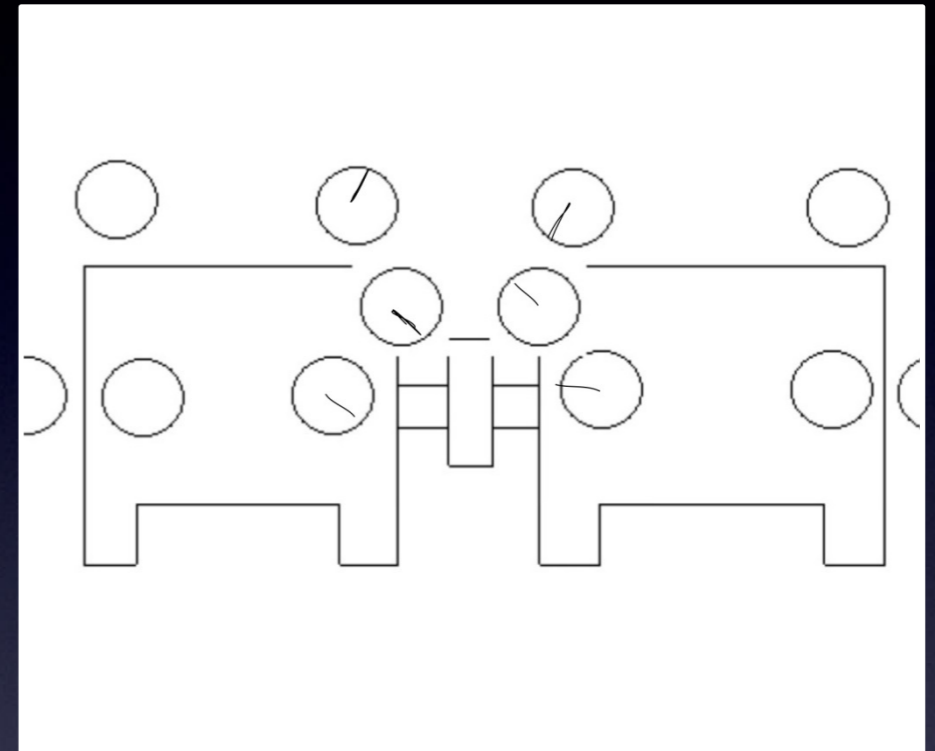
For most of us, this is the first indicator of misalignment.

- Does it trigger an alignment check at your facility?
- Who performs it?
- What evidence are you given that it was actually done?
- Do you re-measure?

Phase Analysis

Back in the "Stone Age"-
we used phase to help
diagnose misalignment

- I miss doing this with a swept filter machine and a strobe light! I know phase angles are used, but I miss the flashing light, and marking down the "clock positions" on paper!



Discussion with mechanics and operators



One of the most important, and most often overlooked, methods of determining machinery problems.

- Has any maintenance been done to this machine recently?
- Have any changes been made in the process?
- Has there been a crash?
- Have you noticed anything different – sound, smell, feel, product quality?
- What do YOU think?

Looking for what isn't misalignment!

- Loose bolting.
- Pipe or duct strain.
- Hangers not “hanging”.
- Broken welds.
- Base or foundation problems.
- Thermal growth.
- A visual inspection of the coupling.
- Check valves.
- Flow rates.
- ?

What happens when you say it's misaligned, and the mechanics say it's not?

Summary

- Misalignment can decrease machine component life dramatically.
- The spectral signature of a misaligned machine can vary greatly, depending on the type and degree of misalignment, the type of coupling, and other factors.
- No single method of reliability testing can determine misalignment. The best way to determine a misaligned coupling is to measure for misalignment.
- Vibration analysis, along with other reliability technologies, can improve determining misalignment on a machine that is running.

Summary

- Utilize your spare parts usage, CMMS data, even how many worn couplings are in the trash can closest to the machine!
- Alignment should be a part of any maintenance department's PM program.
- When in doubt, check it out-yourself!

Many thanks to:

- Bill Pryor, PdM Solutions, Richmond, VA
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Questions/Comments?

