



JENKINS

MOTOR AND RELATED EQUIPMENT PROBLEMS

SHARING PICTURES AND STORIES FROM AN ELECTRO-MECHANICAL REPAIR SHOP

by

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Vibration Institute, Piedmont Chapter #14

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Repair Shops See Many Pieces of Equipment





We All Try To Solve Mysteries

- ⚡ Things that go bump
- ⚡ Things that wiggle
- ⚡ Things that shake and rattle
- ⚡ Things that smell (stink!)
- ⚡ Things that smoke and burn
- ⚡ Things that break and fall apart
- ⚡ Things that wear and wallow out
- ⚡ Things where Electricity “gets out”



An Elevator that goes bump Bump...

- ⚙️ Passenger elevator in a hospital
- ⚙️ Few were willing to ride it
- ⚙️ Motor was suspect, no fault found
- ⚙️ Electronic Drive was suspect, replaced
- ⚙️ Then, \$ 90,000 later, an elevator mechanic had a thought



A Bumpy Elevator Ride in a Hospital





Loose Internal Fan

Repaired Blower

The last of the several times it was

- ⚙️ Put together for dispatch.
- ⚙️ A little clicking noise kept appearing each time it was run.
- ⚙️ Nothing showed up on vibration monitor.
- ⚙️ Finally discovered a loose internal fan on the rotor inside the motor.



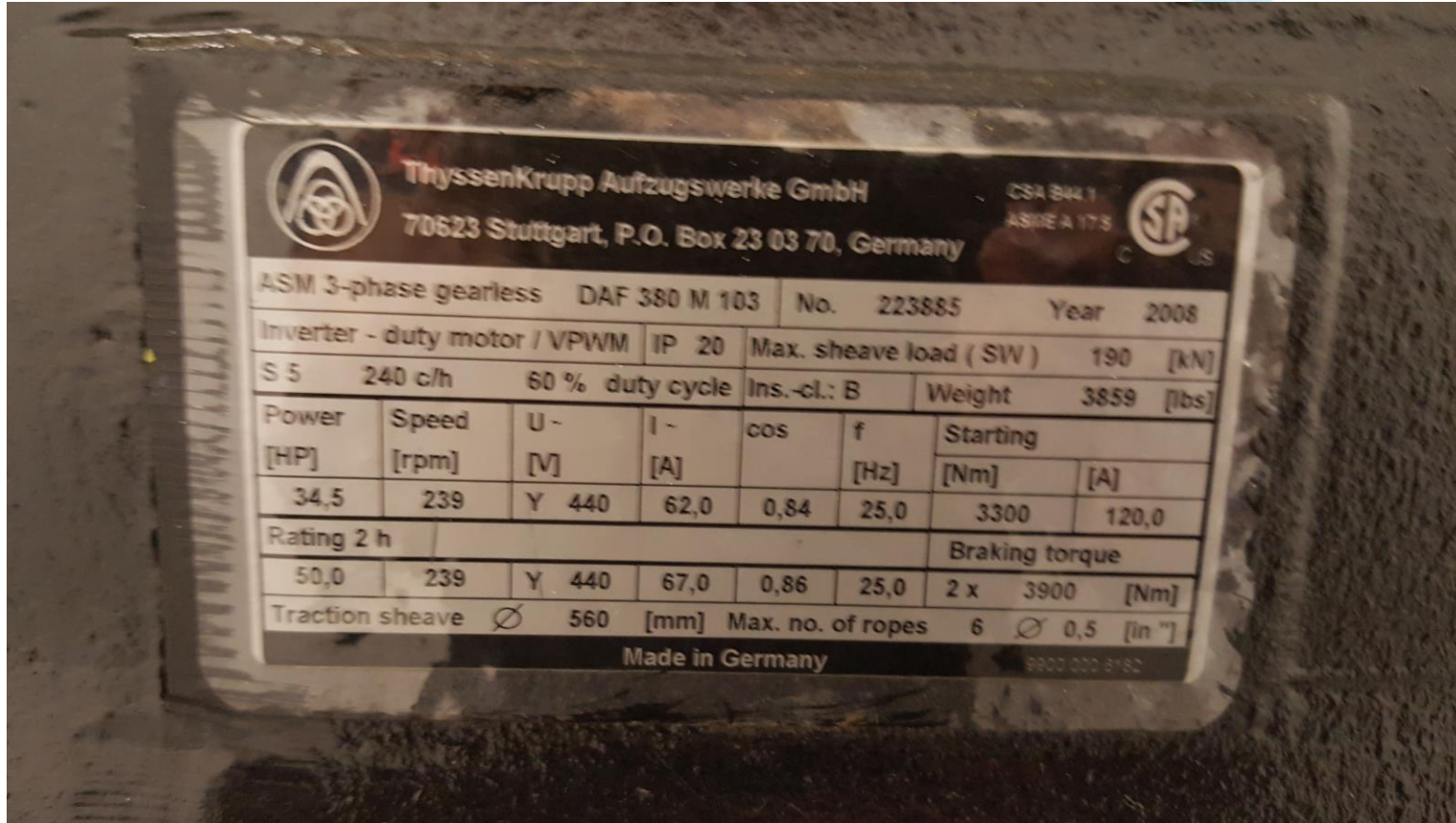


Further Blower Views





Gearless Elevator Drive at Duke Energy Bldg.





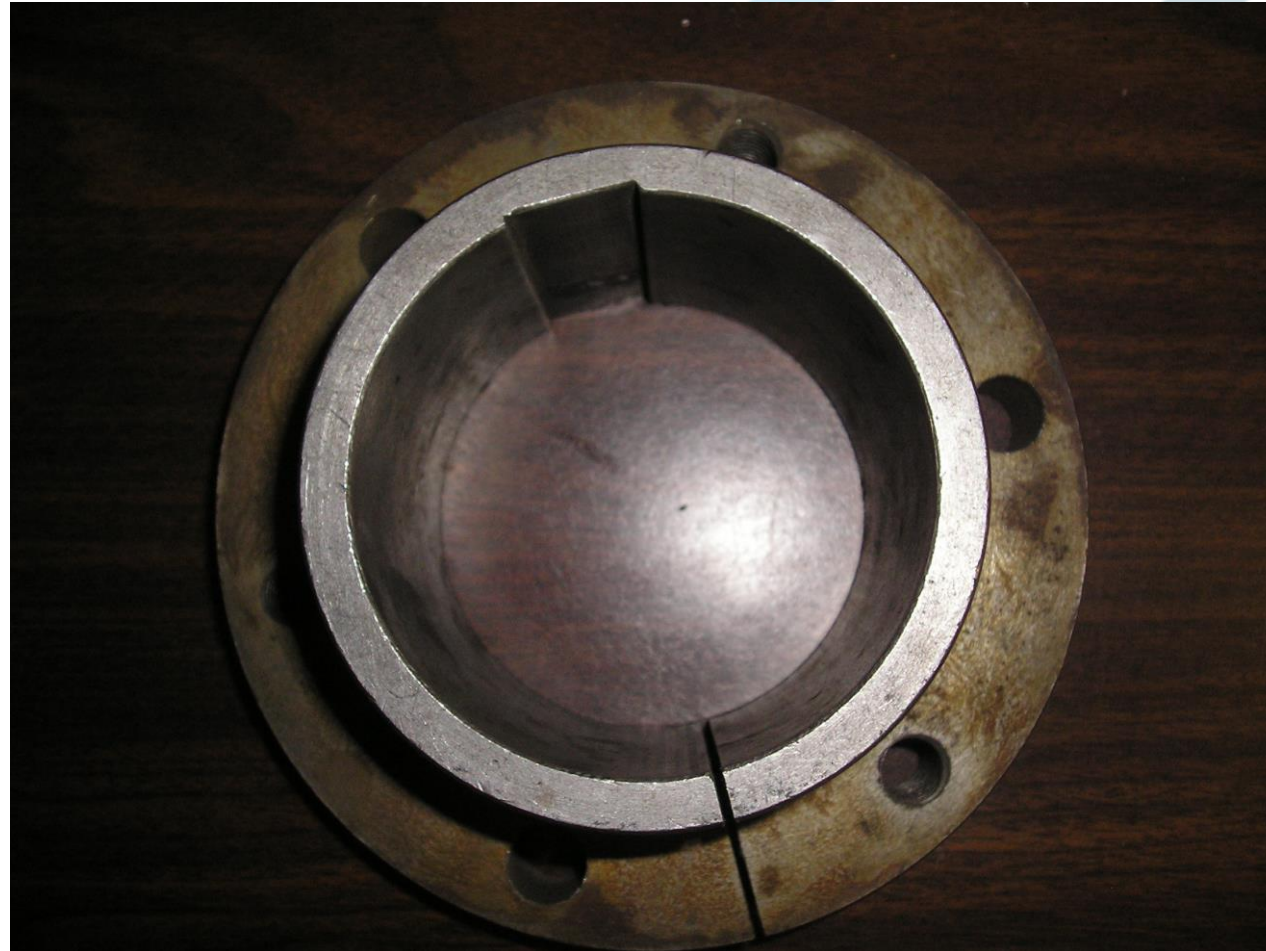
Rotor Moves Before Shaft Starts Turning

- ⚙️ Gearless Elevator Drive built into an office building
- ⚙️ After it warmed up, it would “clunk” every time it started or stopped.
- ⚙️ Rotor loose on shaft, keyway bad
- ⚙️ Some temporary repairs are done with epoxy
- ⚙️ Other attempts involve welding.





Coupling and Key





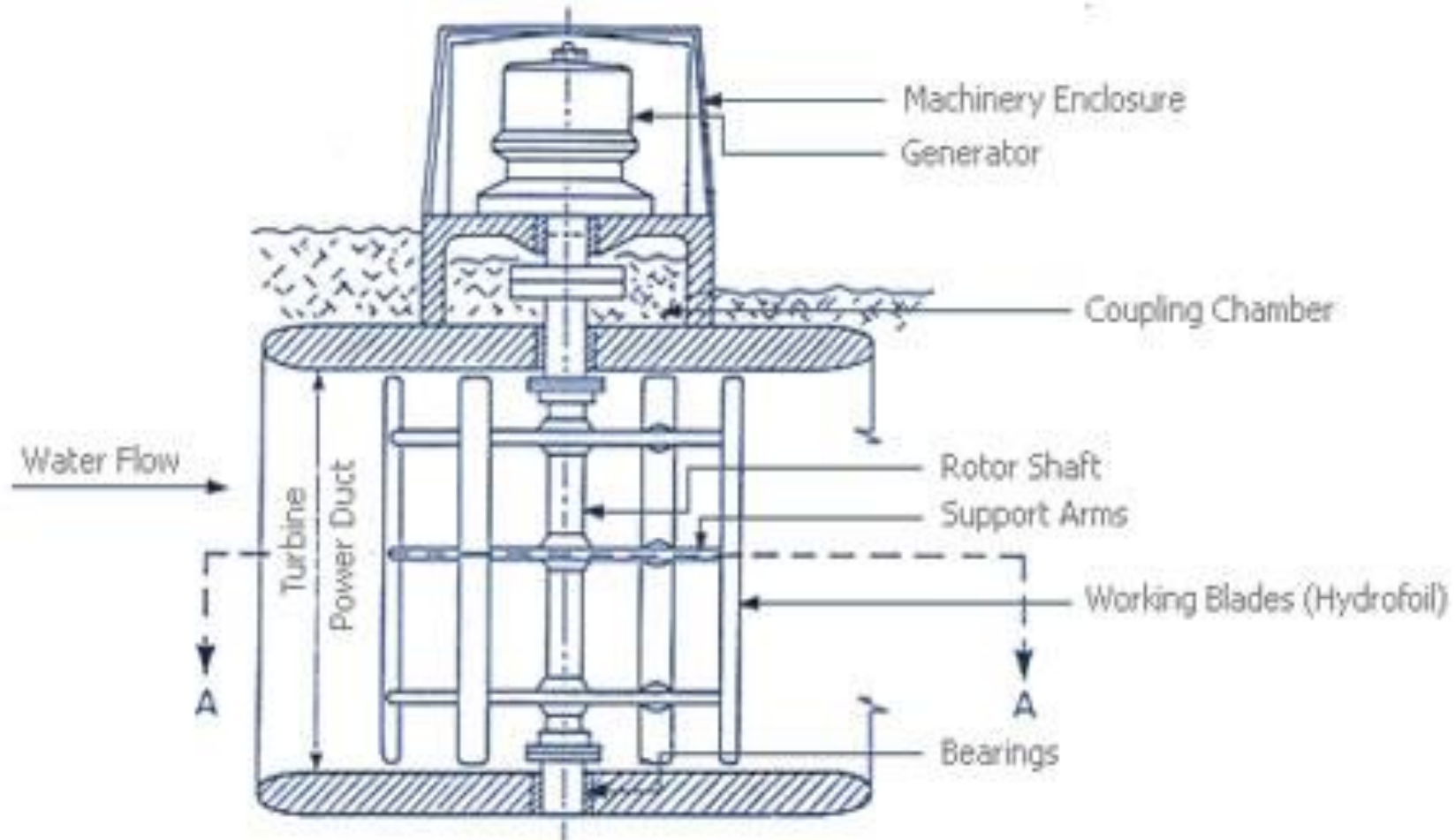
Some body knows!

- ⚙️ Many times an operator or floor employee is aware of problems
- ⚙️ Other times a maintenance job is skipped or ignored
- ⚙️ Occasionally an intelligent process is followed for many years
- ⚙️ Procedures change/ improve, but the word does not get out

- ⚙️ You and I are lucky when we get to talk to the right person to help solve their problems



Vertical Hydro Generator





Waterwheel Drive Connecting Shaft

Shaft



One of the Cracks





View Of Another Crack





Many Motors Run in Difficult Situations

- ⚙️ Blowing off the dust/ dirt occasionally does help
- ⚙️ Watching for bad connections is needed
- ⚙️ Some motor designs are especially resilient
- ⚙️ The next motor illustrated runs in the open air in a rock quarry

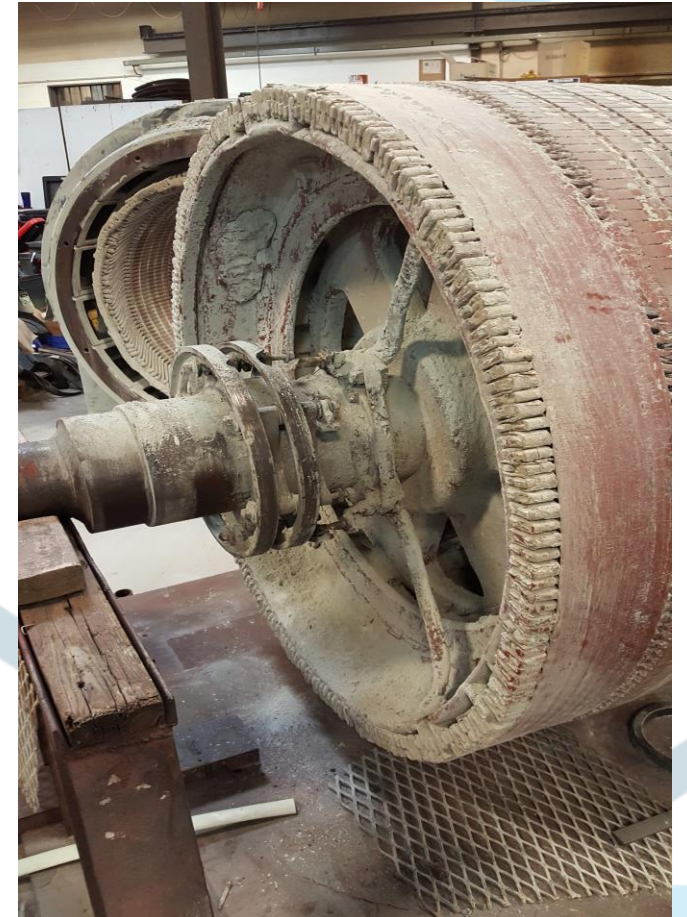


Rock Quarry Crusher Motor

Disassembled motor



Note Collector Ring Failure



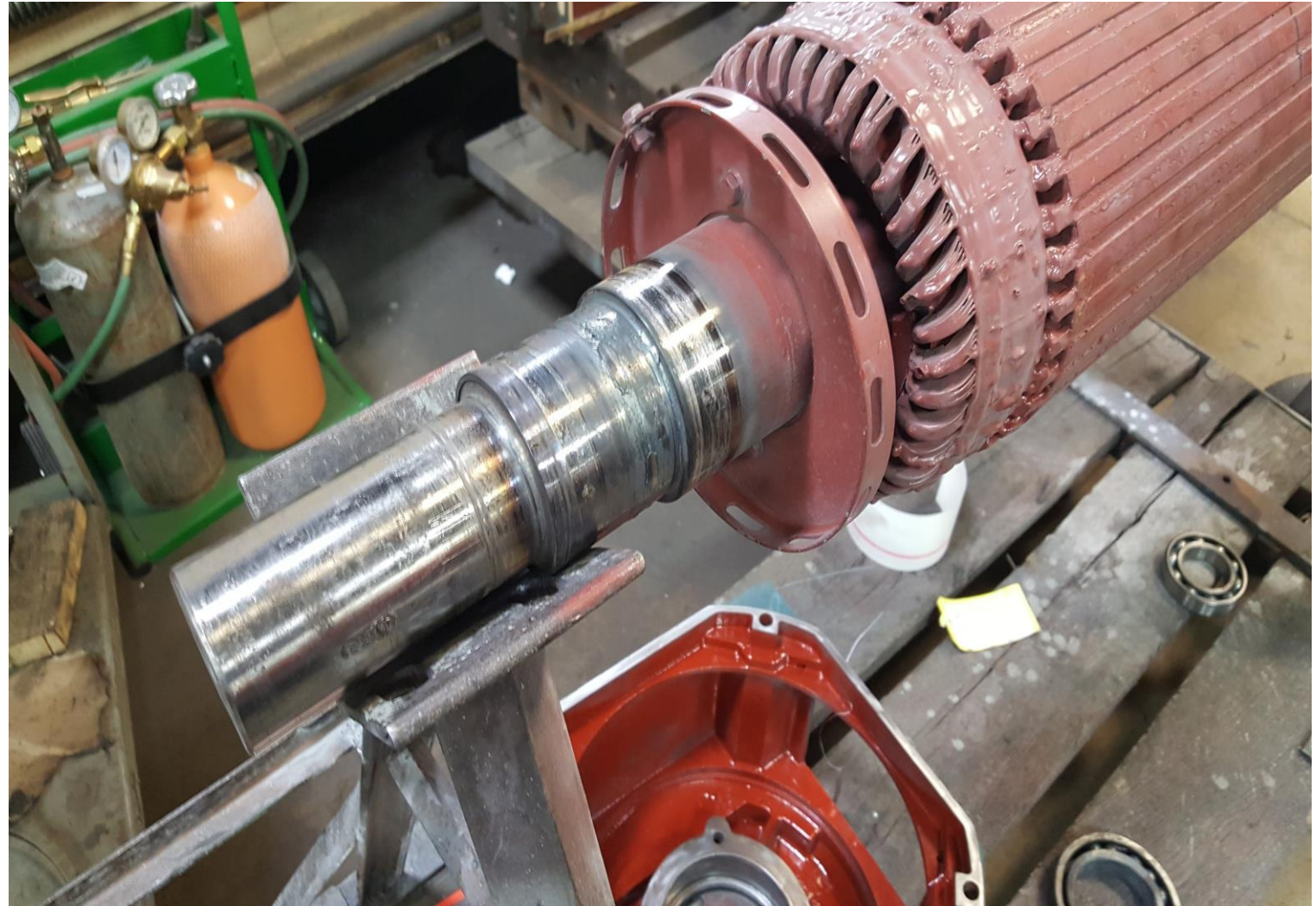


“Running a route is useful... until

- ⚙️ The following motor was monitored about six weeks before it failed
- ⚙️ No faults were indicated in the spectra
- ⚙️ Lubrication may be needed more often than the route is run
- ⚙️ On line monitoring may have been needed
- ⚙️ An observant operator noted problems and had the motor removed from service
- ⚙️ Shaft journal needed repair, but no other damage occurred



Bearing Failure in Service – Recently Checked





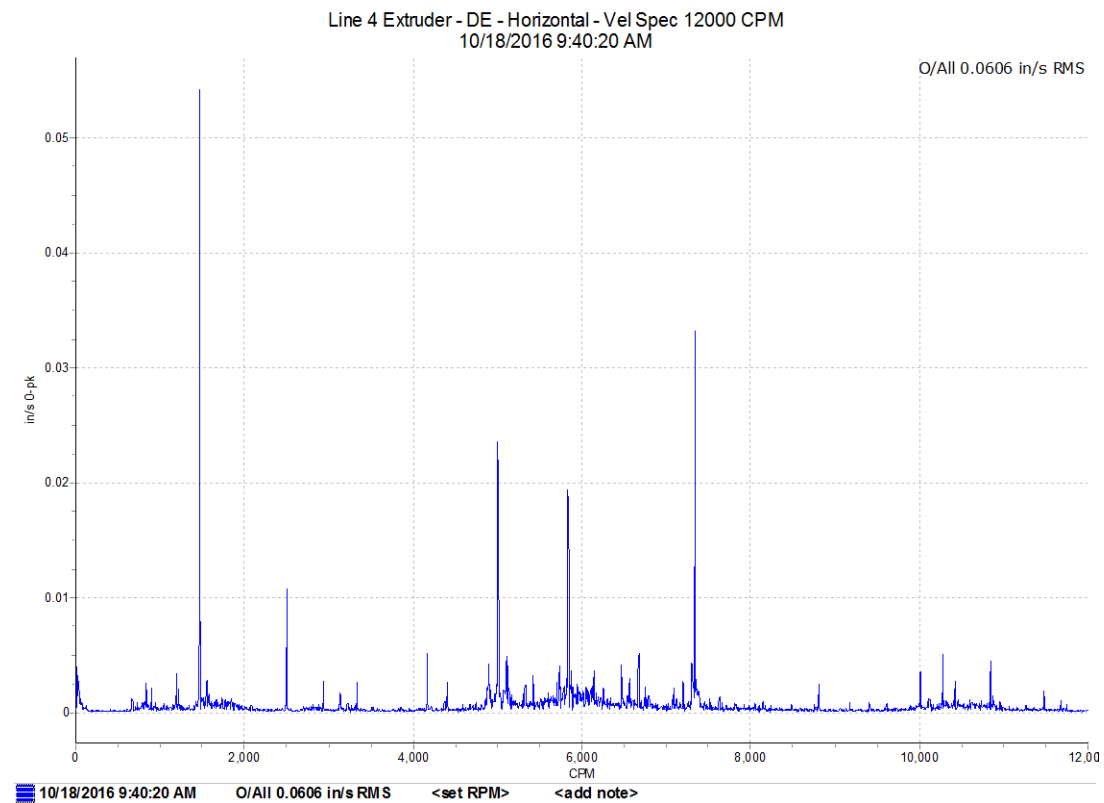
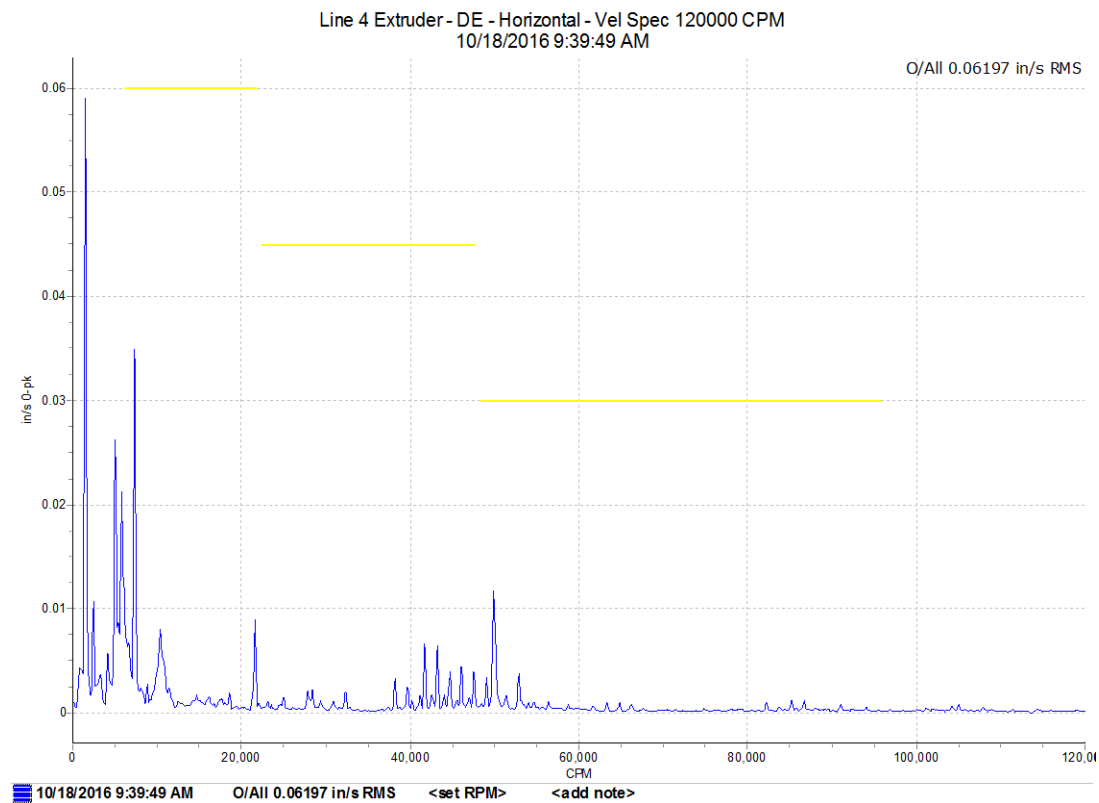
Spectrum a month ago

- ⚙️ Note that the maximum vibration level observed was at running speed and well below alarm.
- ⚙️ No unusual peaks occurred at bearing frequencies
- ⚙️ No evidence bearing was greased in service





Spectrum a month ago



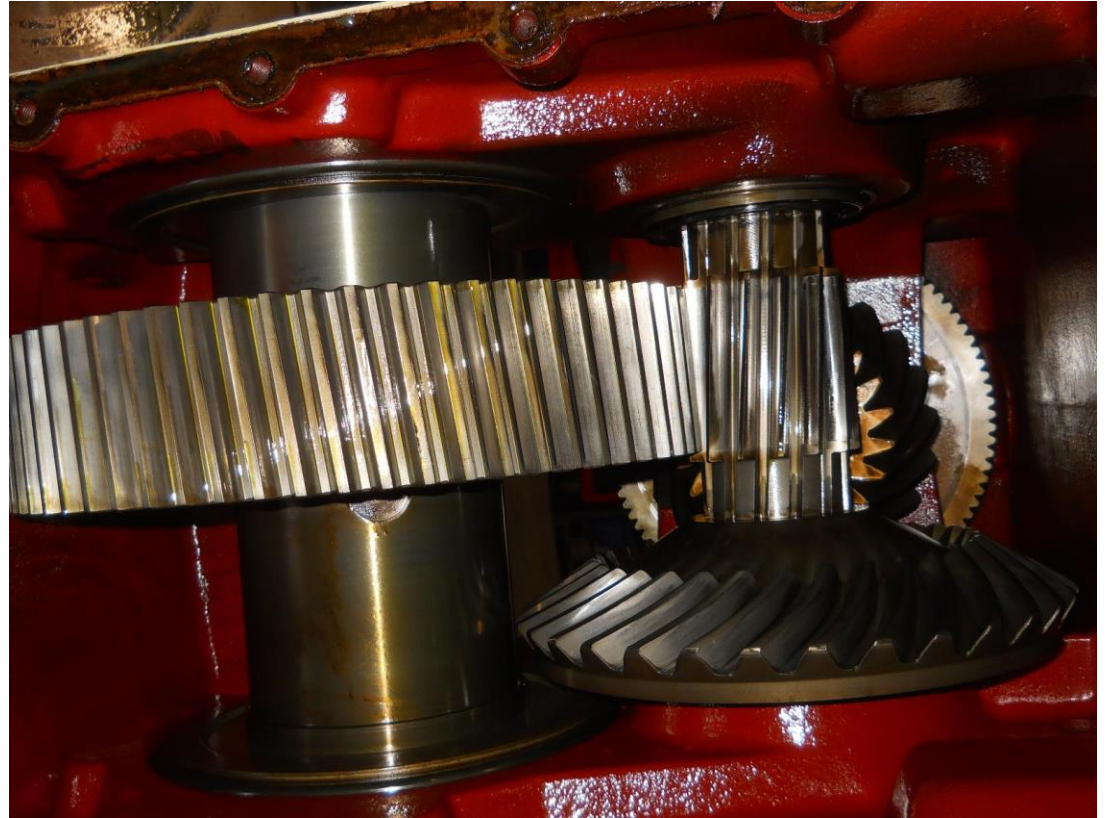


Planned maintenance can pay off

- ⚙️ Tooth paste manufacture is a never ending process
- ⚙️ Mixing/ grinding require high torque and low speeds
- ⚙️ Reliable Gear Boxes are vital
- ⚙️ Running to problem detection or failure may not make economic sense
- ⚙️ This gear box is removed from service every two years and all bearings and seals are replaced
- ⚙️ The gears show very little wear



A Well Planned Maintenance Procedure





Balance May Help Reduce Vibration

Provided You Have:

- ⚙️ Firm equipment foundation
- ⚙️ Structural integrity
- ⚙️ Properly supported rotating elements
- ⚙️ Concentric and smooth bearings
- ⚙️ These conditions do not always occur

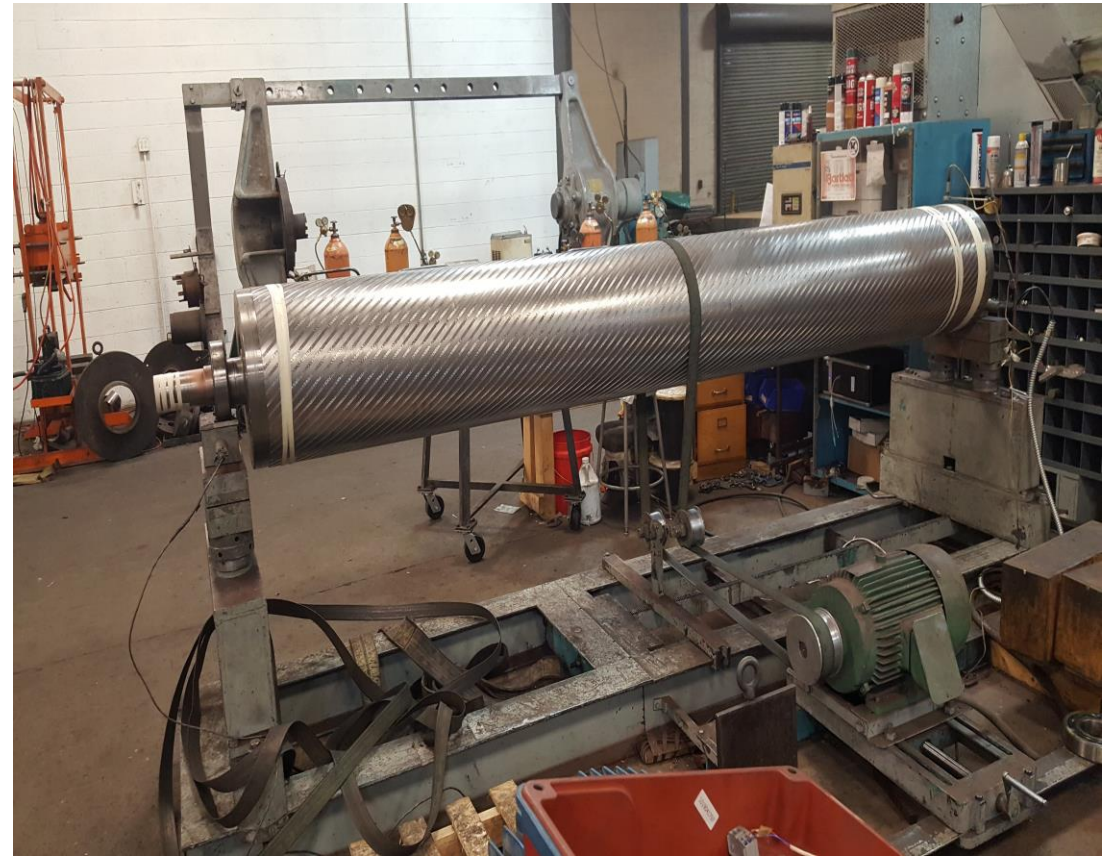
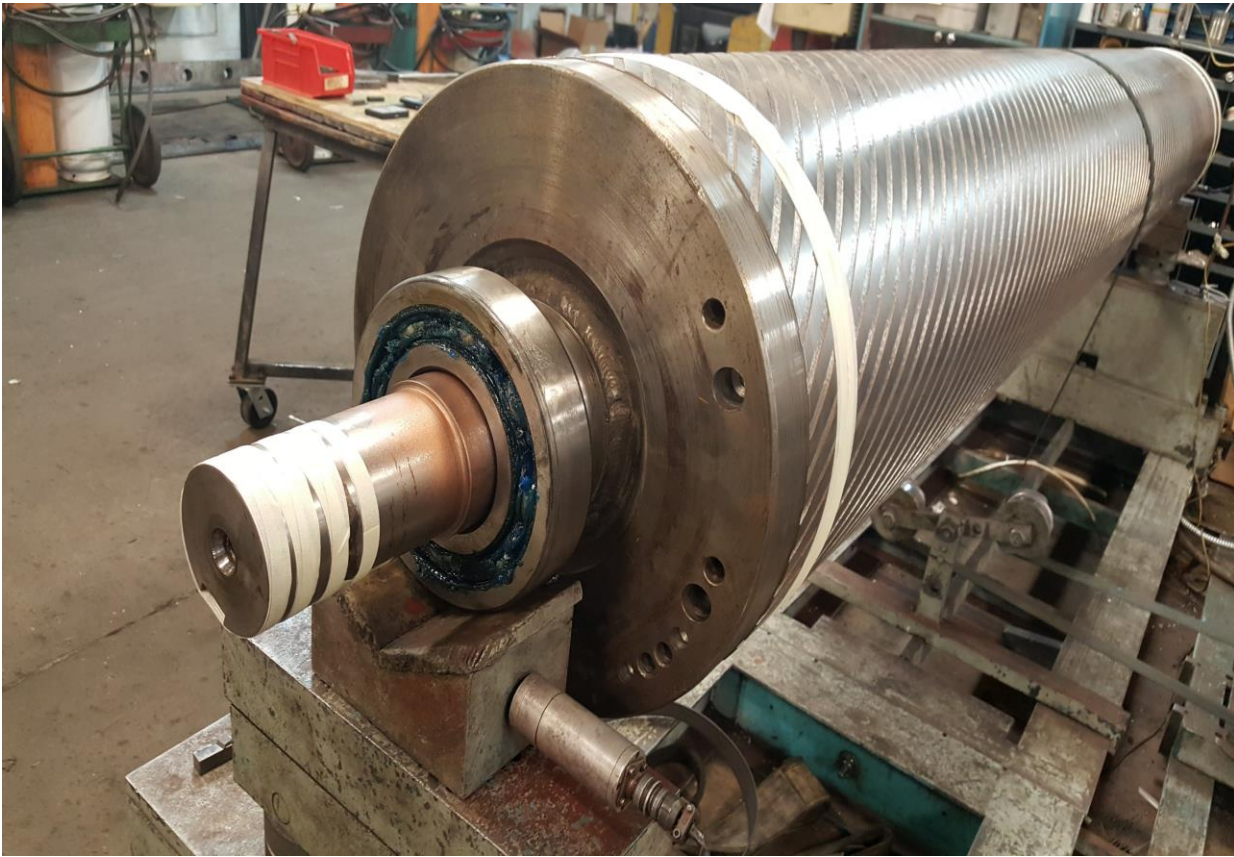


Roll Balance





Final Balance of Roll - Trim by Weight Removal





Balance Report

Computerized Dynamic Balancing Report

Date: 1/12/2017
 Time: 10:13:48 AM
 Operator: SBJB
 Job no.: 311251
 P. O. no.: 29722

Customer: STEINEMAN ROLLS

Two plane balance
 Item balanced: 16.125"dia X .57"lg ROLL
 Balancing specification: ISO G Scale
 Item operating speed: 1150.00 RPM
 Item weight: 1150.00 LB
 Balancing grade: 1.000
 Allowable unbalance in each plane: 0.004 oz-in
 Balancing RPM: 504.6

Balance Conditions

	Start		Finish	
	Mils:	Angle:	Mils:	Angle:
Right End	0.75	211.19	0.04	260.78
Left End	0.36	105.60	0.13	162.10

Beginning unbalance: 128.178 g-in, 4.321 oz-in Right Side
 42.338 g in, 1.493 oz-in Left Side
 Residual unbalance: 0.91 g, 0.03 oz Right Side
 2.12 g, 0.07 oz Left Side
 This item is balanced to: 6.638 g-in, 0.233 oz in Right Side
 15.470 g-in, 0.548 oz-in Left Side

Key Used
 Drive End: 0.99 in wide x 0.29 in thick x 3.50 in long
 Gear End: 0.00 in wide x 0.00 in thick x 0.00 in long

ROLL #: 4986261 - 13 - 024

- ⚙️ Two plane balance
- ⚙️ Operating speed 1150 rpm
- ⚙️ Balance speed 504.61 rpm
- ⚙️ Target Residual Unbalance 5 grams, regardless of roll size or weight??
- ⚙️ Results:
 - ⚙️ 0.001 and 0.003 inch/second
 - ⚙️ 0.91 and 2.12 grams Residual
 - ⚙️ 0.04 and 0.13 mils



Balanced rotating elements help, but...

- ⚙️ This external blower had a heavy steel blade
- ⚙️ The blade was balanced within specs
- ⚙️ The drive motor was balanced within spec
- ⚙️ Excess Vibration still occurred

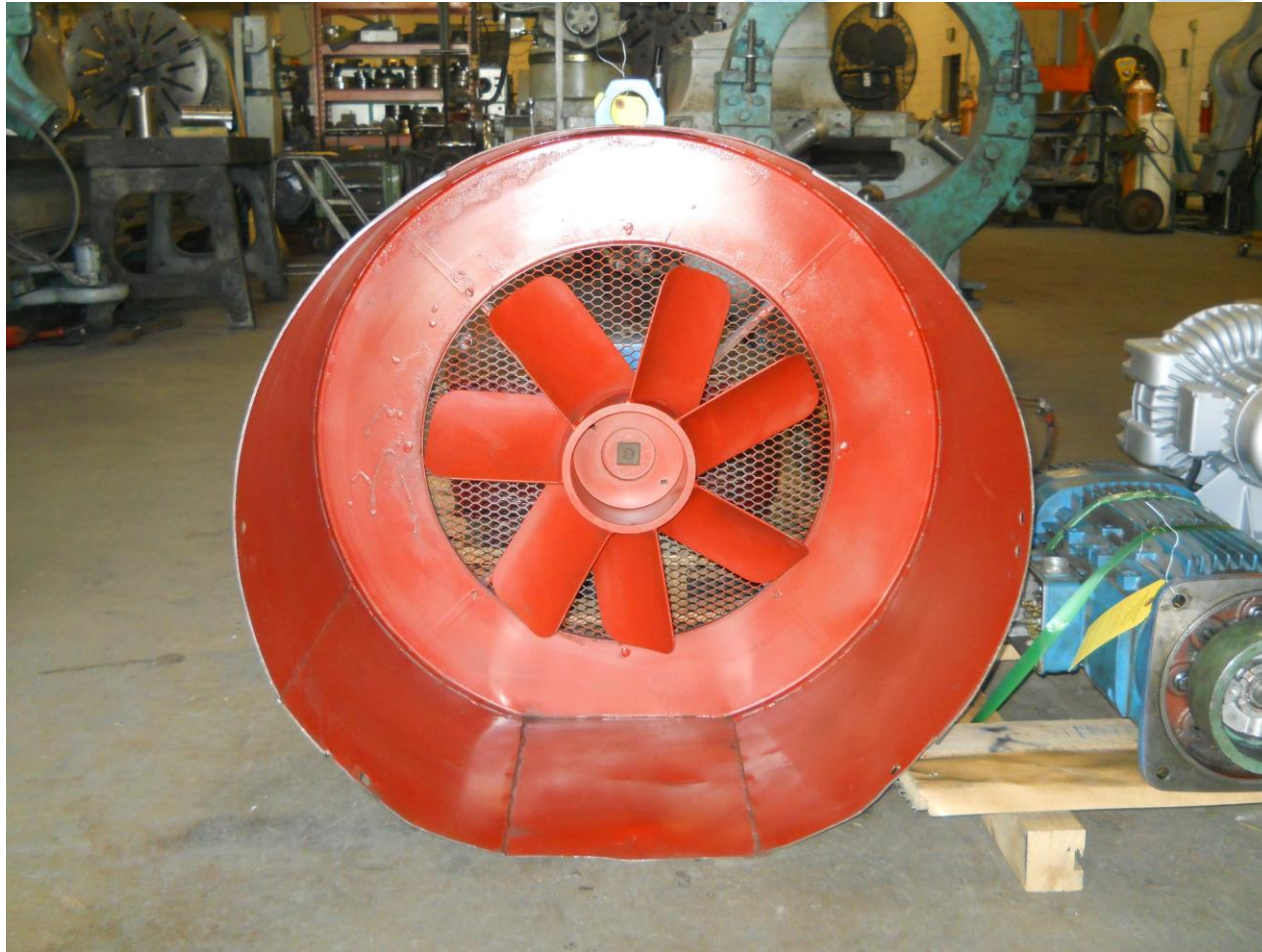


External Blower Motor





Heavy Steel Fan Blade





Broken Supports





Vibration in Sewage Pump

- ⚙️ Once the “Stuff” was cleaned out, the pump ran smoothly.
- ⚙️ No damage to the impeller
- ⚙️ No problems in bearings
- ⚙️ No seal leakage





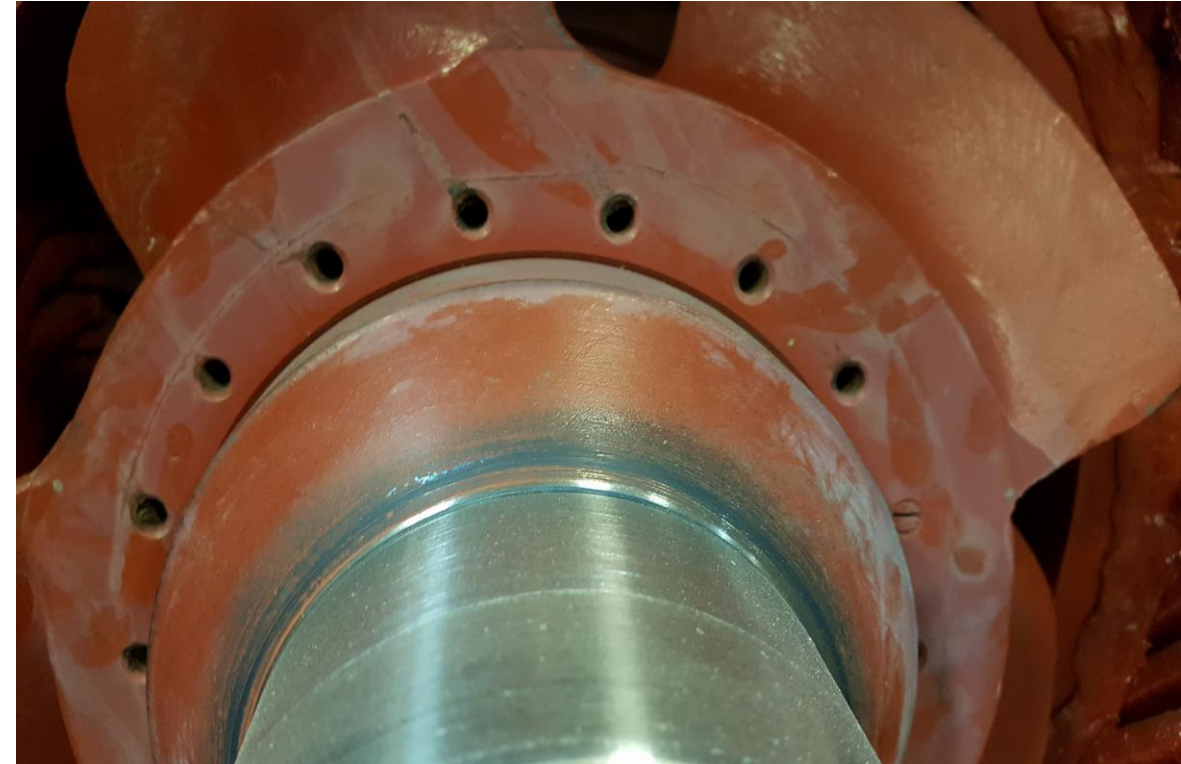
Balance Weights Must Be Applied Securely

- ⚙️ Epoxy balance compound relies on adhesion /support
- ⚙️ Sometimes mixed with lead shot to increase weight
- ⚙️ Welds on weights can crack
- ⚙️ Balancing rings provide many angular positions
- ⚙️ Weights on fan blades ? Stress, air flow, appearance?



Balance Weights Can Come Off

Photo of balance ring on rotor –
not available





Our Five Senses Are Very Useful

- ⚙️Hearing – irregular operation
 - ⚙️Touch – vibration and heat
 - ⚙️Smell – insulation or hot grease
 - ⚙️Taste – digestive safety
 - ⚙️Sight – observation of normal and abnormal situations
- ⚙️SAFE OPERATION ?
 - ⚙️Ear Muffs - Plugs
 - ⚙️Gloves – Many types available
 - ⚙️Masks – dust and gas control
 - ⚙️Safety Glasses with Side Panels
 - ⚙️Arc Flash Protection Clothing



Protective Gear





Heat Sensing Can Also Be Useful

Nov 15th 7pm Minutes
Meet's Chart unit's
Nov 28

How Augmented Reality Is Changing the Way We Work

AR devices can assist in a number of ways BY AMANDA DAVIS

INDUSTRY IS A test bed for AR's capabilities. Workers on construction sites, in water treatment plants, and elsewhere are trying smart helmets and headsets that can display step-by-step instructions to help fix faulty machinery. And they can communicate and share what they're looking at with colleagues, even if they're hundreds of kilometers apart. These are just some of the benefits of AR. Examples like the DAQRI Smart Helmet (DSH) [photo, center] and the Microsoft HoloLens headset [bottom].

DSH-FREE can be awkward to repair or recalibrate a piece of complicated machinery while holding onto an operator's manual to read instructions. AR helmets from DAQRI will overlay the instructions on the machinery, freeing the worker's hands. "This reduces the time it takes to complete a task and cut down on errors," says Paul Sweeney.

Also, thermal cameras in the DSH can visualize for the wearer the temperature of the surrounding area. That view can help predict equipment failures before they happen because, notes Sweeney, many machines "run hot" before they break.

Seventy Emerson vice president Hannifield He the hel

VIRTU Micros make in two to see hologery, a front

It this cour the i an e com is e AR:



minutes before they happen because, notes Sweeney, many machines "run hot" before they break.

company based in Boston. The group is exploring possible applications for AR and VR devices for its customers.



The DAQRI Smart Helmet [top] projects instructions on machinery to let people work hands-free. The Microsoft HoloLens [bottom] projects images in front of the wearer and allows workers to collaborate with each other in the form of avatars.

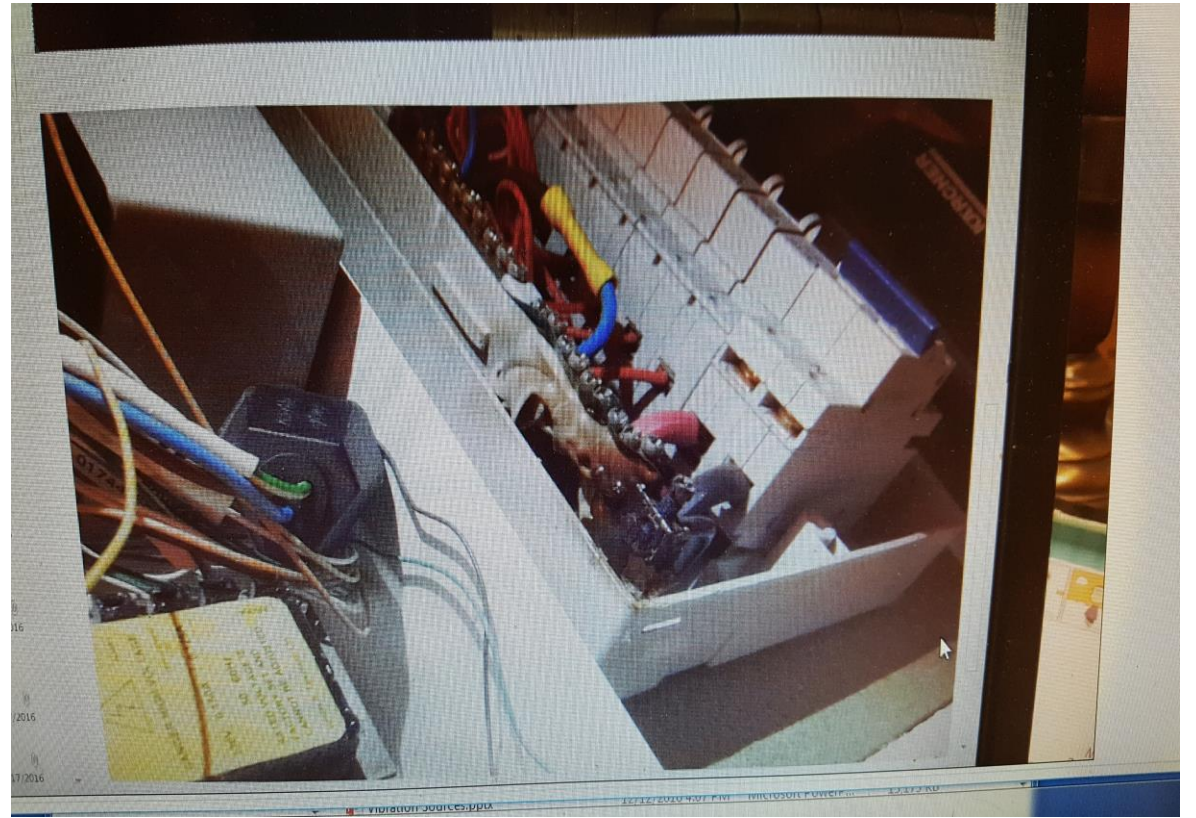


Intermittent Connections

- ⚙️ Disconnect, fuse block
- ⚙️ Wiring to starter / vfd or scr drive
- ⚙️ Breaks or grounds in conduit
- ⚙️ Poor connections in terminal box
- ⚙️ Vibration loosened winding connections
- ⚙️ Bad solder joints / lugs not crimped tight



Smell is Useful





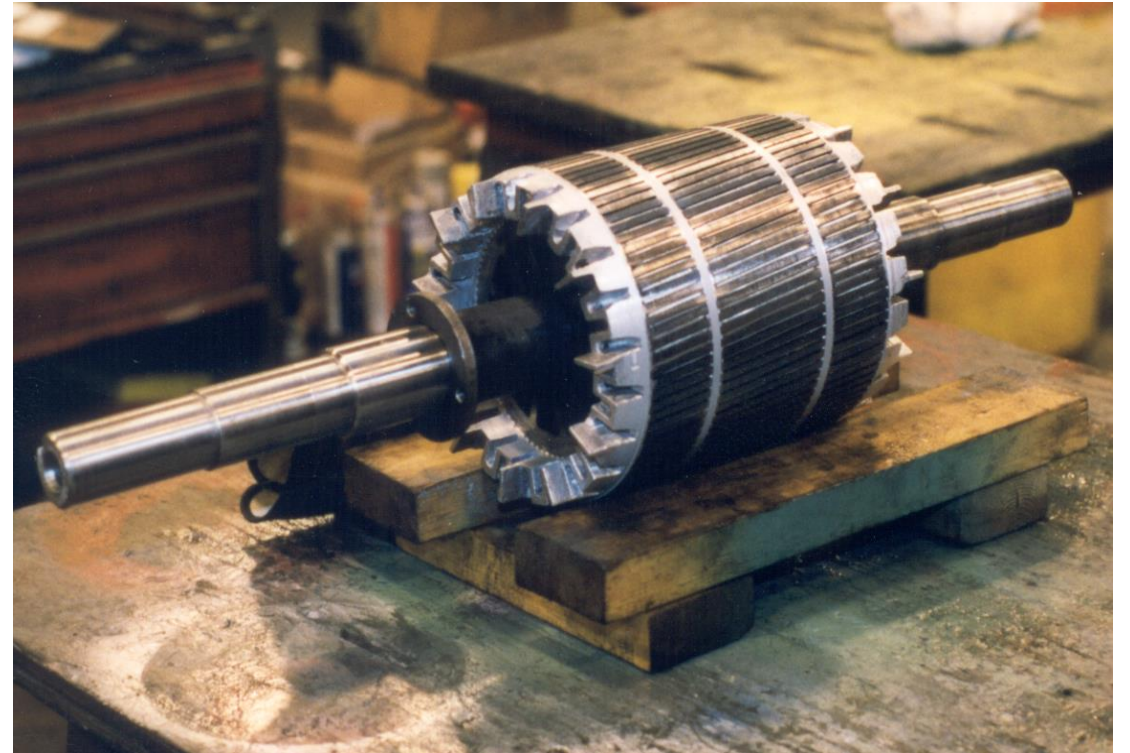
Hearing Is Useful





Rotor Problems

- ⚙️ Difficult to diagnose
- ⚙️ Construction varies
- ⚙️ Subject to extreme heat on start
- ⚙️ Slot has to be large enough to allow bars to be inserted
- ⚙️ Steel coefficient of expansion differs from those of copper and aluminum





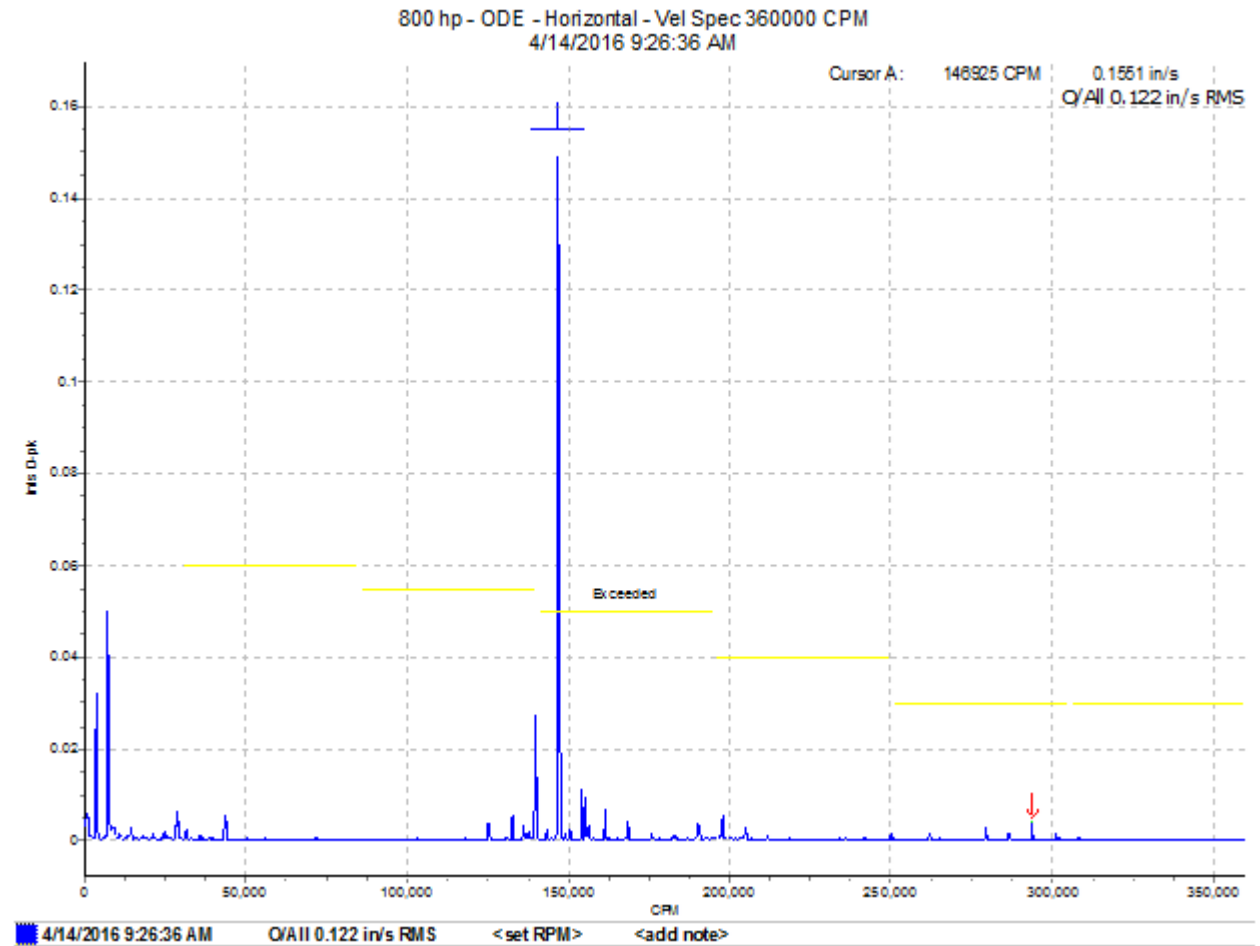
Questionable Rotor for Compressor





High Frequency Vibration in Motor

Here is the Vibration data taken on the Charlotte Pipe with loose rotor bars.



$$146925/3583 = 41 \text{ bars}$$

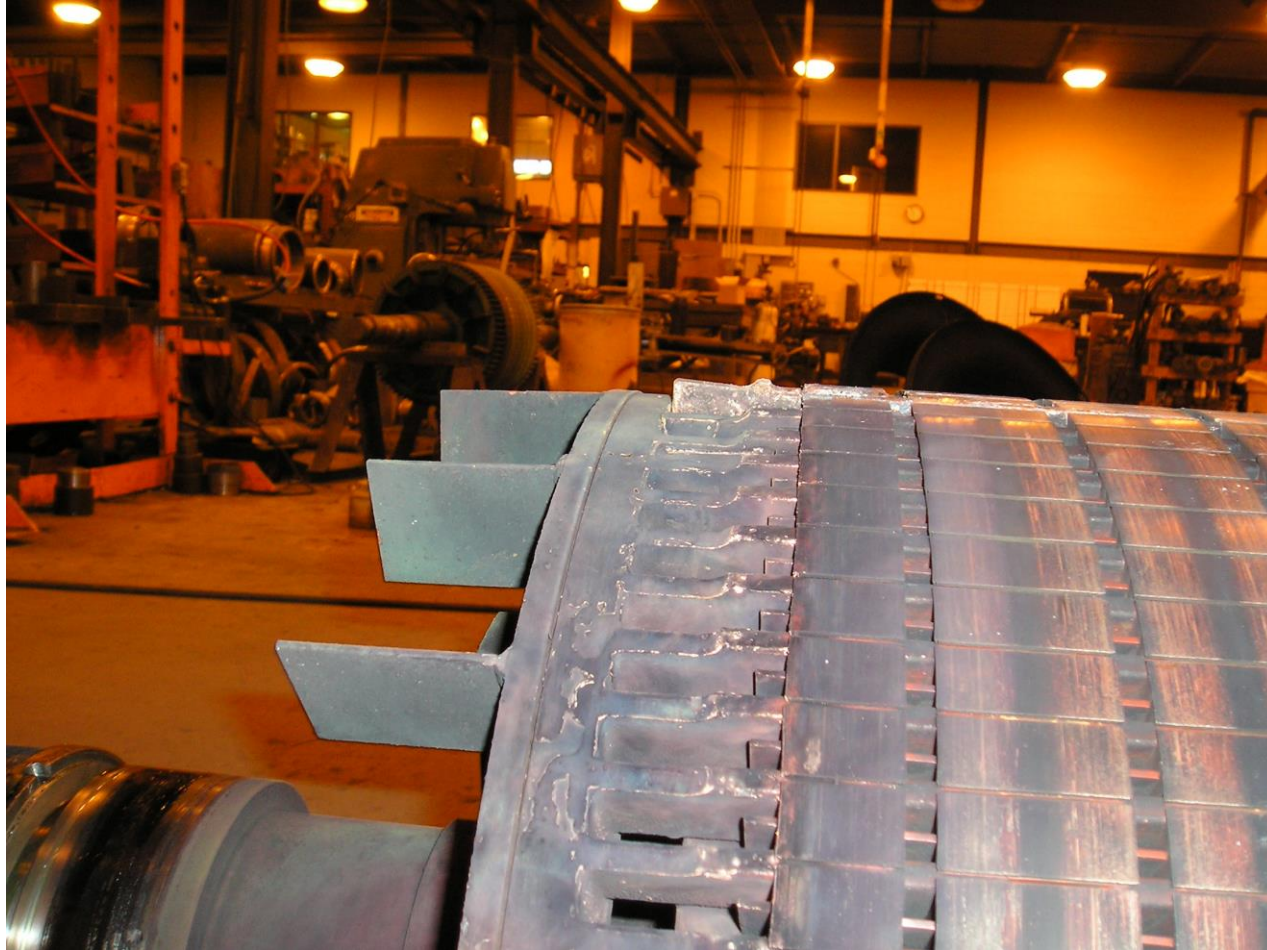


Rotor Bars Have Varied Shapes



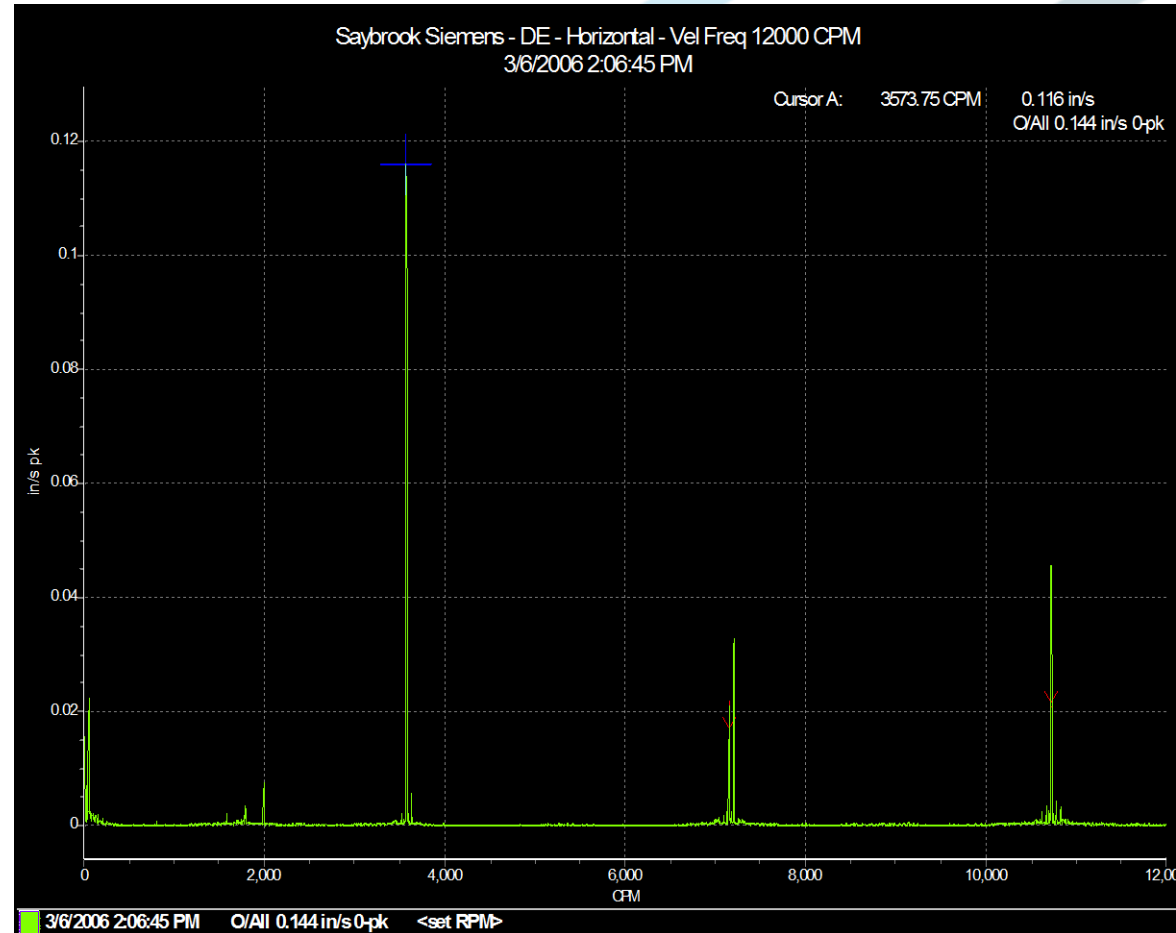


Broken Rotor Bars





1250 HP Compressor Motor



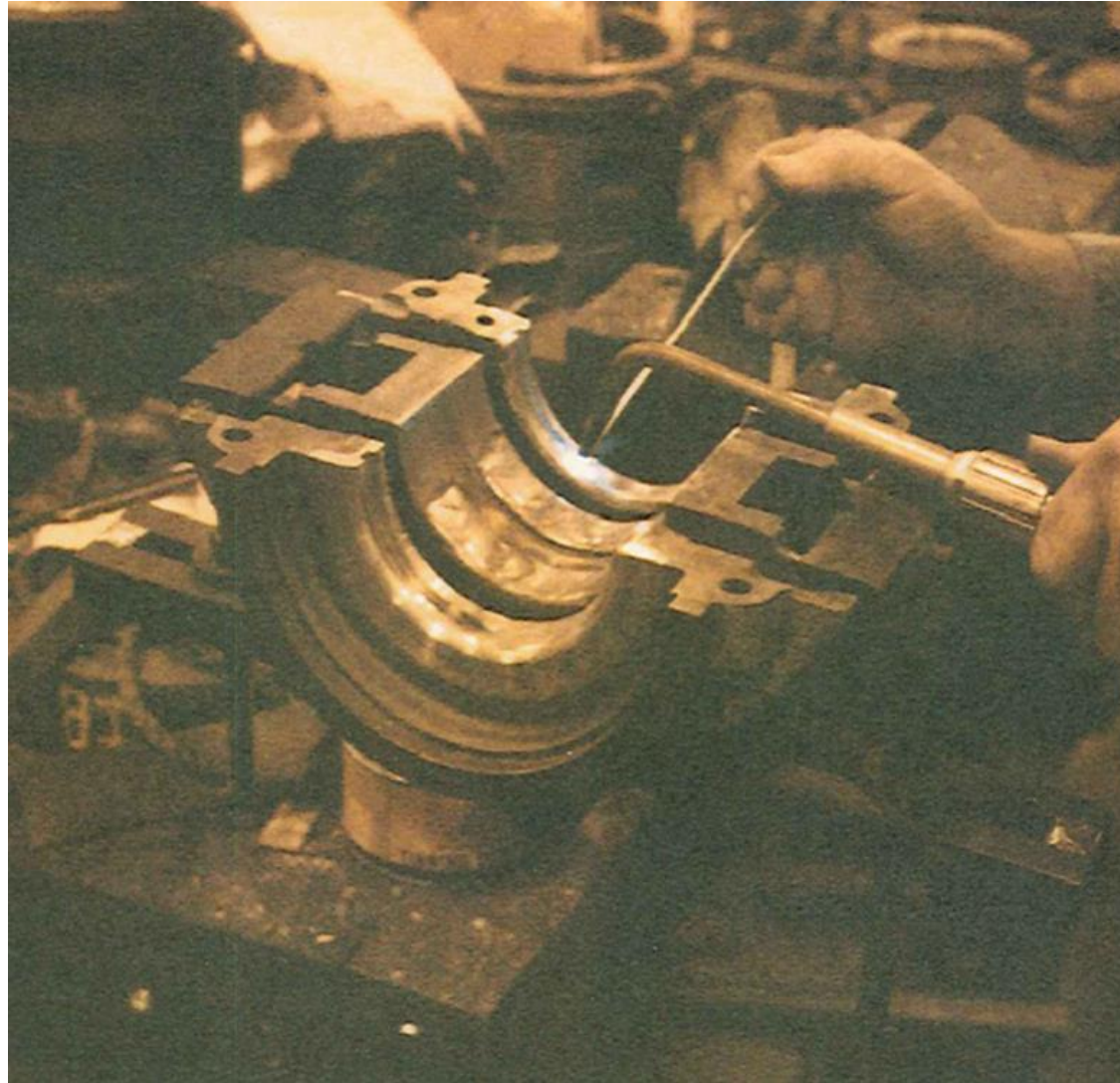


Bearings Have An Impossible Job . . . They Cannot Last Forever

- ⚙ Sleeve Bearings properly lubricated and kept clean have very long lives and can be repaired
- ⚙ Ball and roller bearings have a finite life
- ⚙ Proper application and loading are essential
- ⚙ Lubrication is a major factor in bearing life



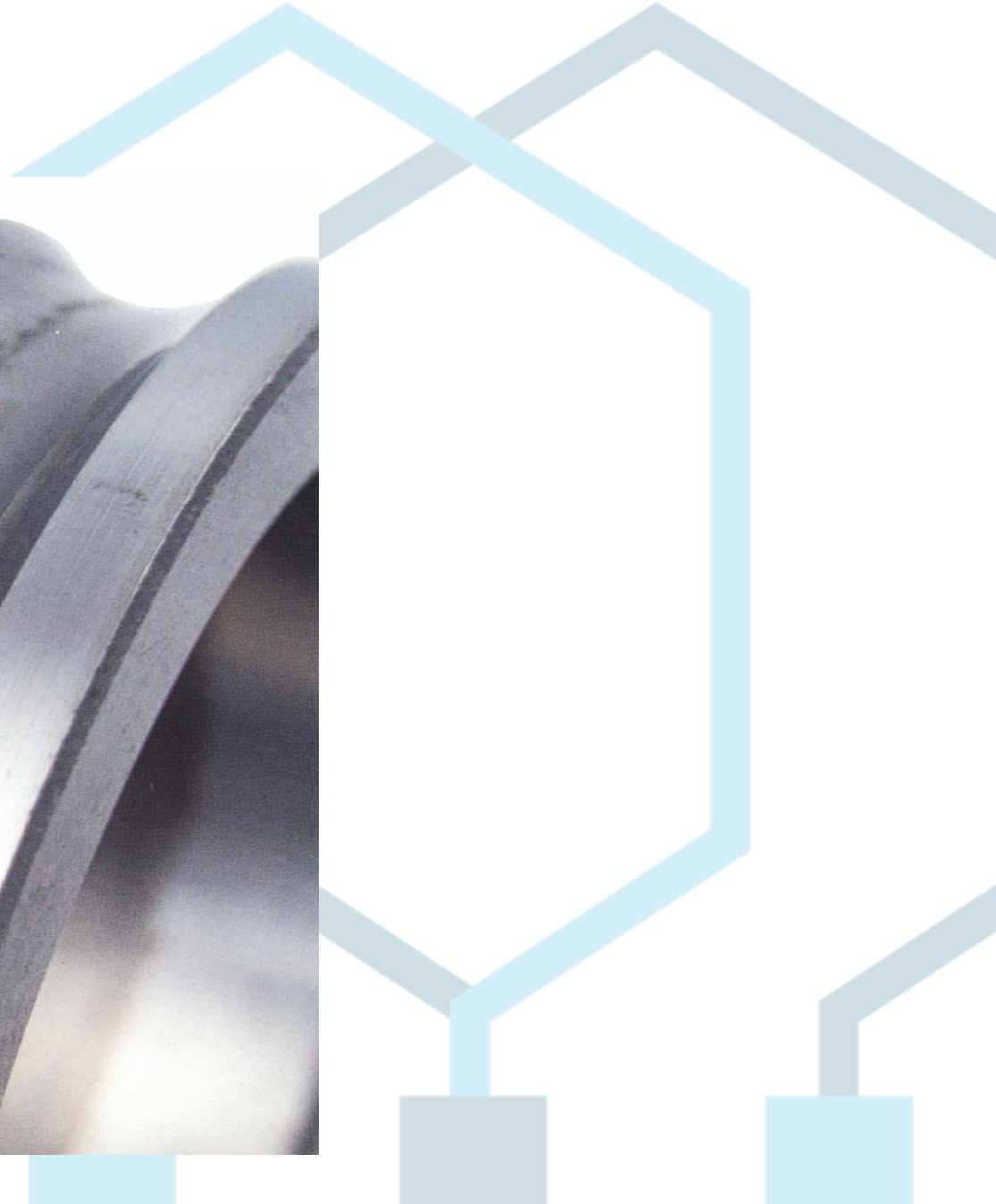
Eccentricity – Bearing





Roughness In Bearing

Careful handling and installation practices can minimize or eliminate true brinelling problems.





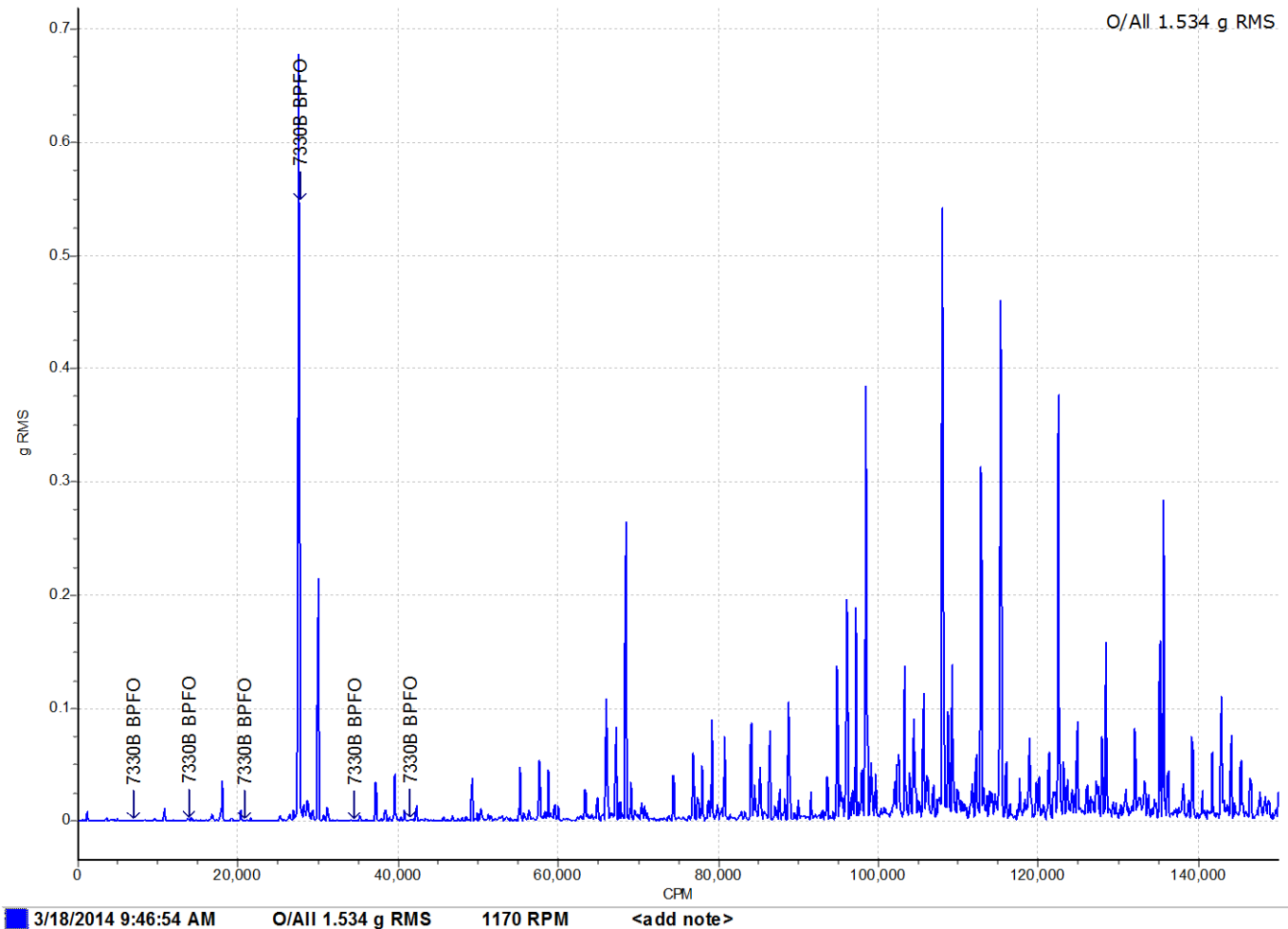
Water Pump Thrust Bearing Failure – Inner Race





Thrust Bearing Inner Race Spectrum

Motor test 2014 - ODE - Vertical - Acc Spec 150000 CPM
3/18/2014 9:46:54 AM





Bearing Failure – Outer Race

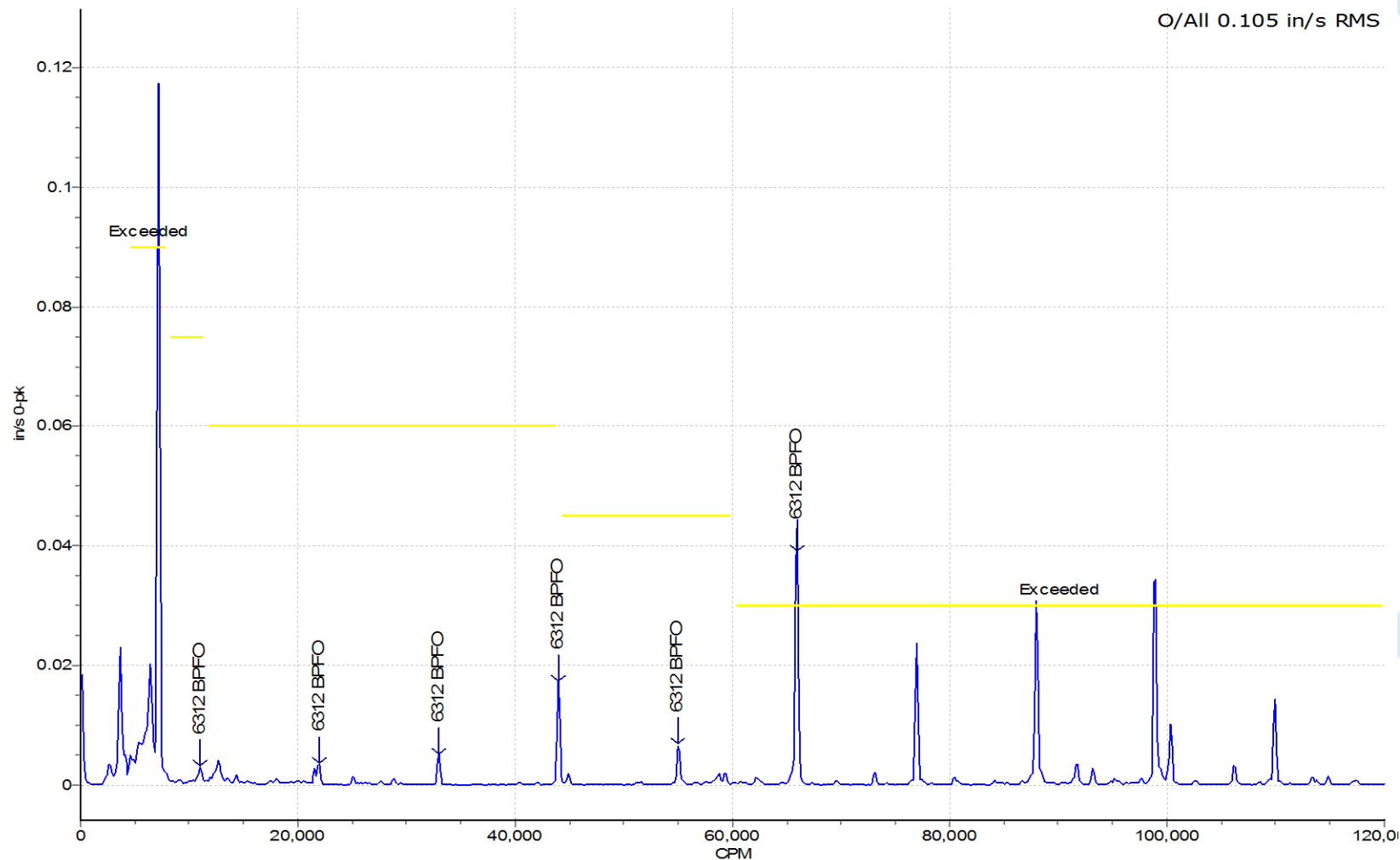




Outer Race Spectrum

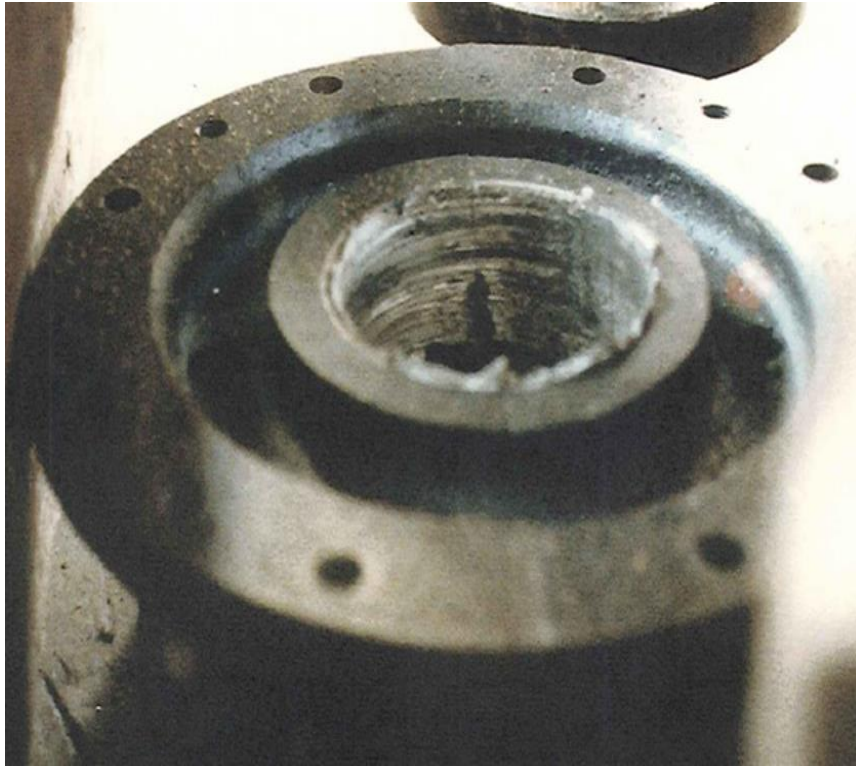
2-pole - DE - Horizontal - Vel Spec 120000 CPM
2/16/2015 11:50:43 AM

O/All 0.105 in/s RMS





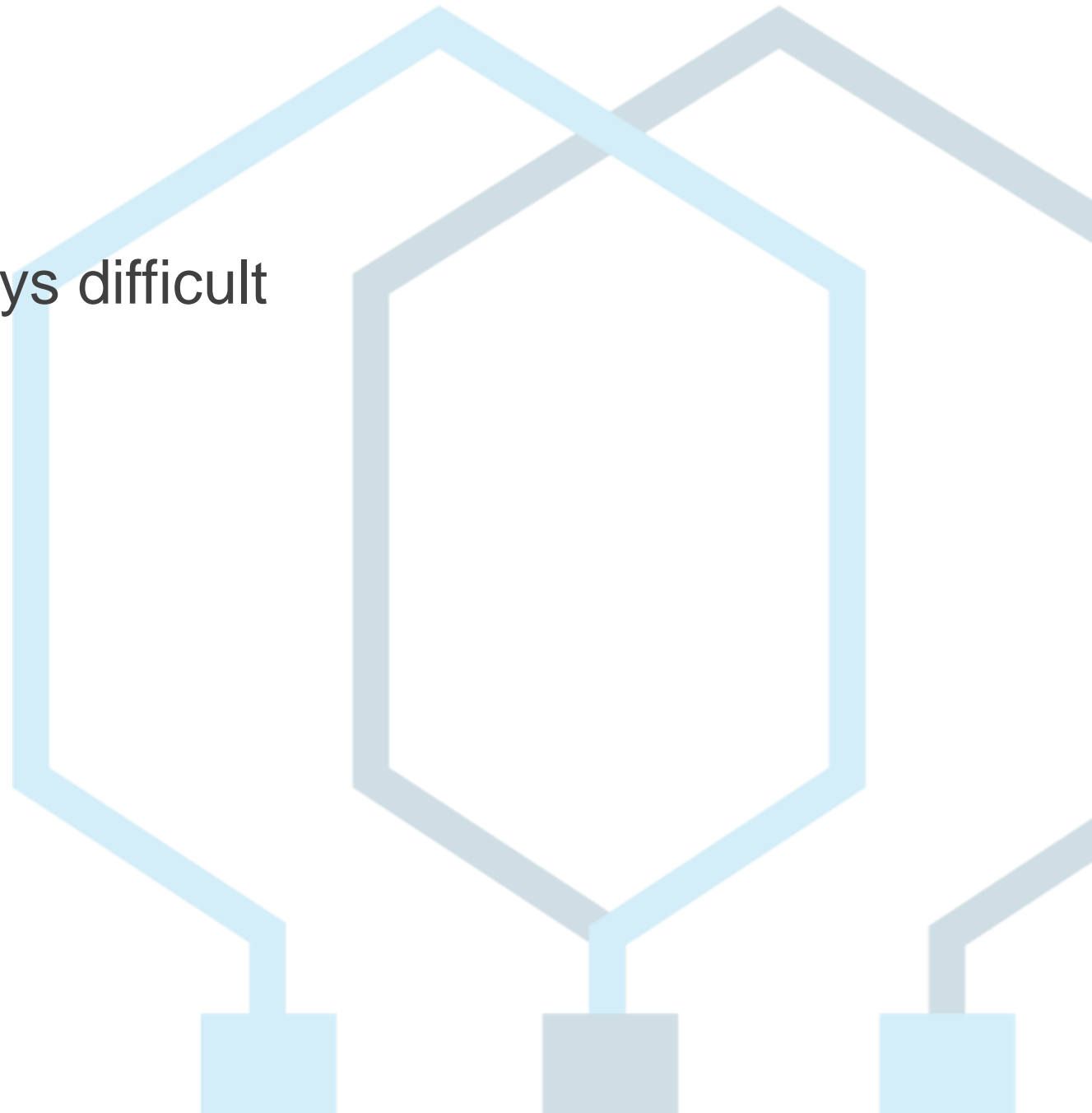
Rubbing - Bearing





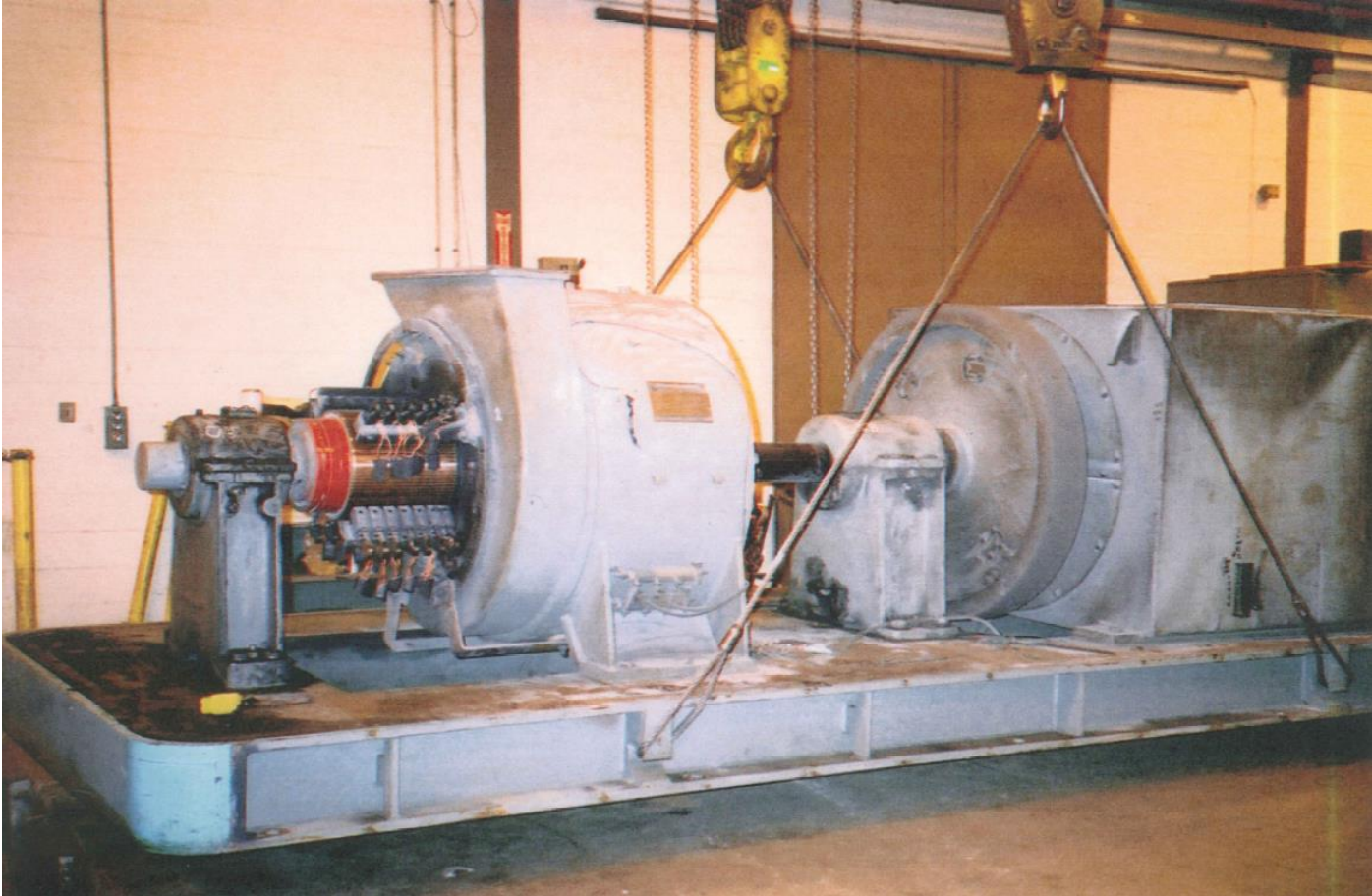
Alignment Is Important

Three bearing units are always difficult



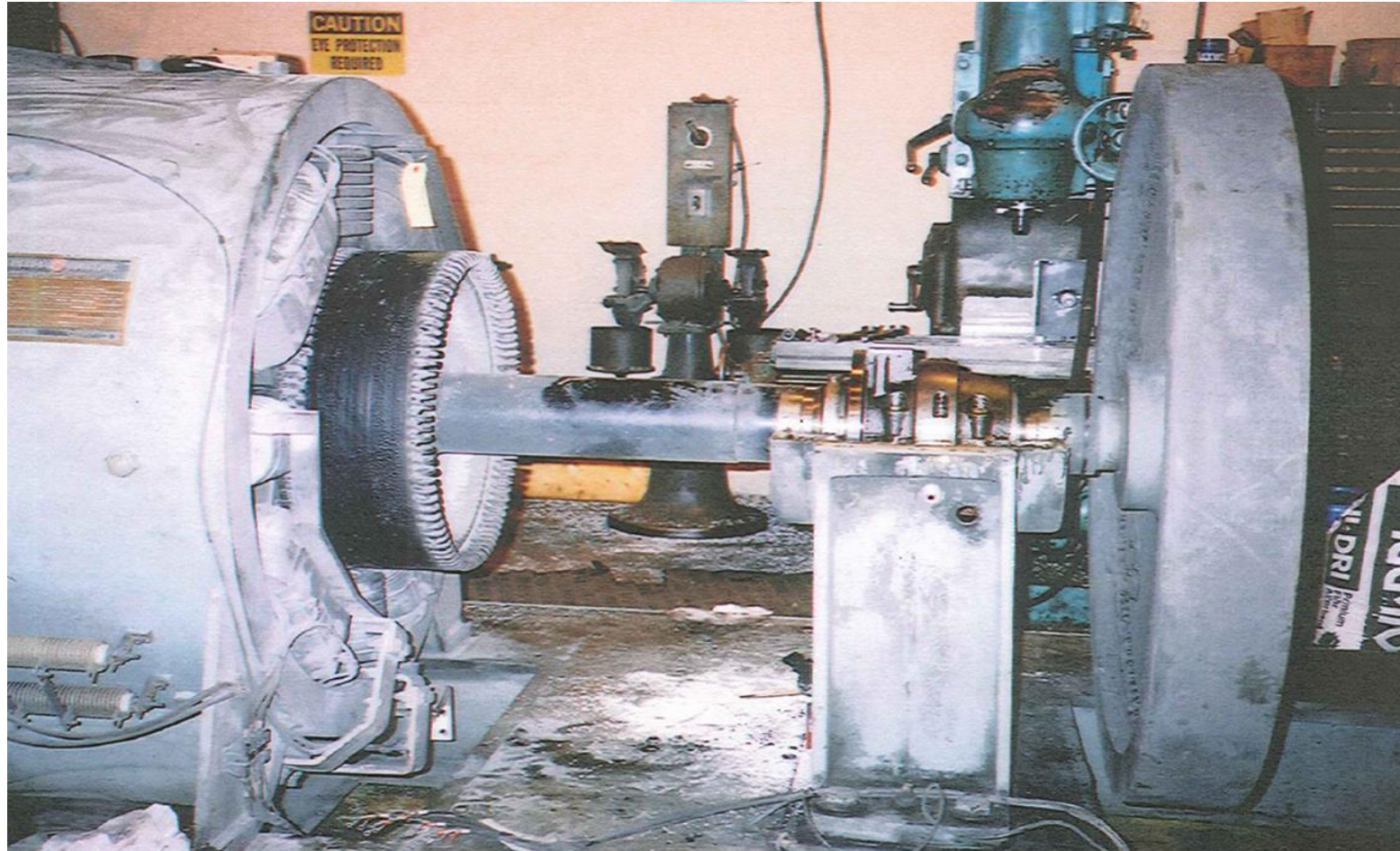


Misalignment





Amplifier Effects – Looseness – Pedestal





Warped Frame

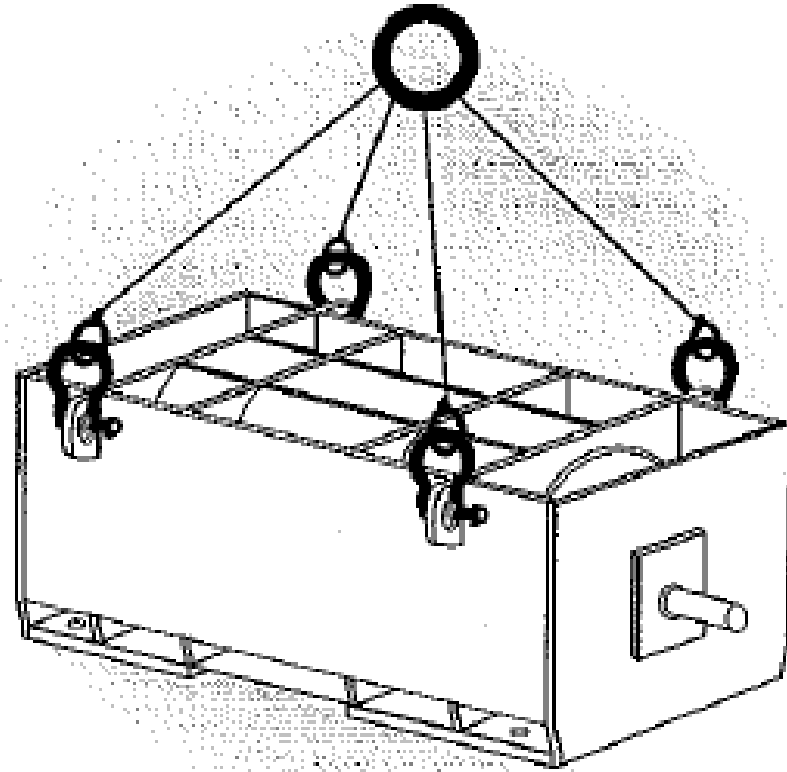
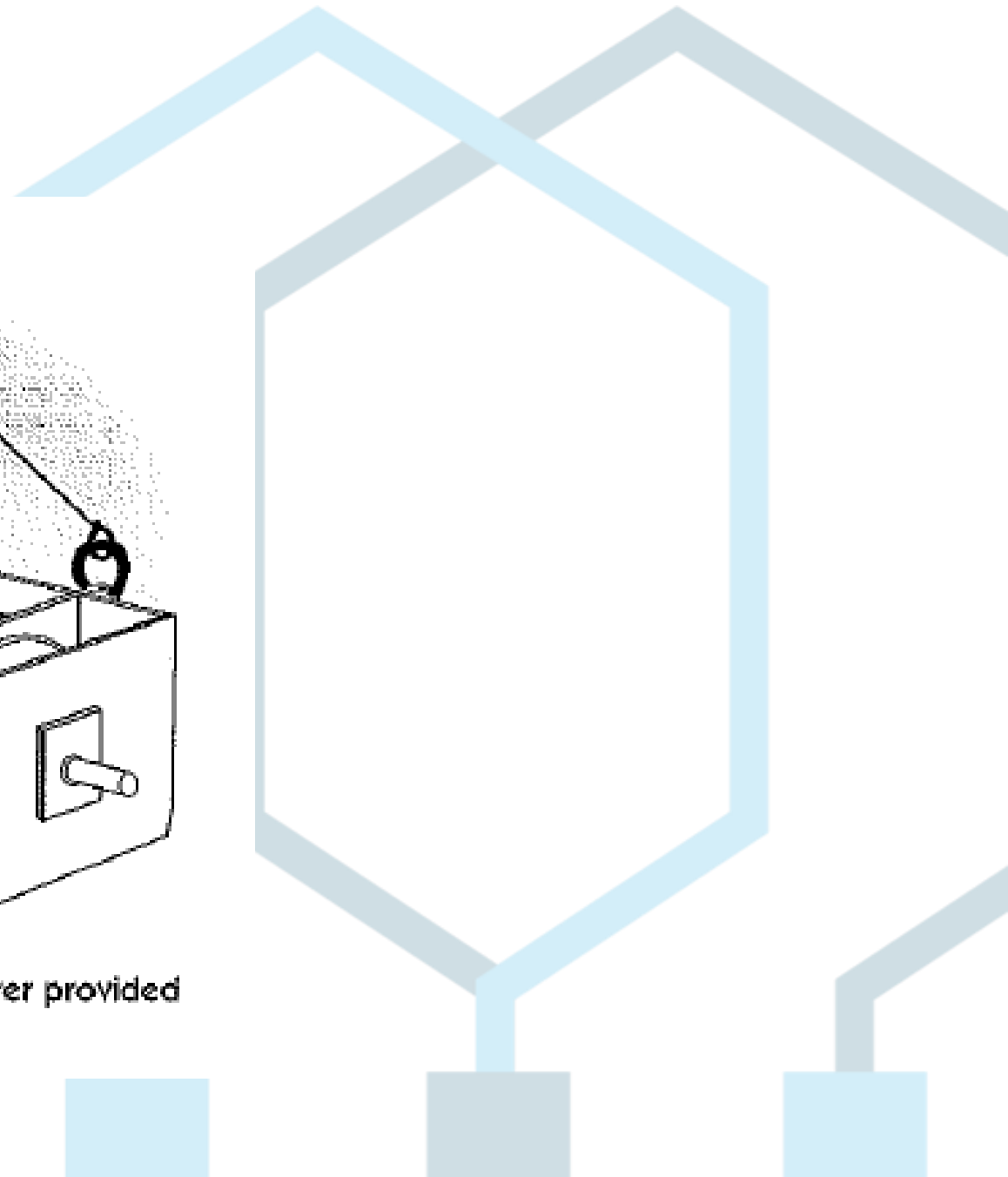


Figure 1. Always use the manufacturer provided lifting points.





Amplifier Effects – Soft Foot





As Received, 125 hp, 1750 rpm Compressor Motor

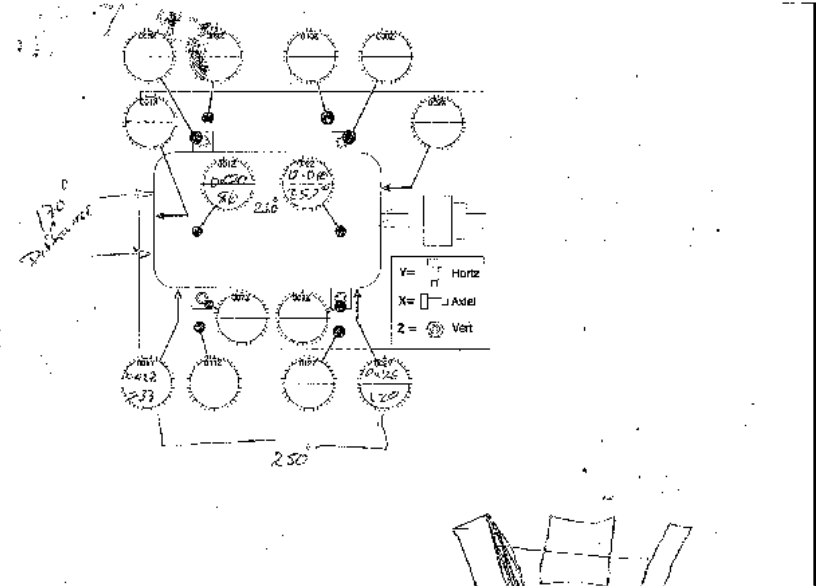




Error in Machining the End Brackets

- Motor received with both end brackets oversize and one journal undersize.
- Repairs made, but DE end bracket slipped in the lathe and was bored cocked, 0.004 inch.
- Vibration levels OK (0.02 in/sec), but Roller bearing was noisy.
- ODE readings out 170 degrees.

811022 125 hp 1800 rpm - Compressor Motor

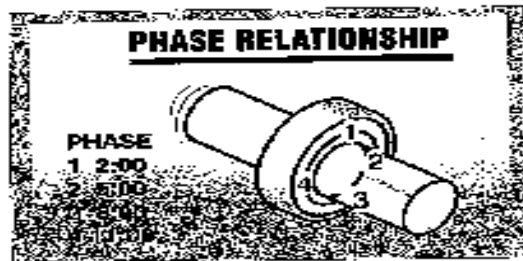
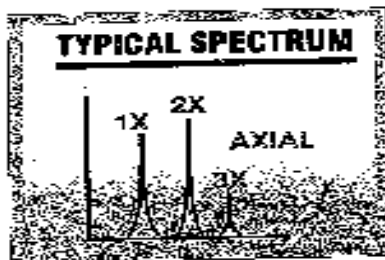


COCKED



Cocked End Bell(s)

MISALIGNMENT MISALIGNED BEARING COCKED ON SHAFT



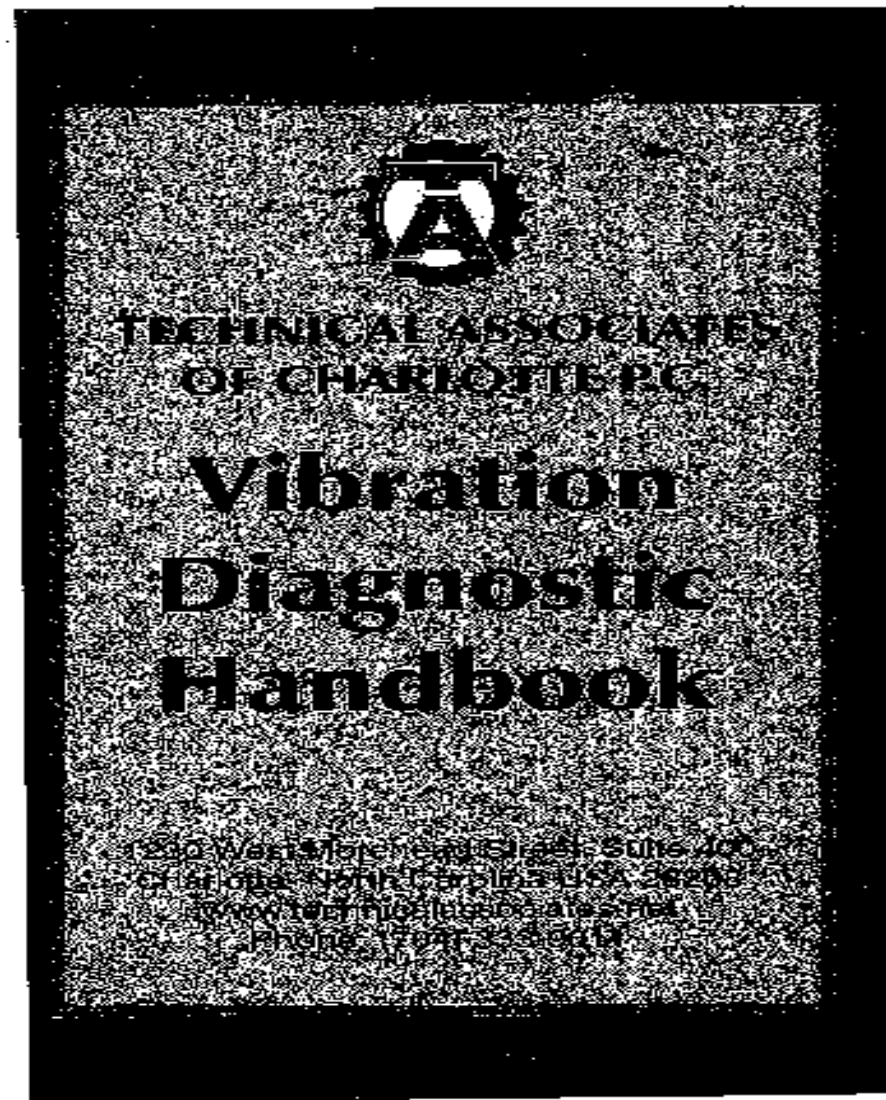
Cocked Bearing will generate considerable axial vibration. Will cause Twisting Motion with approximately 180° phase shift top to bottom and/or side to side as measured in axial direction of same bearing housing. Attempts to align coupling or balance the rotor will not alleviate problem. Bearing must be removed and correctly installed.

Mechanical
Looseness

Rolling
Element
Bearings

Resonance

Rotor Rub





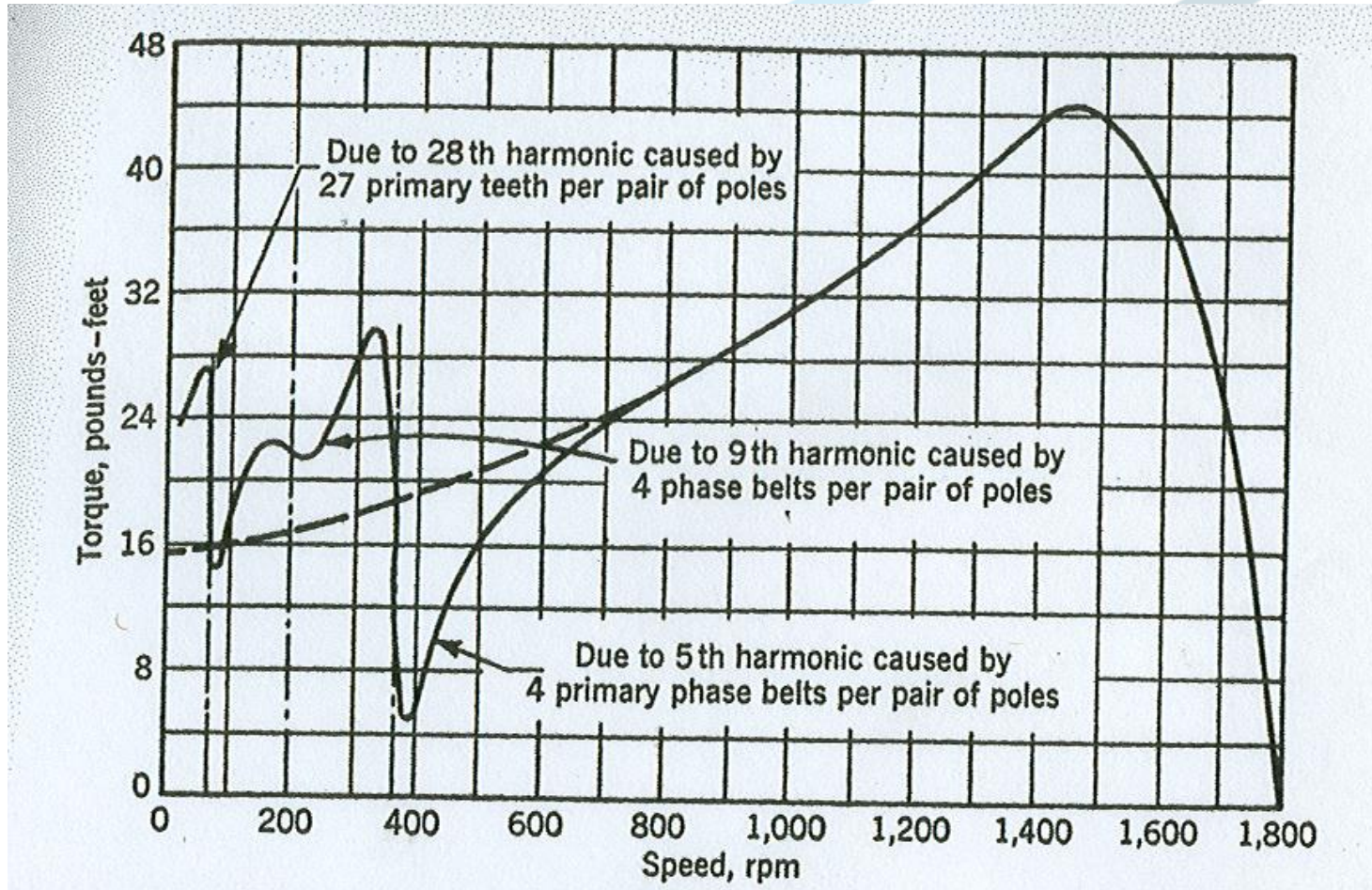
Resonance Will Occur

- ⚙️ All systems will have some degree of imbalance
- ⚙️ Operating at a resonant frequency is dangerous.





Harmonics From Motor Or Drive





A Troubled History

- ⚙️ Pump motors manufactured in Brazil
- ⚙️ Moved to Mexico for acceptance testing
- ⚙️ One hit a bridge during road transport
- ⚙️ Installed in water supply pump station
- ⚙️ Excess vibration occurred
- ⚙️ Rotors were balanced
- ⚙️ Reed vibration occurred... strengthening required in motor frame
- ⚙️ Final trim balance was acceptable

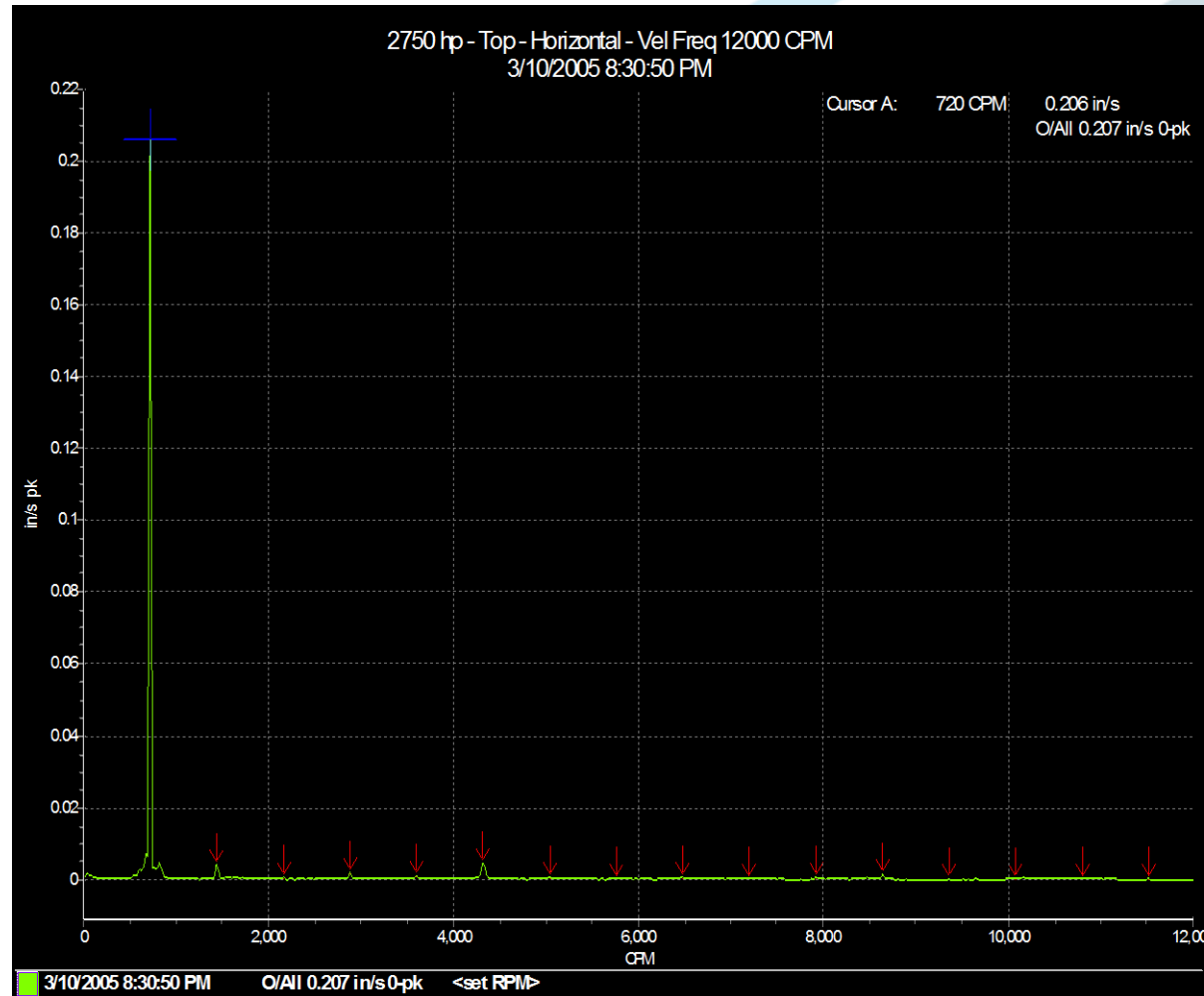


Amplifier Effects - Resonance



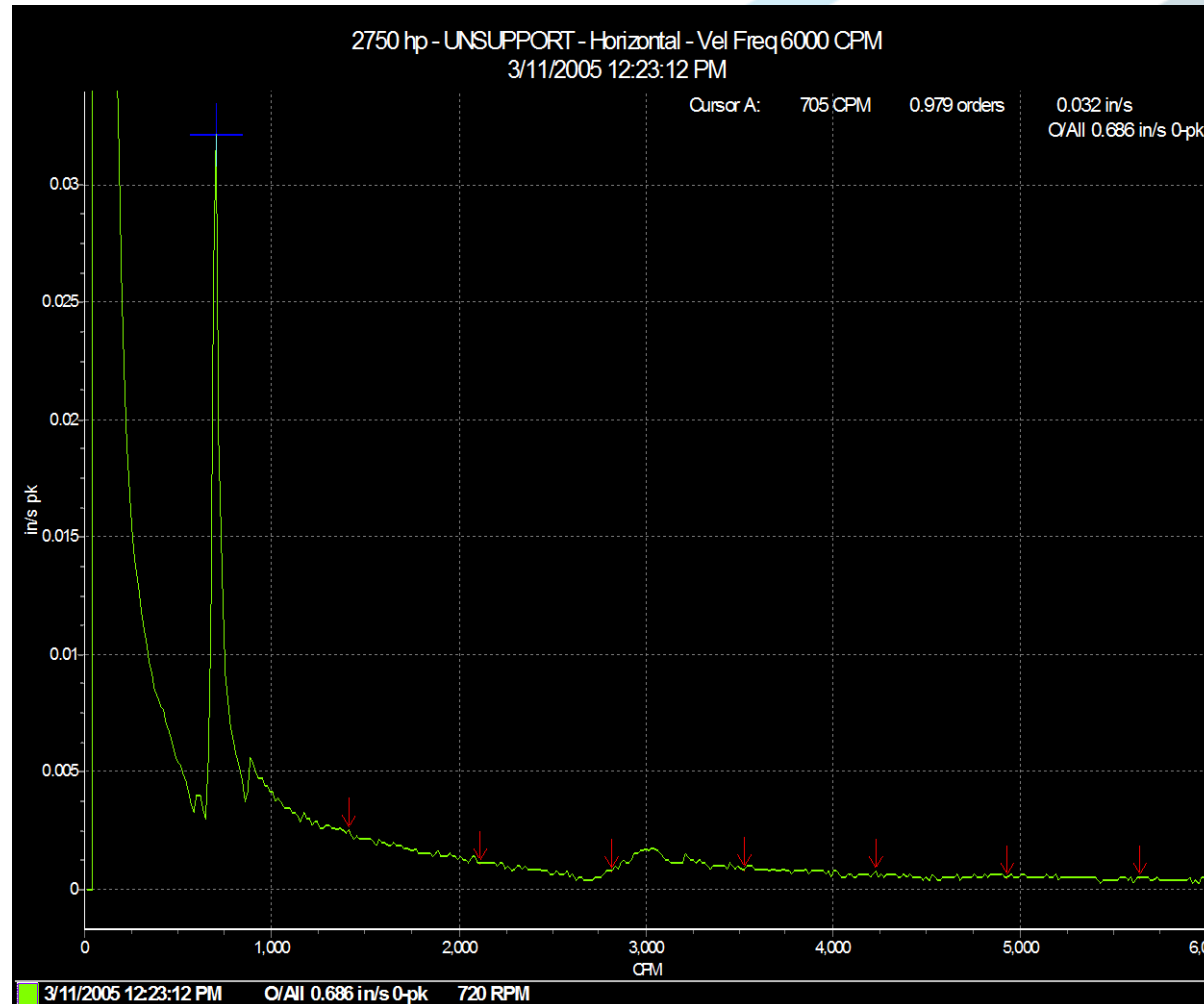


2750 Hp Vertical Pump Motor



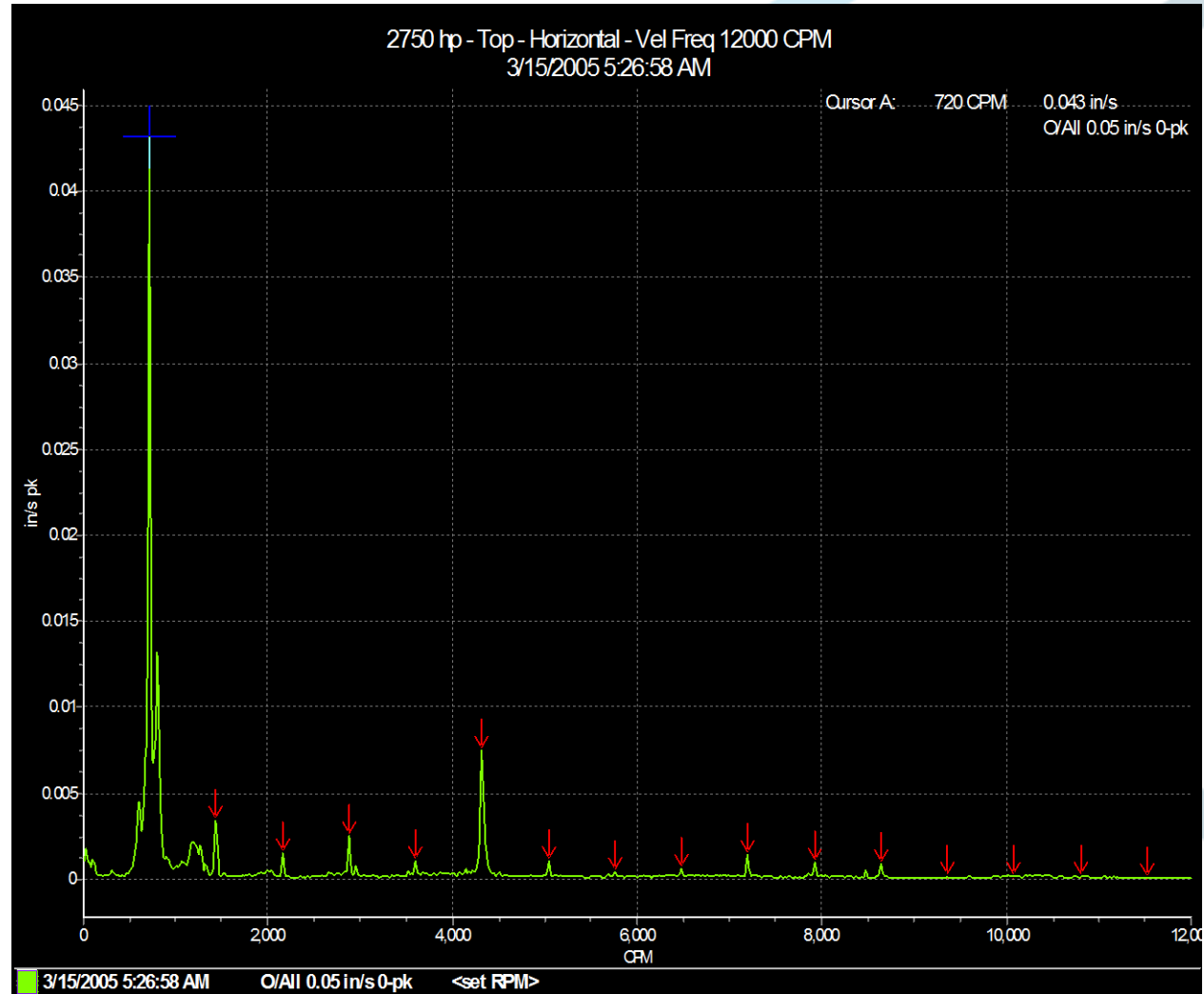


2750 Hp 720 rpm Vertical Pump Motor Bump Test





After Balancing



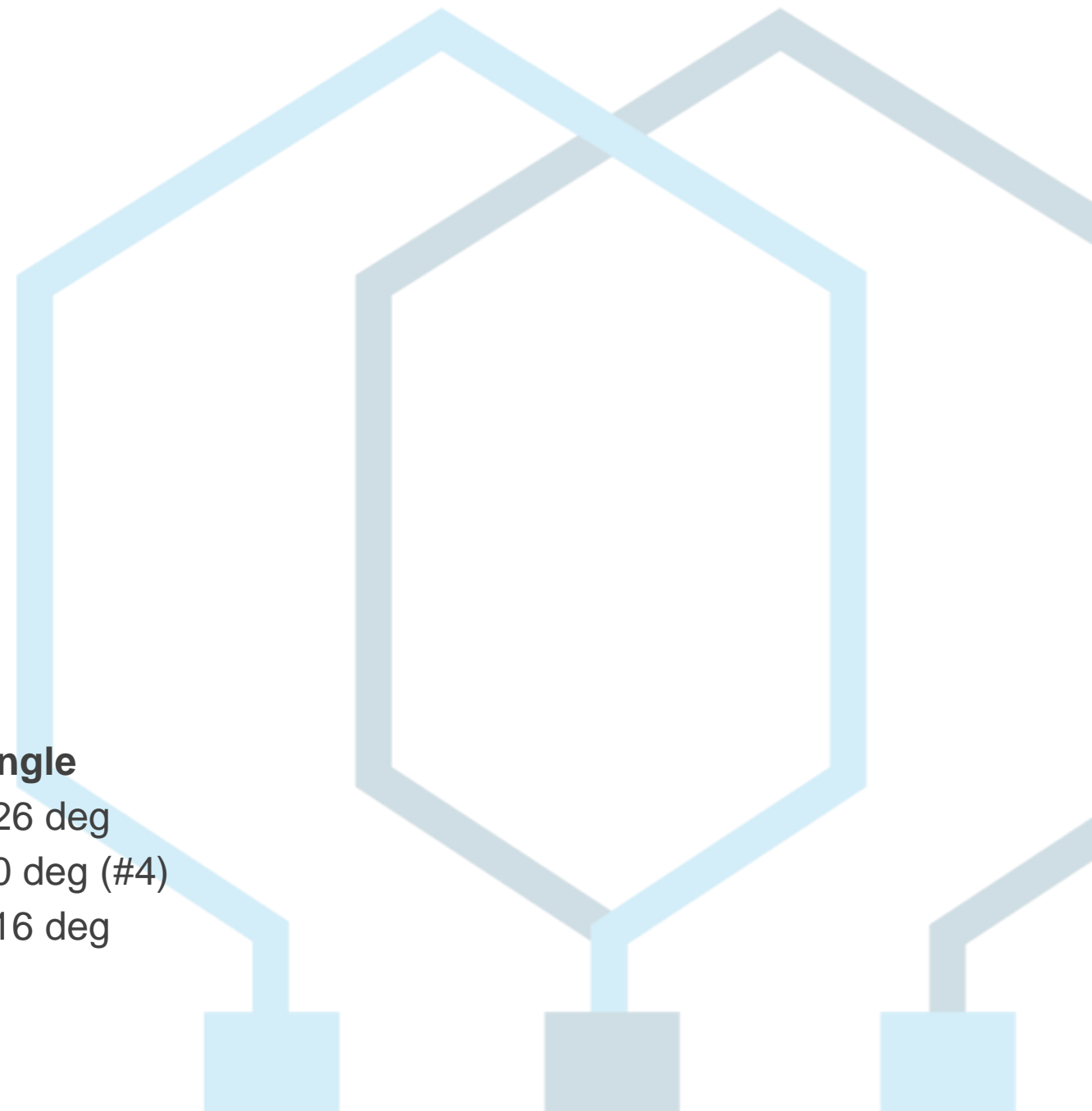


Balancing Report

- Folder: Jenkins Electric
- Machine: 2750 hp
- Date/Time: 3/14/2005 2:36:18 PM
- Machine Speed: 720 RPM / 12.00 Hz

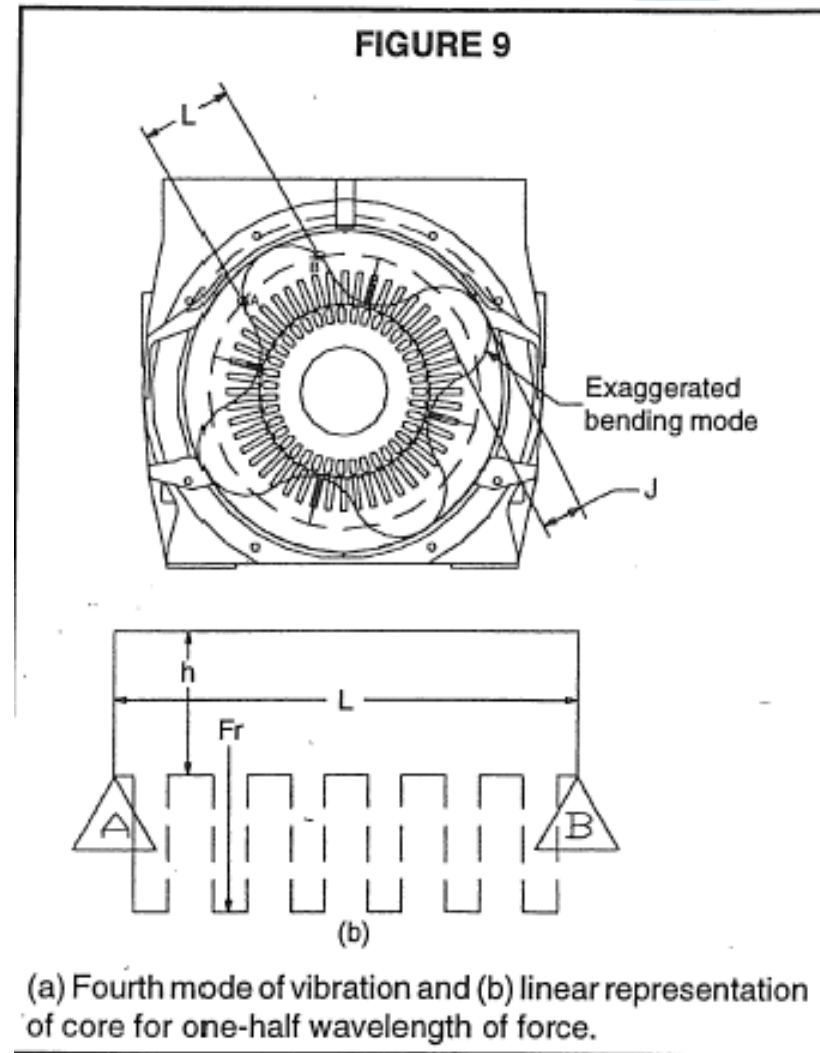
- Single Plane Balance, Velocity (in/s pk)
- Trial Weights Removed
- Weight Locations: 12
- Normal Filter Bandwidth (+/- 150 RPM)

		Magnitude/Mass Angle	
Initial Reading		0.232 in/s pk	326 deg
Trial Reading	Weight	297.6 grams	90 deg (#4)
Reading		0.09 in/s pk	316 deg





Amplifier Effects – Looseness – Stator Core



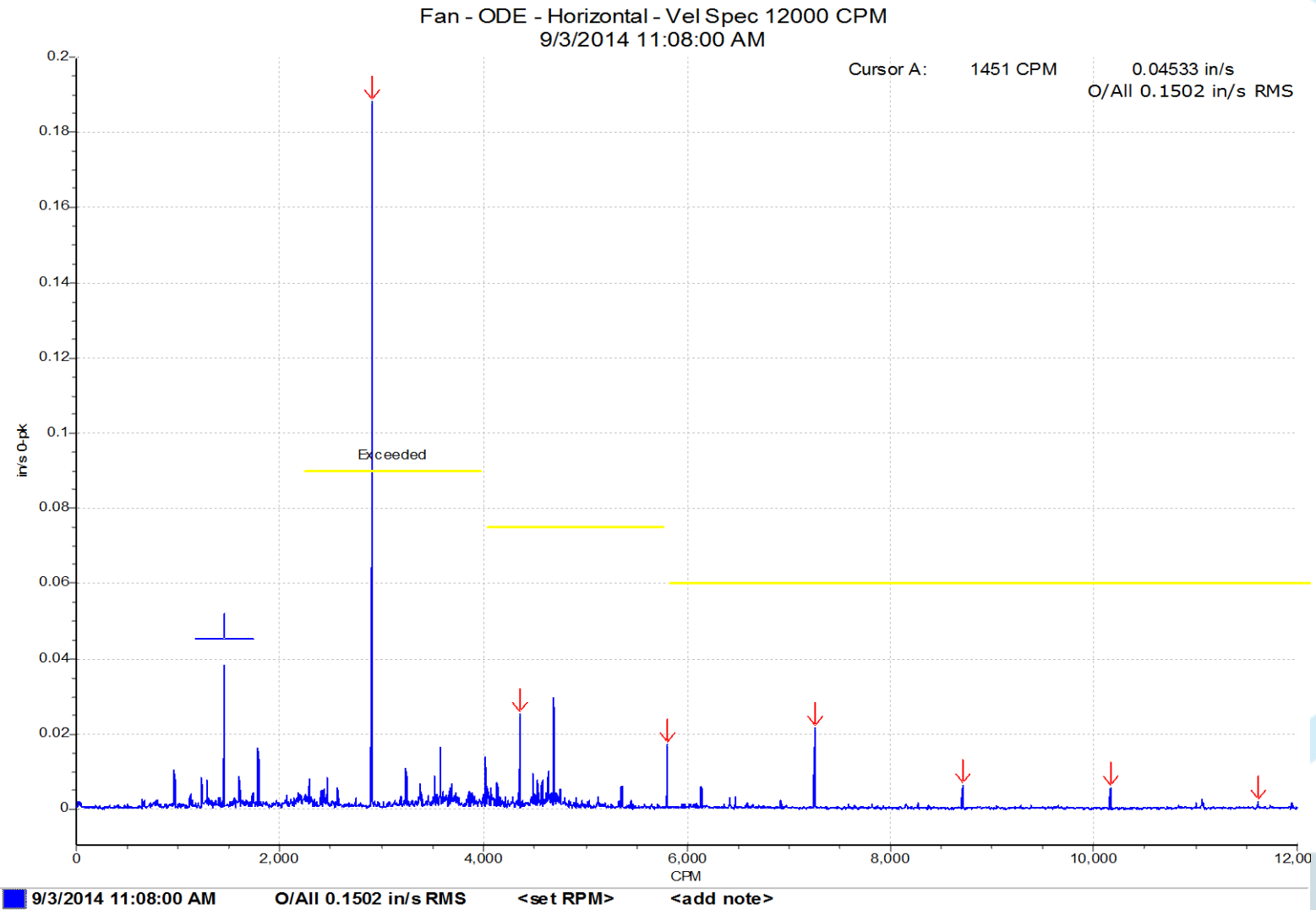


Amplifier Effects – Looseness – Pedestal/ Base





Effect of Loose Base



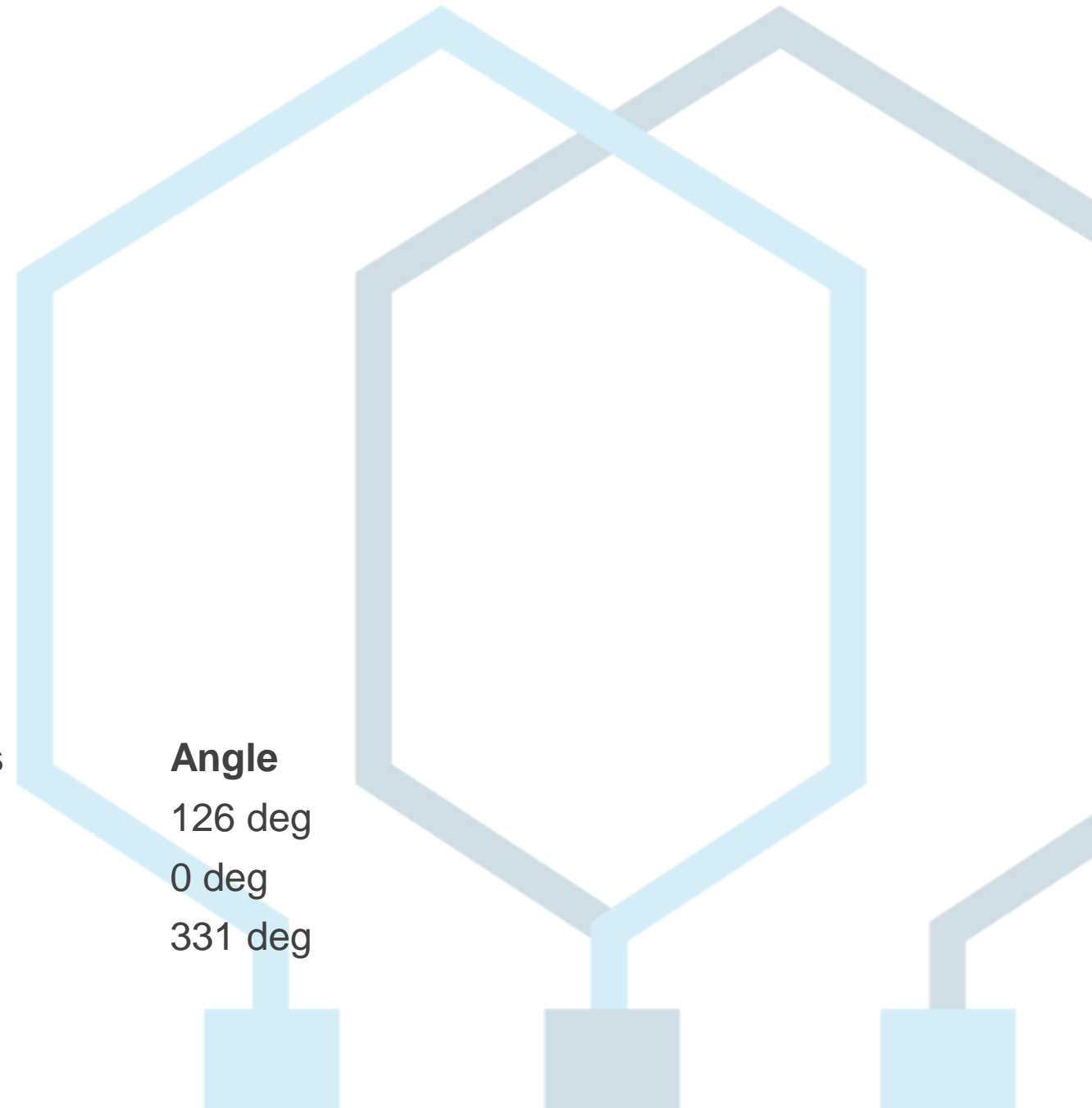


Balancing Report

- Folder: Jenkins Electric
- Machine: Fan
- Date/Time: 9/3/2014 12:43:45 PM
- Machine Speed: 1451 RPM / 24.18 Hz

- Single Plane Balance, Velocity (in/s pk)
- Trial Weights Removed
- Narrow Filter Bandwidth (+/- 15 RPM)

	Magnitude/Mass	Angle
Initial Reading	0.03164 in/s rms	126 deg
Trial Reading Weight	240.0 grams	0 deg
Final Reading	0.01123 in/s rms	331 deg





Some Systems Provide Many “Opportunities”

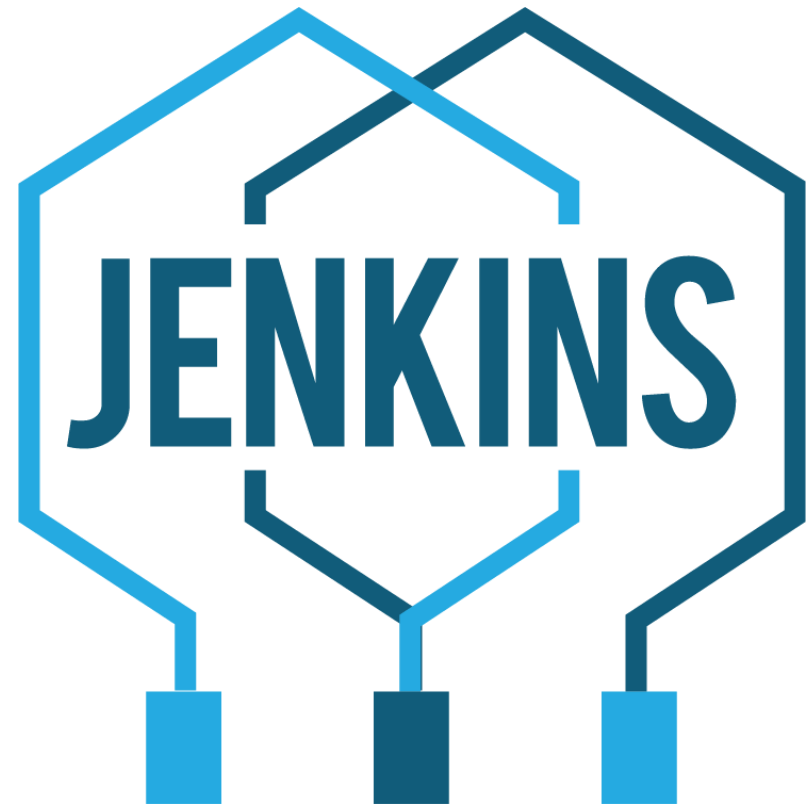
- ⚙️ Large 30 HP blower on shredded paper transport
- ⚙️ Tools, etc may enter the waste stream and impact the blade
- ⚙️ Paper can coat the TEFC motor fan cover
- ⚙️ The system base had many loose bolts
- ⚙️ Some foundation bolts were missing
- ⚙️ All can be fixed and operate satisfactorily, if . . .



Blower Configuration



**Thanks For
Listening**





References

1. William R. Finley, Mark M. Hodowanec, and Warren G. Holter, “An Analytical Approach to Solving Motor Vibration Problems,” EASA Tech Note 40, Electrical Apparatus Service Association, Inc., St. Louis, March 2002, 16 pages.
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3. Richard L. Nailen, Managing Motors, Barks Publication, Inc. Chicago, 1991.
4. S.A. Naser, Handbook of Electric Machines, McGraw Hill, NY, 1987
5. Richard L. Nailen, “Motor installation depends upon foundation design” , Electrical Apparatus, Vol. 67, No. 12, pp.19-25.
6. Amanda Davis, “How Augmented Reality is Changing the Way We Work”, The Institute (IEEE), Vol. 40, No. 4, p. 6.
7. Richard L. Nailen, “Solving the rotor bar dilemma,” Electrical Apparatus, Vol. 70, No. 1, pp. 25 – 30.