Predictive and Proactive Maintenance • Getting the Most Out of Your Budget

HACC

Harrisburg, PA
(Fan and Pump Diagnostics Report)

8/10/2005

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Harrisburg Branch

• Vibration Analysis • Motor Current • Refrigerant Analysis • Oil Analysis • Eddy Current •

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I. ANALYSIS BACKGROUND

The vibration measurements were collected on the machine casing at bearing locations in a vertical, horizontal, and axial direction using an accelerometer and vibration data collector. The vibration levels were compared to the JCI Machine Database vibration severity levels. The vibration severity levels are based on the vibration characteristics of machines with similar mechanical configurations from the JCI Machine Database and on ISO Standard 10816. The vibration levels were compared to previous measurements to establish the trend and determine the final severity.

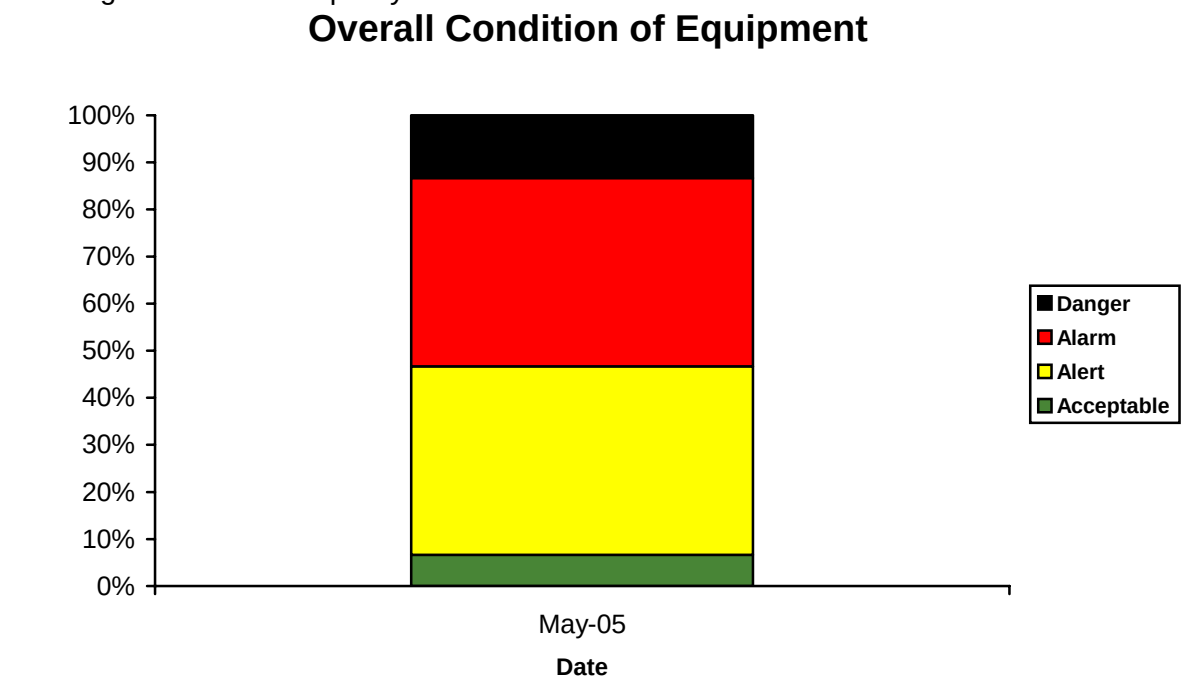
CONDITION DEFINITIONS

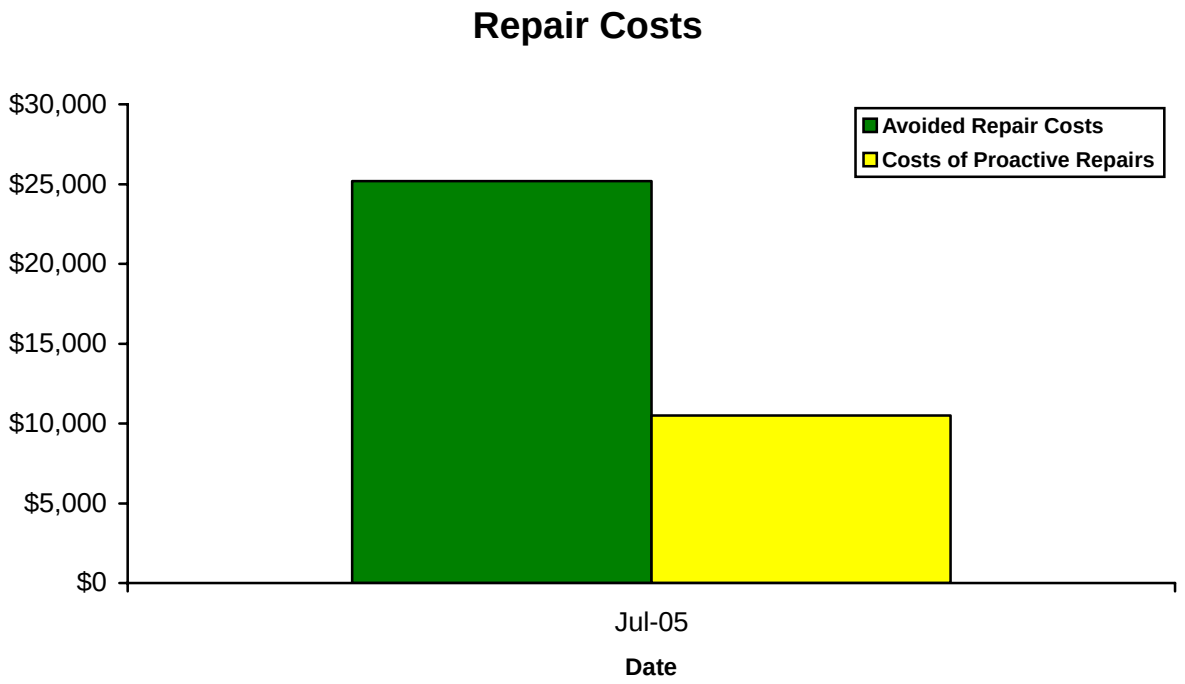
Condition Level	Vibration Analysis Indicates	Action
Acceptable	Little or no deterioration in equipment condition.	There is no cause for concern. Note for future analysis.
ALERT	Developing problems.	Monitor the vibration levels more frequently to establish a trend and to determine if repairs should be made during next shutdown.
ALARM	The machine is running rough.	Plan for a repair outage at the nearest opportunity. Until repaired, monitor machine closely.
DANGER	A severe problem.	Correct problems immediately or at the first opportunity to avoid machine failure, unscheduled downtime, and secondary damage.

II. EQUIPMENT SUMMARY

The overall condition of equipment can have a large impact on the operation of any facility. As the condition of the equipment improves, there are several factors that are affected:

- Operating Costs will decrease.
- Reliability will increase.
- Building Environmental quality will increase.





III. PRIORITIZED REPAIR RECOMMENDATIONS

EQUIPMENT CONDITION

The following machine's condition is:

Blocker Hall

	Unit ID	Date of Collection	Machine Condition	Repairs Recommended
1.	AHU A SF	7/20/2005	**ALERT**	Check the sheave alignment and runout.
2.	AHU C (3) SF	7/20/2005	**ALARM**	Check the sheave alignment and runout. Replace the fan bearings.
3.	AHU E (4) SF	7/20/2005	**ALERT**	Check the sheave alignment and runout.
4.	AHU-A RF	7/20/2005	**Acceptable**	Continue to monitor with predictive tests
5.	AHU-C (3) RF	7/20/2005	**ALERT**	Check for loose or worn belts.
6.	AHU-E (4) RF	7/20/2005	**ALERT**	Check for loose or worn belts. Check the sheave alignment and runout.

Cooper

	Unit ID	Date of Collection	Machine Condition	Repairs Recommended
7.	AHU-1A SF	7/20/2005	**ALARM**	Check the sheave runout and alignment. Check for loose or worn belts. Clean and balance the fan.
8.	AHU-2A SF	7/20/2005	**ALARM**	Replace the motor bearings.
9.	AHU-3 SF	7/20/2005	**ALERT**	Check for loose or worn belts.
10	AHU-4 SF	7/20/2005	**ALARM**	Check for loose or worn belts. Clean and balance the fan.

McCormick

	Unit ID	Date of Collection	Machine Condition	Repairs Recommended
11.	AHU-1 SF	7/20/2005	DANGER	Replace the motor bearings.
12.	AHU-1 RF	7/20/2005	ALARM	Replace the motor bearings.

Whitaker

	Unit ID	Date of Collection	Machine Condition	Repairs Recommended
13.	AHU-1 SF	7/20/2005	ALERT	Continue to monitor the motor bearings.
14.	AHU-2 SF	7/20/2005	DANGER	Perform further testing to determine the root cause of the vibration.
15.	ASU-3 SF	7/20/2005	ALARM	Replace the motor bearings. Correct the mechanical looseness on the fan. Check the fan bearings for excessive clearance.

REPAIRS PERFORMED:

Unit ID	Repairs Performed Since Previous Measurement	Technician that Performed Repair and Date

Estimated Repair Costs – Fans (The prices provided in this table are example of pricing based on historical costs experienced and not an estimate for repair. The local Johnson Controls branch should be contacted for an actual written estimate for repair that may be more or less than what is provided below.)

If machine hp is…	and the primary problem is…	and the severity is…	# of machines	Estimated Cost of Proactive Repairs(CPR)		Total CPR	Run to failure repair costs		Avoided Repair Cost (ARC)	Total ARC
less than 30	imbalance misalign	alarm or danger	**4**	$400.00	dynamic balance or align	$1,600.00	$1,800.00	replace fan bearings & balance	$1,400.00	$5,600.00
		danger		$400.00	dynamic balance or align	$0.00	$5,400.00	replace brngs & fan shaft & balance	$5,000.00	$0.00
	worn or defective motor bearings	alarm or danger	**2**	$1,050.00	replace motor bearings	$2,100.00	$2,000.00	replace motor	$950.00	$1,900.00
	worn or defective fan bearings	alarm or danger		$1,400.00	replace fan shaft bearings	$0.00	$5,000.00	replace fan shaft & bearings	$3,600.00	$0.00
		danger		$1,400.00	replace fan shaft bearings	$0.00	$7,500.00	replace shaft & bearings & cage	$6,100.00	$0.00
30 to 60	imbalance misalign	alarm or danger	**4**	$400.00	dynamic balance or align	$1,600.00	$2,500.00	replace bearings & balance	$2,100.00	$8,400.00
		danger	**1**	$400.00	dynamic balance or align	$400.00	$7,500.00	replace brngs & fan shaft & balance	$7,100.00	$7,100.00
	worn or defective motor bearings	alarm or danger	**1**	$1,850.00	replace motor bearings	$1,850.00	$4,000.00	replace motor	$2,150.00	$2,150.00
	worn or defective fan bearings	alarm or danger		$2,100.00	replace fan shaft bearings	$0.00	$7,100.00	replace fan shaft & bearings	$5,000.00	$0.00
		danger		$2,100.00	replace fan shaft bearings	$0.00	$10,850.00	replace shaft & bearings & cage	$8,750.00	$0.00
more than 60	imbalance misalign	alarm or danger		$400.00	dynamic balance or align	$0.00	$3,200.00	replace bearings & balance	$2,800.00	$0.00
		danger		$400.00	dynamic balance or align	$0.00	$10,000.00	replace brngs & fan shaft & balance	$9,600.00	$0.00
	worn or defective motor bearings	alarm or danger	**1**	$2,950.00	replace motor bearings	$2,950.00	$6,000.00	replace motor	$3,050.00	$3,050.00
						$0.00				$0.00
	worn or defective fan bearings	alarm or danger		$2,800.00	replace fan shaft bearings	$0.00	$9,600.00	replace fan shaft & bearings	$6,800.00	$0.00
		danger		$2,800.00	replace fan shaft bearings	$0.00	$16,000.00	replace shaft & bearings & cage	$13,200.00	$0.00
					Total CPR	$10,500.00			**Total ARC**	**$28,200.00**

IV. RECOMMENDATIONS FOR IMPROVING MAINTENANCE PRACTICES

COMMON MAINTENANCE PRACTICE RECOMMENDATIONS

Does Problem Exist?	Problems	Possible Causes	Maintenance Practices
	Belt problems	Belt too tight or loose Damaged belt Mismatched belts Sheave misalignment Eccentric sheave	• Perform vibration analysis for belt problems. • Check belt for proper tension. • Check belt for wear and damage. • Replace all the belts at the same time with matched set. • Verify proper alignment.
	Eccentric sheave	Damaged or worn sheave Cocked sheave Variable pitched sheave	• Check sheave runout for eccentricity. Runout should be 5 mils or less. • During installation, uniformly tighten the taper lock while checking the face with dial indicator. If uniformly tightening the taper lock does not have any effect on the mounting problem, then remount the sheave. • Replace variable pitched sheave with fixed pitched sheave.
	Sheave misalignment	Damaged sheave Equipment arrangement Variable pitched sheave Excessive belt tension	• Perform alignment using a straight edge or a long string.
	Bent shaft	Damaged or impaired shaft Excessive heat	• Straighten or replace shaft. Check shaft runout, which should be 2 mils or less.
	Cracked shaft	Excessive belt tension Improper shaft repair	• Perform vibration analysis for belt problems. • Check belt for proper tension.
	Shaft misalignment	Damaged or worn shaft Out of tolerance Looseness problems	• Check coupling and shaft runout for wear. Runout should be 2 mils or less. • Inspect coupling for damages. • Perform precision shaft alignment.
	Bearing	Damaged or worn bearings Over- or under-greased Cocked or loose bearings	• Perform vibration analysis for bearing problems. • Properly lubricate the bearings. Follow OEM recommended intervals and quantity. • Install bearings properly per manufacturer's recommendations.

COMMON MAINTENANCE PRACTICE RECOMMENDATIONS (continued)

Does Problem Exist?	Problems	Possible Causes	Maintenance Practices
	Soft foot	Damaged or worn frame Improper mounting pad Bent motor feet Too many shims Frame distortion	• Check for soft foot with shims or dial indicator. Soft foot should be 3 mils or less. • Replace many thin shims with fewer thicker shims.
	Looseness	Loose mounting bolts Structural looseness Improper fit between component parts Soft foot	• Perform vibration analysis. • Tighten all mounting bolts to prevent looseness or frame distortion. • Check for soft foot with shims. Soft foot should be 3 mils or less. • Inspect the frame for damages.
	Frame distortion	Damaged or worn	• Check frame for damage. • Check for soft foot with shims. Soft foot should be 3 mils or less. • Repair frame.
	Imbalance	Heavy spot Dirt build-up on fan blades Cracked hub on vane axial fan	• Perform fan balancing. • Inspect fan for dirt build-up on the blades. • On vane axial fans, inspect hub for damages and looseness.
	Resonance	Loose mounting bolts Damaged isolation springs Cracked or damaged frame Frame distortion Insufficient support	• Perform bump test to determine the natural frequency. • Perform an ODS analysis. • Tighten all mounting bolts. • Check isolation springs for damages. • Add additional bracing. • Repair frame.
	Air Flow problems	Variations in pressure or velocity which causes turbulence Flow restrictions	• Adjust guide vanes for proper flow. • Check ductwork for plugged filter or coil. • Check for proper air balance.
	Cavitation in pumps	Insufficient suction pressure	• Check for proper flow at the discharge. • Check for proper head, especially on the suction valve settings. • Prevent restrictions in the return.
	Electrical problems	Phase imbalance Loose connectors Stator problem Poor quality power	• Check motor for broken or corroded connectors. • Check all motor connections for a tight fit. • Check power quality. • Check for soft foot with shims. Soft foot should be 3 mils or less.

V. DETAILED ANALYSIS AND DATA

Johnson Controls uses fan and pump vibration worksheets to document the analysis performed on each machine. This section includes these worksheets.

Additionally, we collect data (spectra) before and after repairs. Collecting data after repairs is just as important as collecting it before because we can offer you:

- Efficient correction of equipment problems *to minimize disruption to operations*.
- Verification that repairs were made *to help you avoid future repair costs*.
- A baseline for trending the equipment's condition *to help you avoid unscheduled downtime*.

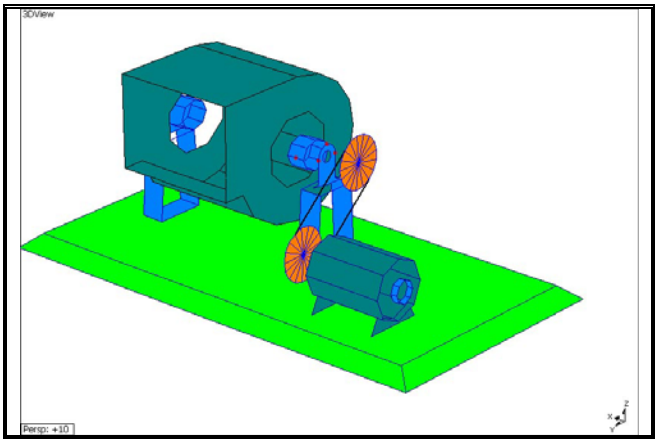
AHU A SF – Blocker Hall

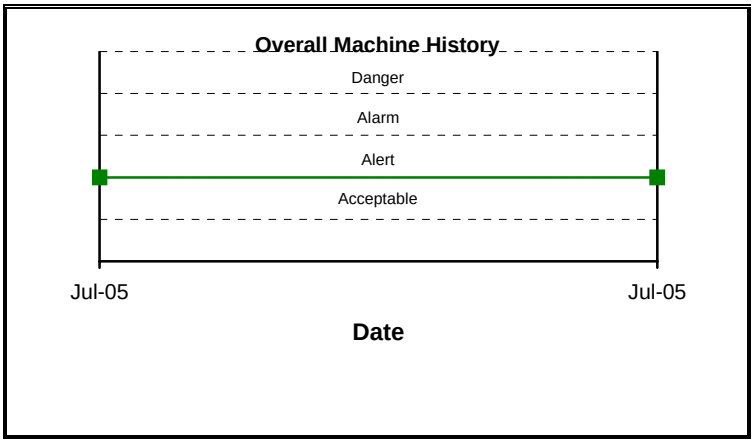
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Align the sheaves and check for runout.**

Condition: **ALERT** **Analyzed By:** Joe Keckeisen





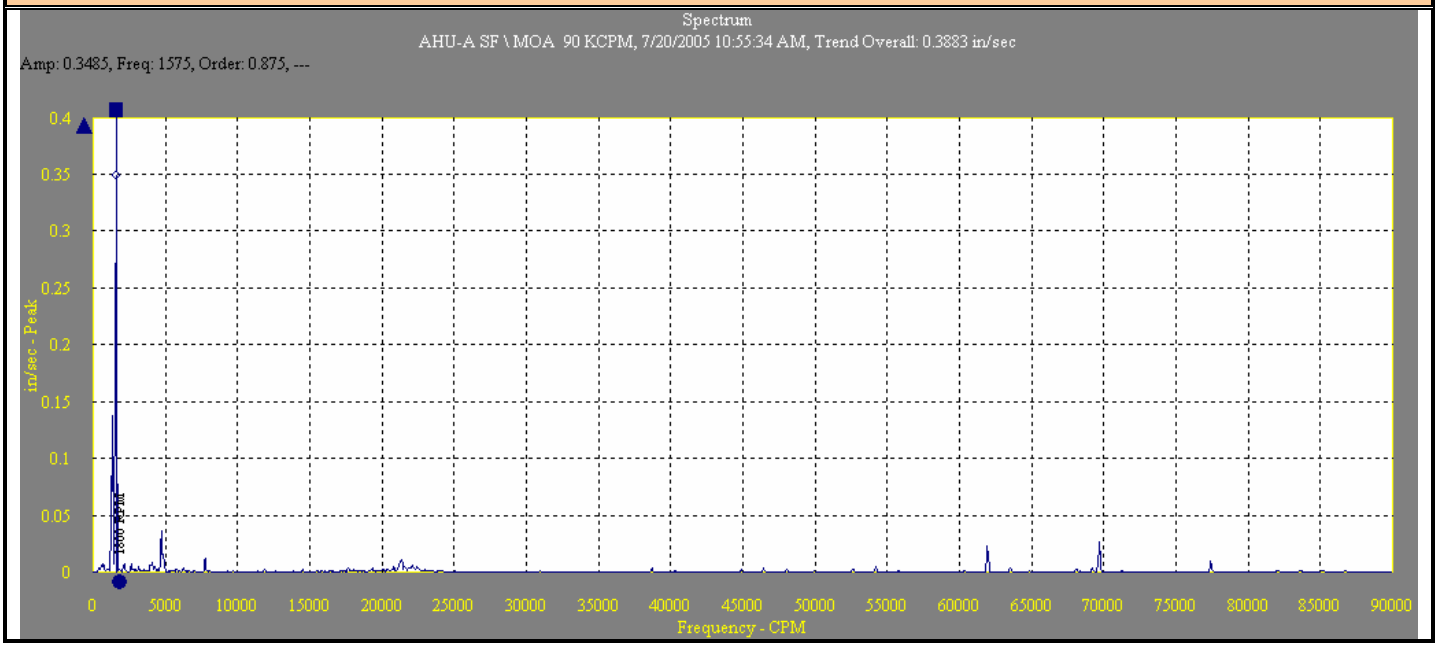
Recommendations

Check the alignment on motor and fan sheaves during the next scheduled maintenance. Check the fan and motor sheave face and groove runout during the next scheduled maintenance. The sheave runout should be 0.005 inches or less.

Diagnosis

The vibration levels and harmonics of the motor and/or fan turning speed indicate a possible sheave misalignment. The vibration levels at the motor and/or fan speed in the radial and\or axial direction indicate possible face or groove runout of the motor and/or fan sheaves.

Physical Observations



AHU C (3) SF – Blocker Hall

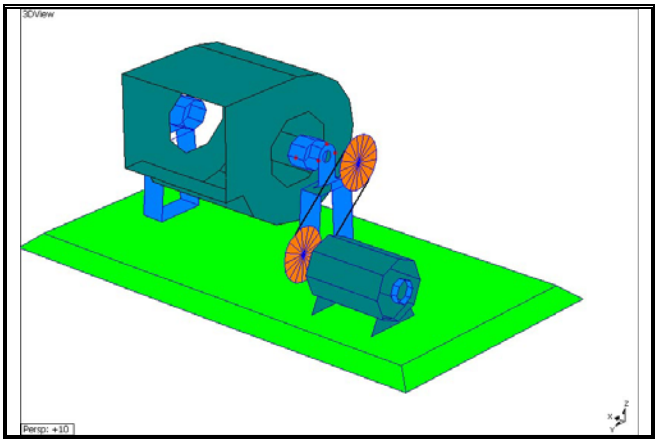
Report Date: August 10, 2005

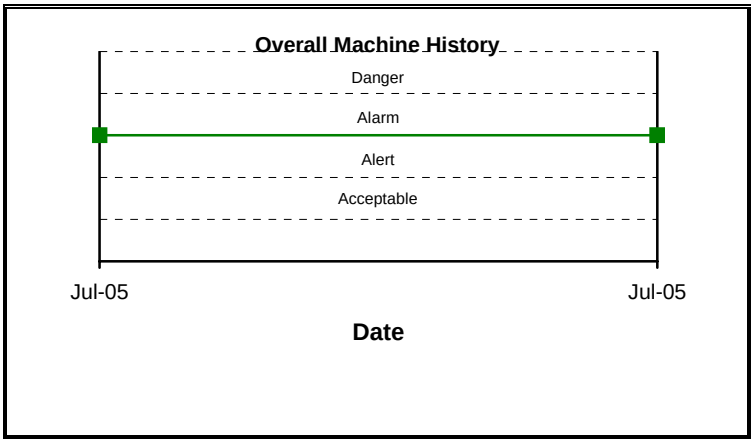
Survey Date: July 20, 2005

Recommendations: **Align the sheaves and check for runout. Replace the fan bearings.**

Condition: **ALARM**

Analyzed By: Joe Keckeisen





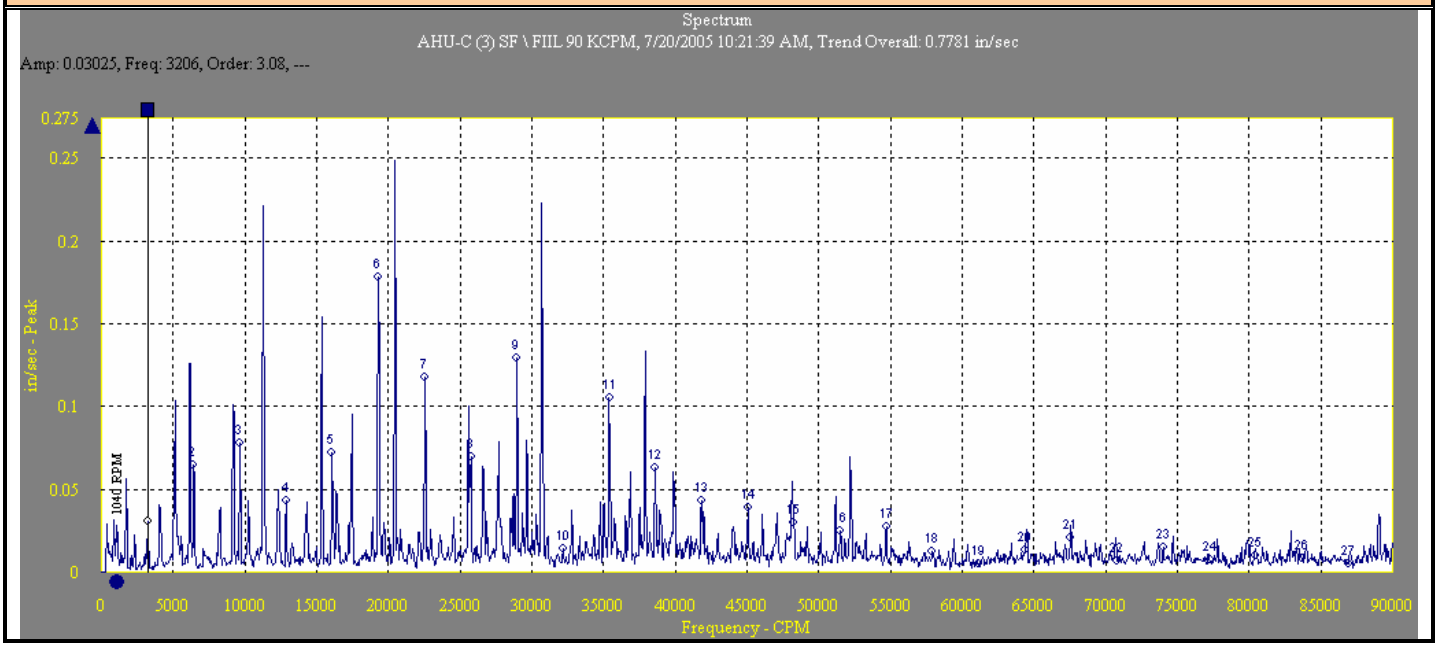
Recommendations

Check the alignment on the motor and fan sheaves. Check the fan and motor sheave face and groove runout. The sheave runout should be 0.005 inches or less. Replace the fan bearings.

Diagnosis

The vibration levels and harmonics of the motor and/or fan turning speed indicate a sheave misalignment. The vibration levels at the motor and/or fan speed in the radial and\or axial direction indicate face or groove runout of the motor and/or fan sheaves.

Physical Observations



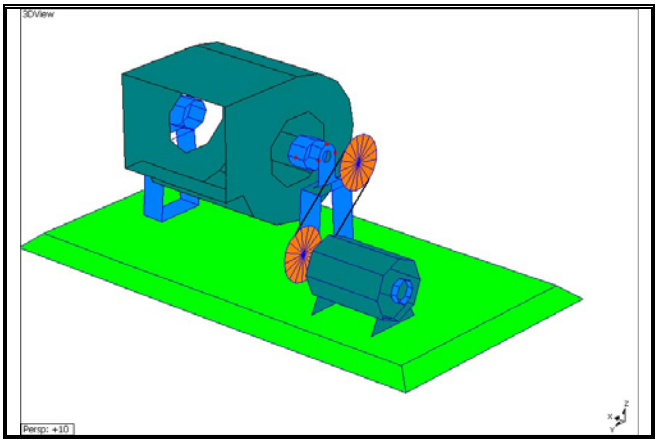
AHU E (4) SF – Blocker Hall

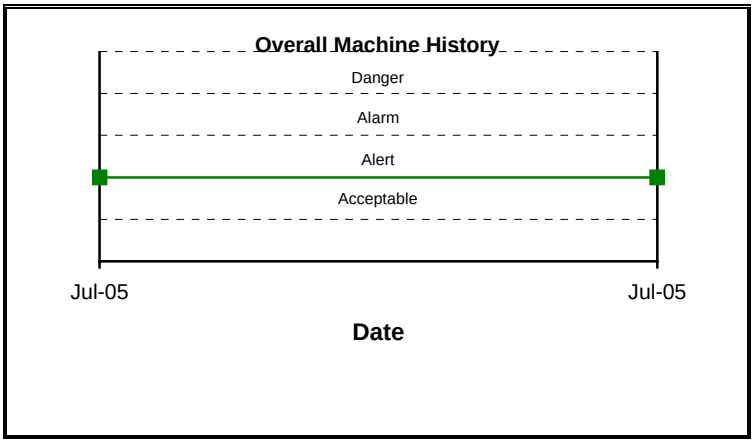
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Align the sheaves and check for runout.**

Condition: **ALERT** **Analyzed By:** Joe Keckeisen





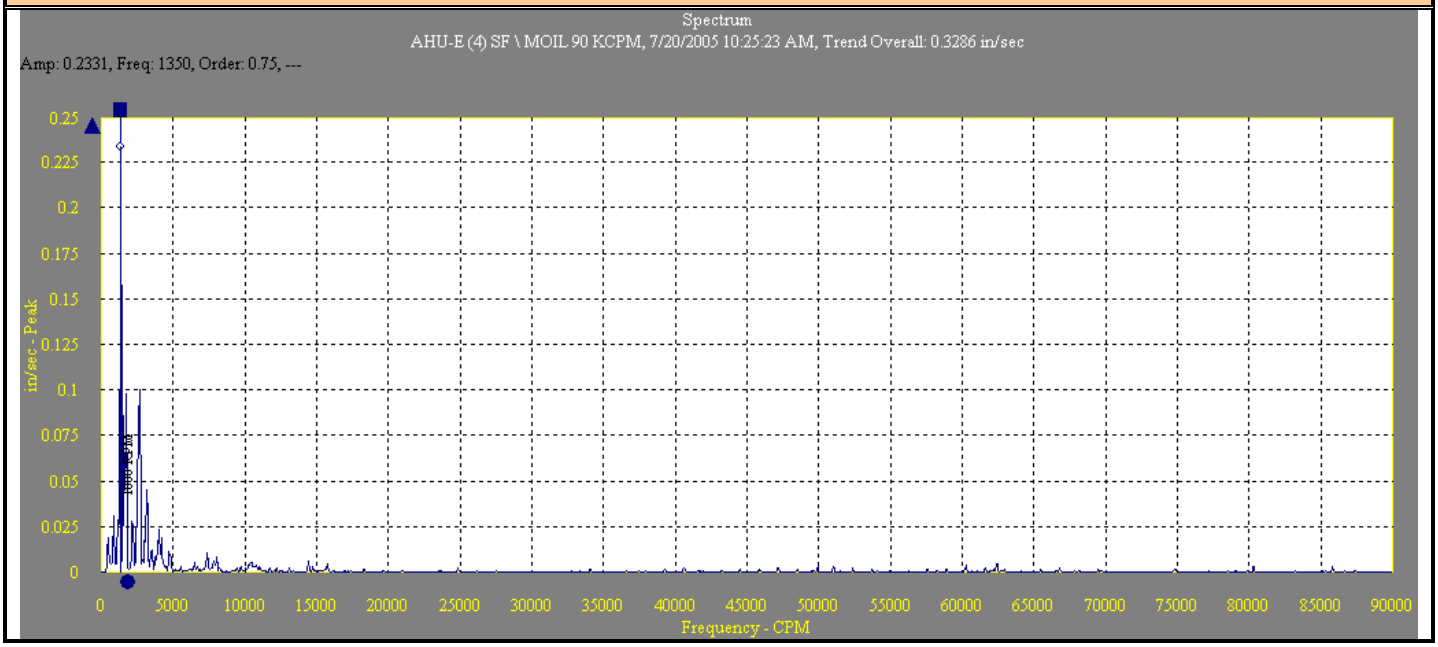
Recommendations

Check the alignment on motor and fan sheaves during the next scheduled maintenance. Check the fan and motor sheave face and groove runout during the next scheduled maintenance. The sheave runout should be 0.005 inches or less.

Diagnosis

The vibration levels and harmonics of the motor and/or fan turning speed indicate a possible sheave misalignment. The vibration levels at the motor and/or fan speed in the radial and/or axial direction indicate possible face or groove runout of the motor and/or fan sheaves.

Physical Observations



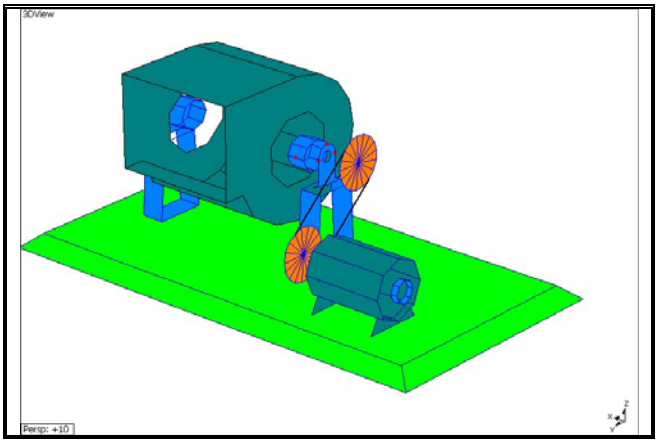
AHU C (3) RF – Blocker Hall

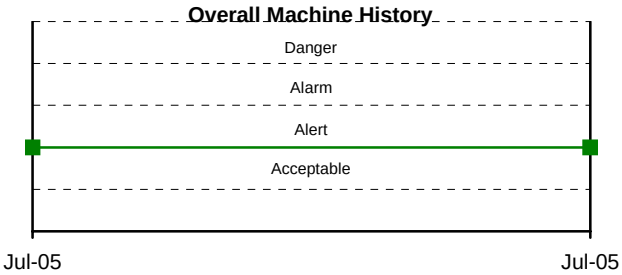
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Check for loose or worn belts.**

Condition: **ALERT** **Analyzed By:** Joe Keckeisen





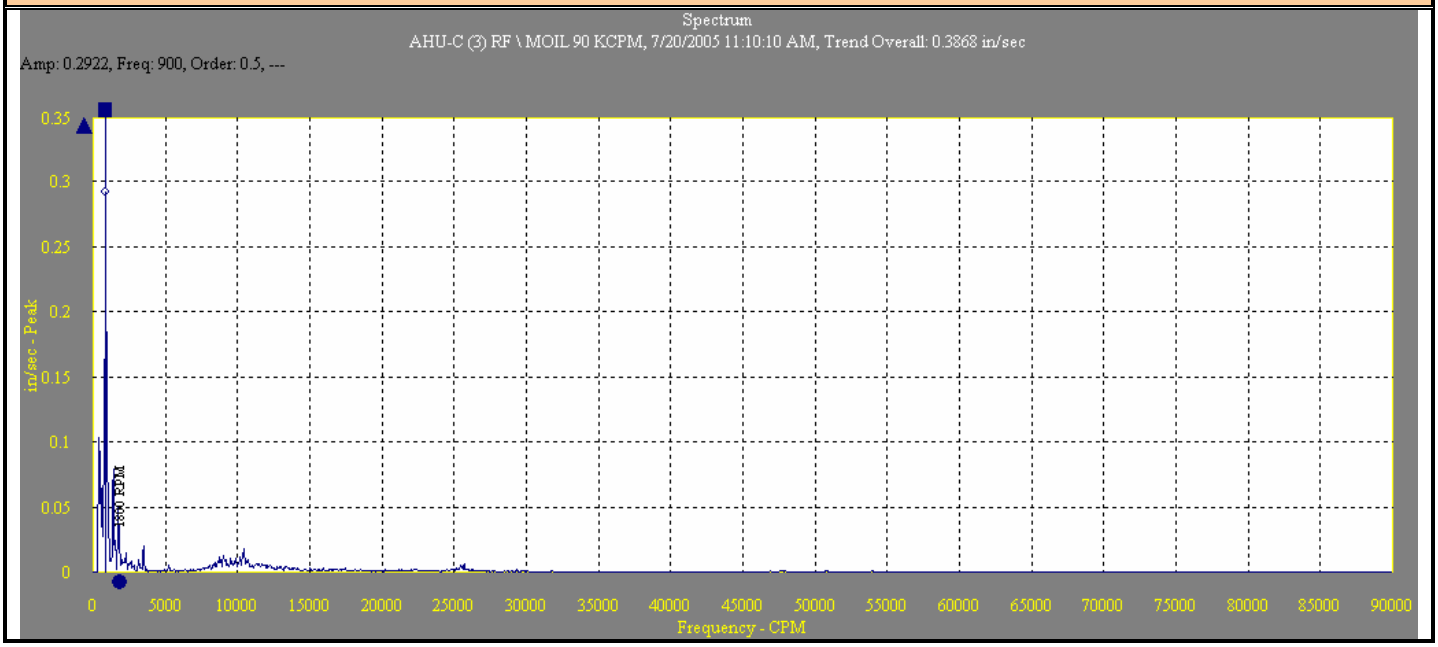
Recommendations

Check the belts for proper tension and wear during the next scheduled maintenance.

Diagnosis

The vibrations at the belt turning frequency indicate a possible problem with the belt tension.

Physical Observations



AHU E (4) RF – Blocker Hall

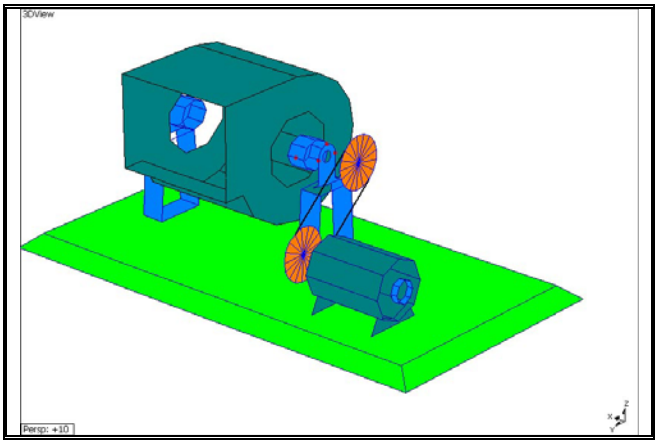
Report Date: August 10, 2005

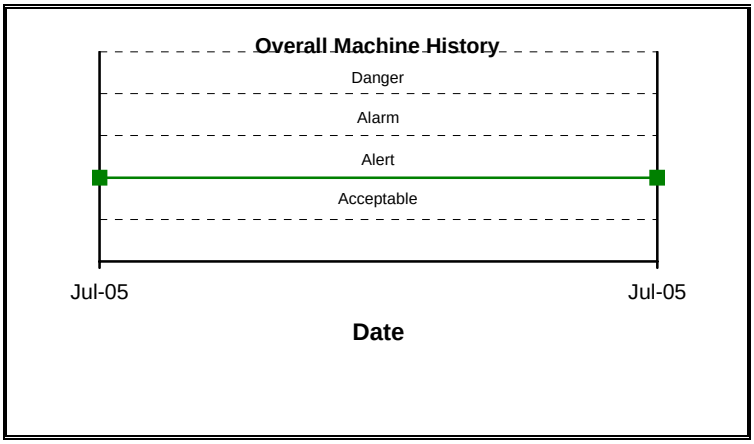
Survey Date: July 20, 2005

Recommendations: **Check for loose or worn belts. Align the sheaves and check for runout.**

Condition: **ALERT**

Analyzed By: Joe Keckeisen





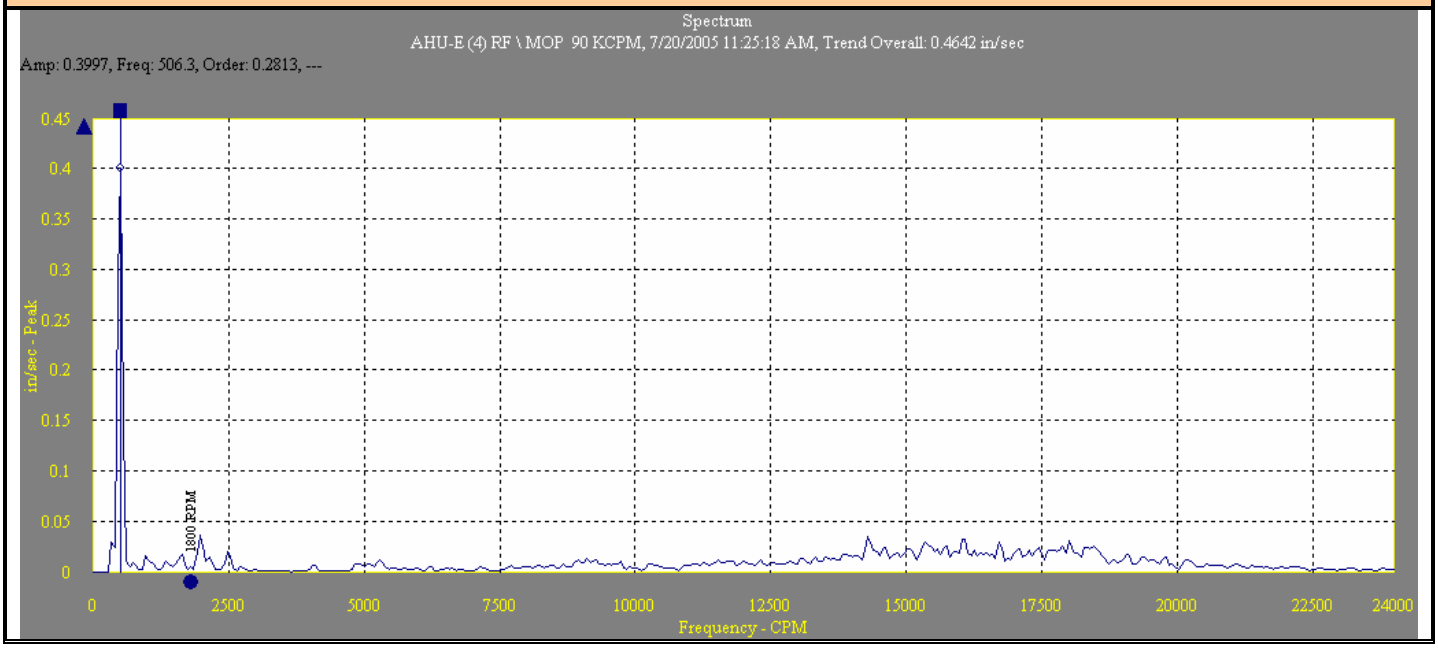
Recommendations

Check the belts for proper tension and wear during the next scheduled maintenance. Check the alignment on motor and fan sheaves during the next scheduled maintenance. Check the fan and motor sheave face and groove runout during the next scheduled maintenance. The sheave runout should be 0.005 inches or less.

Diagnosis

The vibrations at the belt turning frequency indicate a possible problem with the belt tension. The vibration levels and harmonics of the motor and/or fan turning speed indicate a possible sheave misalignment. The vibration levels at the motor and/or fan speed in the radial and\or axial direction indicate possible face or groove runout of the motor and/or fan sheaves.

Physical Observations



AHU 1A SF – Cooper

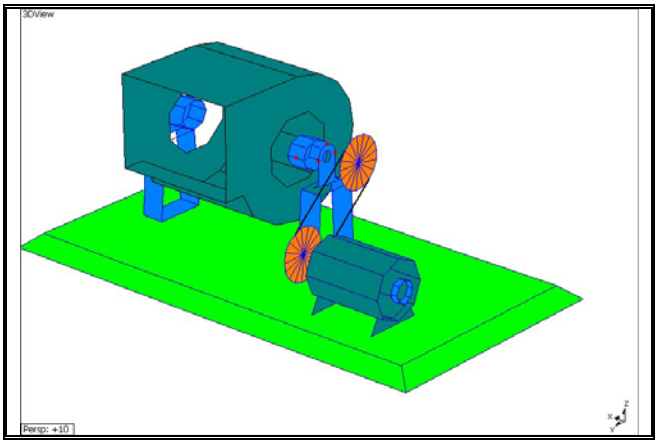
Report Date: August 10, 2005

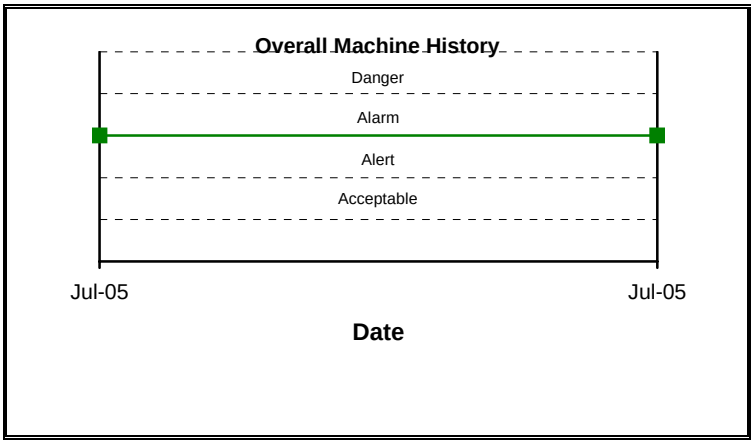
Survey Date: July 20, 2005

Recommendations: **Check for loose or worn belts. Align the sheaves and check for runout. Clean and balance the fan.**

Condition: **ALARM**

Analyzed By: Joe Keckeisen





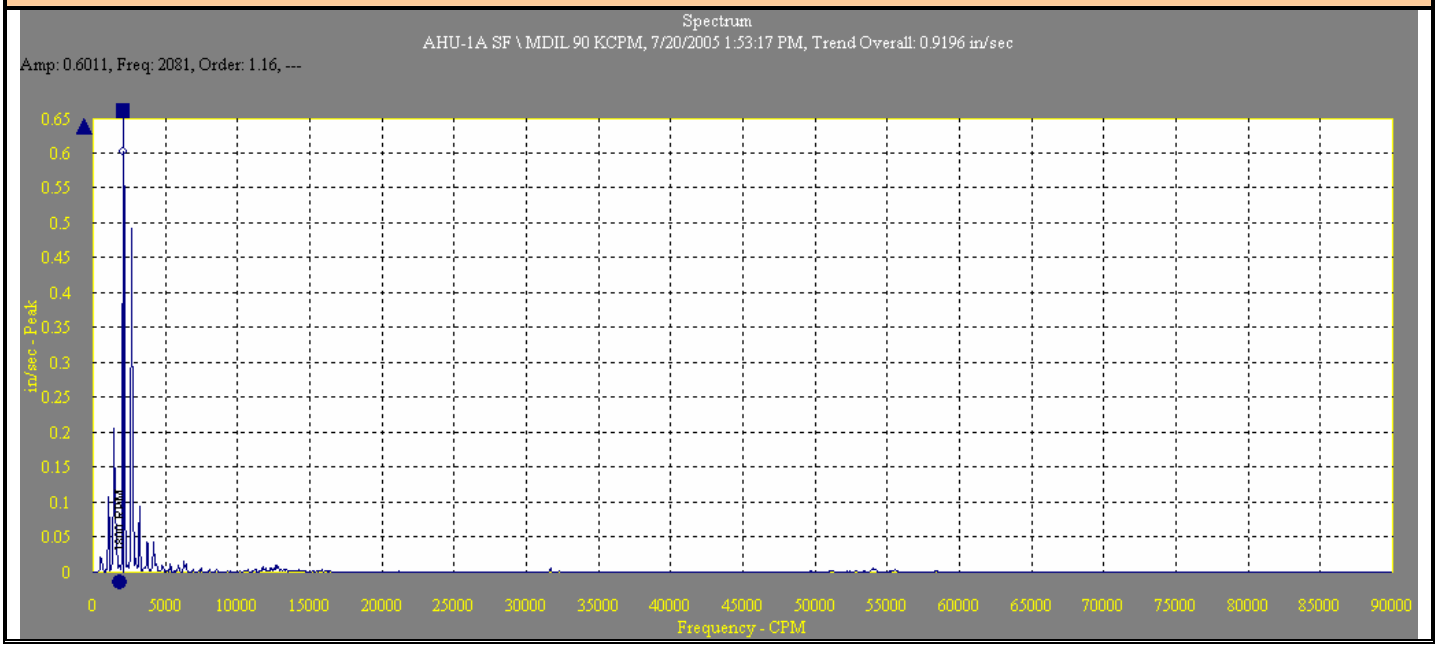
Recommendations

Check the belts for proper tension and wear. Check the alignment on motor and fan sheaves. Check the fan and motor sheave face and groove runout. The sheave runout should be 0.005 inches or less. Clean fan blades of excessive dirt and balance the fan.

Diagnosis

The vibrations at the belt turning frequency indicate a problem with the belt tension. The vibration levels and harmonics of the motor and/or fan turning speed indicate a sheave misalignment. The vibration levels at the motor and/or fan speed in the radial and\or axial direction indicate face or groove runout of the motor and/or fan sheaves. The vibration levels at the fan running speed indicate a fan imbalance.

Physical Observations



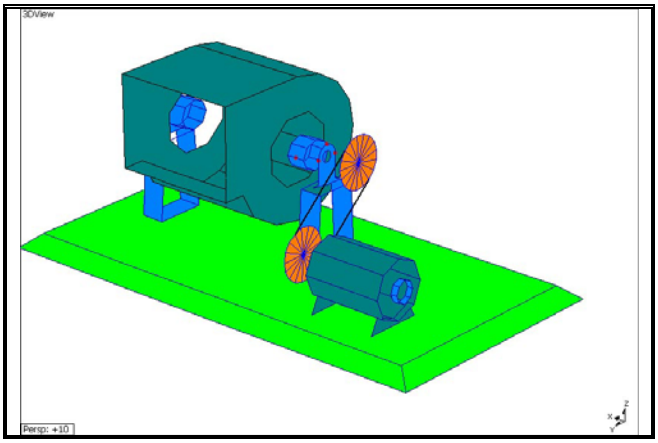
AHU 2A SF – Cooper

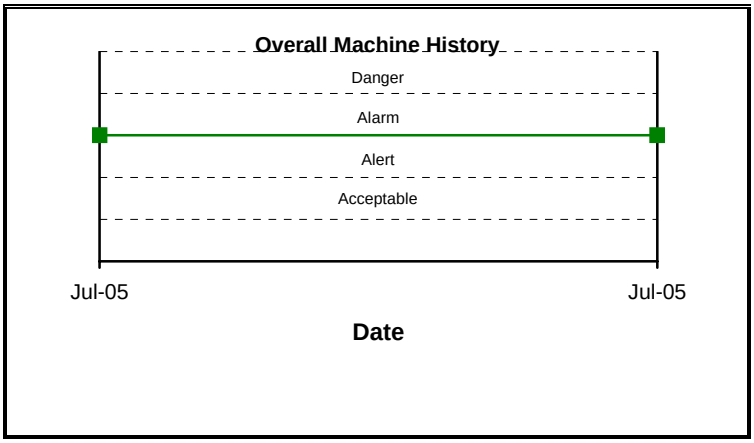
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Replace the motor bearings.**

Condition: **ALARM** **Analyzed By:** Joe Keckeisen





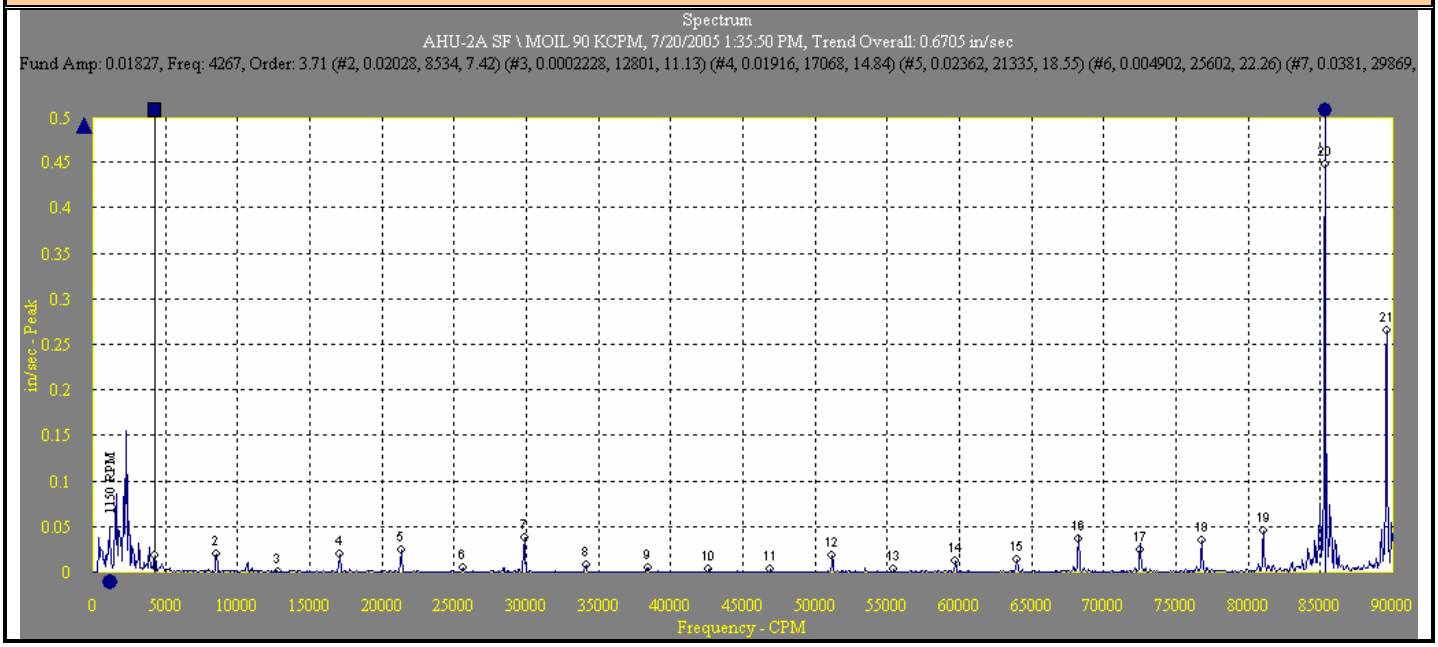
Recommendations

Replace the motor support bearings at the next most convenient opportunity.

Diagnosis

The vibrations at a ball bearing defect frequencies indicate a problem with the motor support bearings.

Physical Observations



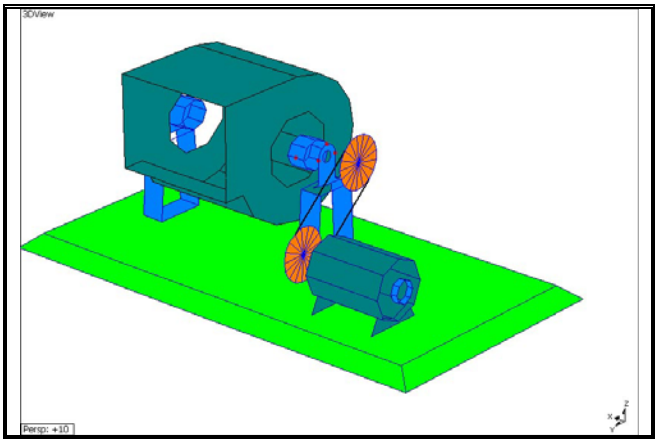
AHU 3 SF – Cooper

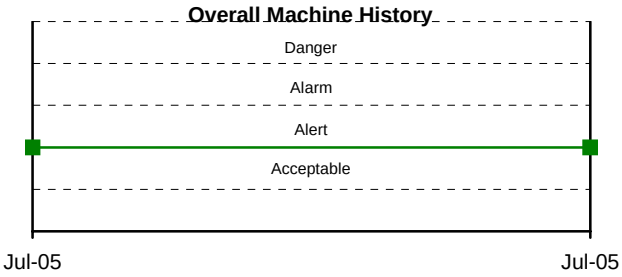
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Check for loose or worn belts.**

Condition: **ALERT** **Analyzed By:** Joe Keckeisen





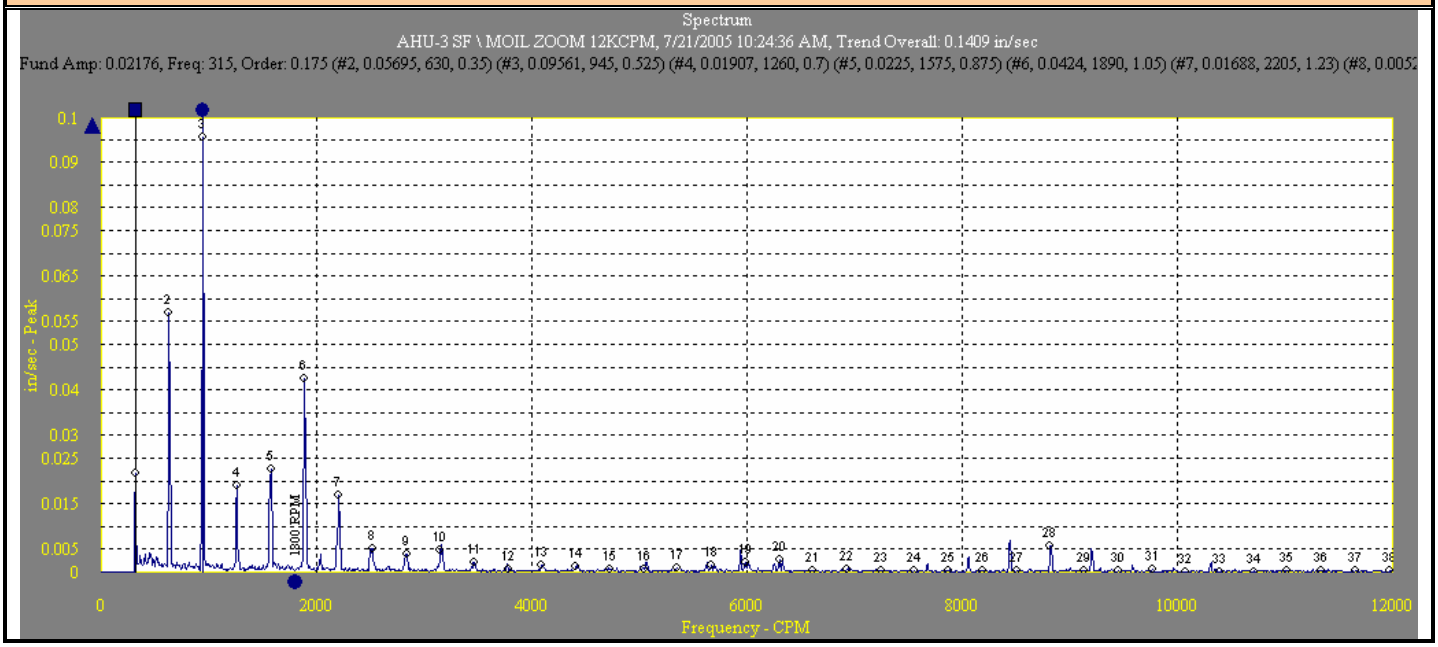
Recommendations

Check the belts for proper tension and wear during the next scheduled maintenance.

Diagnosis

The vibrations at the belt turning frequency indicate a possible problem with the belt tension.

Physical Observations



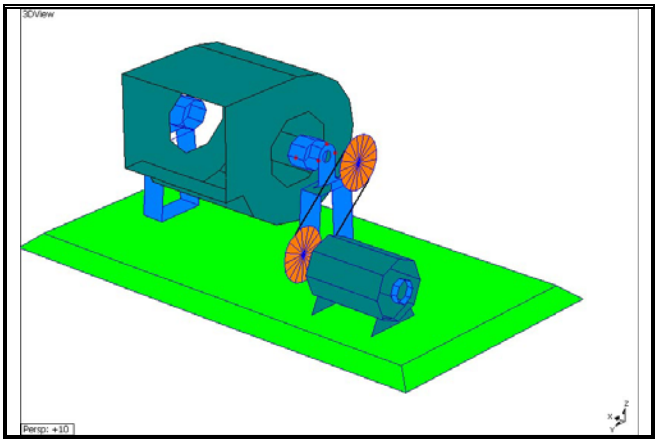
AHU 4 SF – Cooper

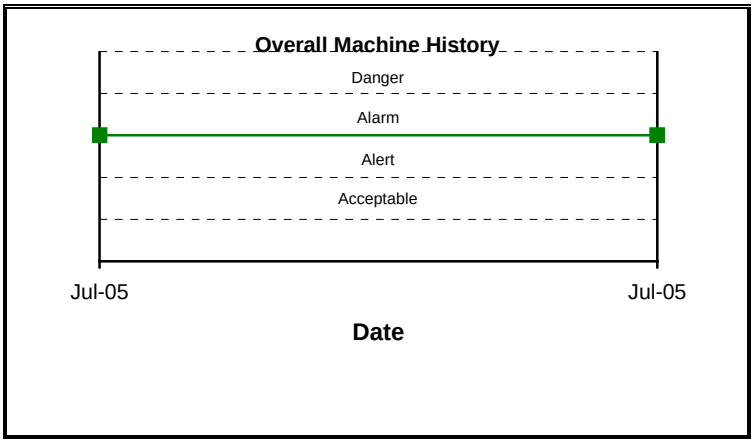
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Check for loose or worn belts. Clean and balance the fan.**

Condition: **ALARM** **Analyzed By:** Joe Keckeisen





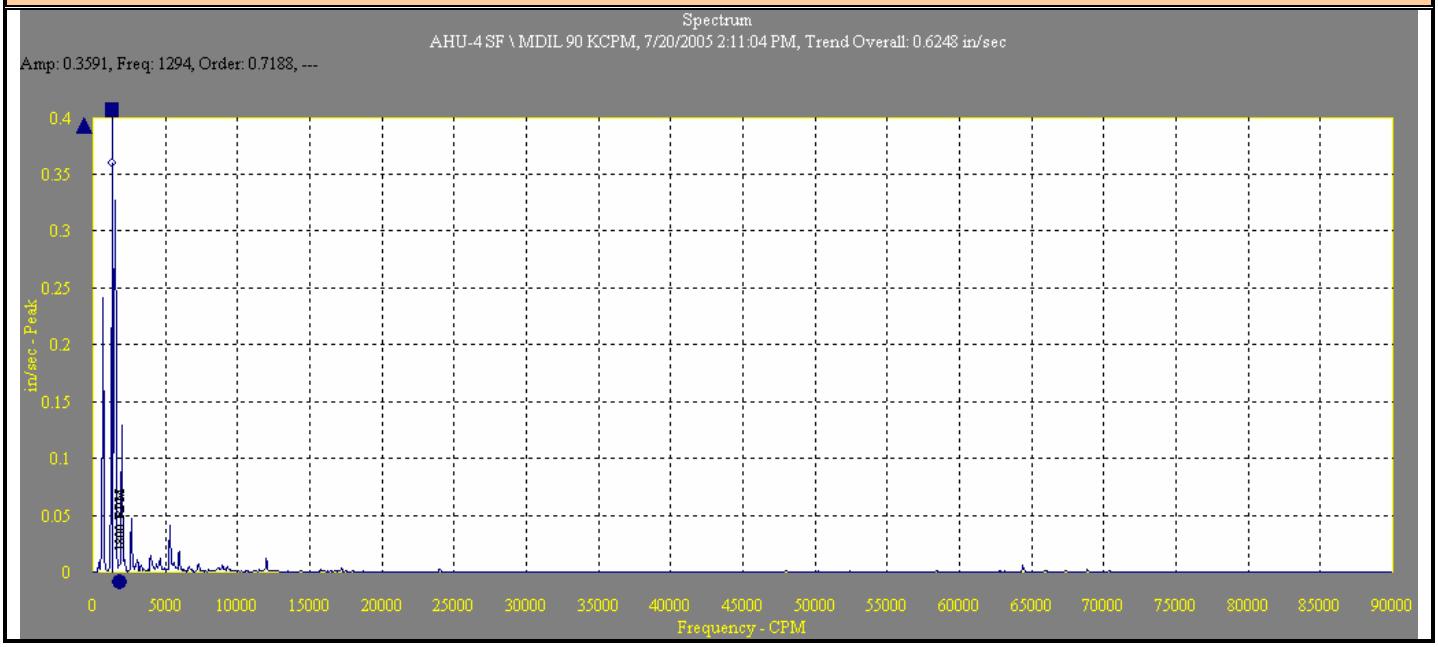
Recommendations

Check the belts for proper tension and wear. Clean fan blades of excessive dirt and balance the fan.

Diagnosis

The vibrations at the belt turning frequency indicate a problem with the belt tension. The vibration levels at the fan running speed indicate a fan imbalance.

Physical Observations



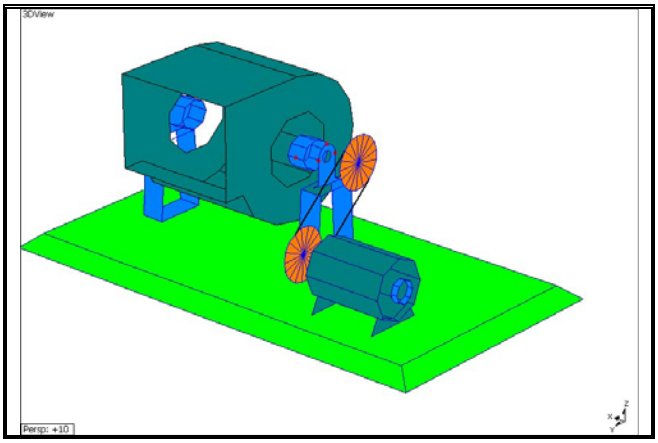
AHU 1 SF – McCormick

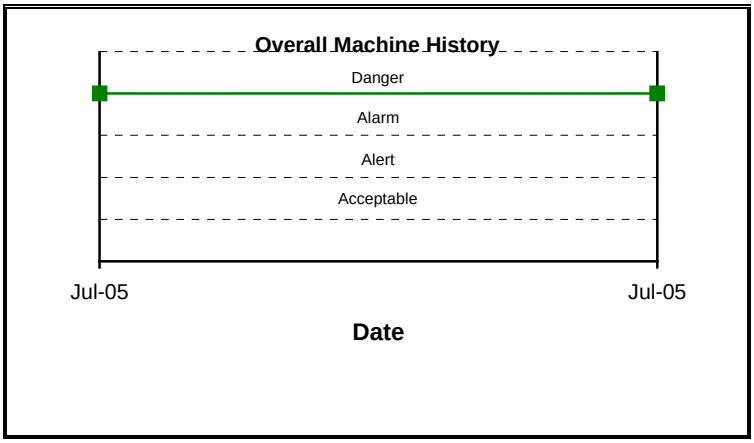
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Replace the motor bearings.**

Condition: **DANGER** **Analyzed By:** Joe Keckeisen





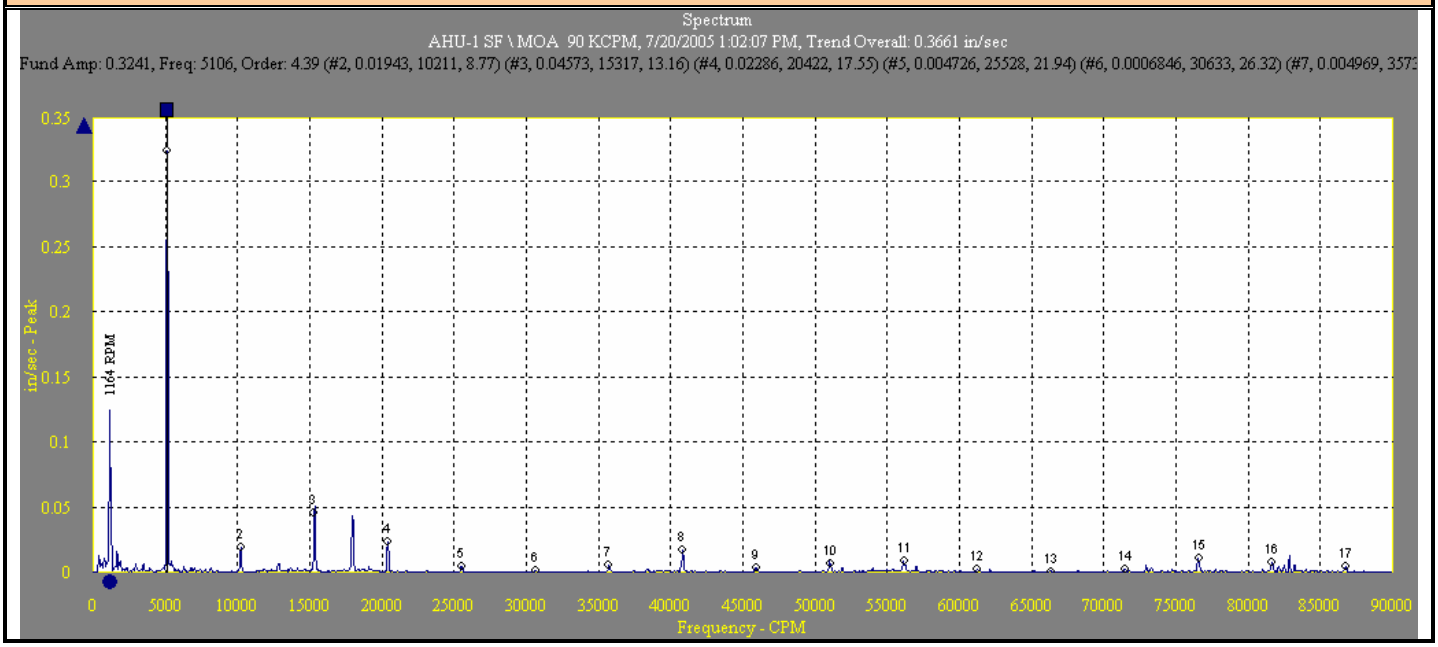
Recommendations

It is recommended to not run this machine. Replace the motor support bearings.

Diagnosis

The vibrations at a ball bearing defect frequencies indicate a severe problem with the motor support bearings.

Physical Observations



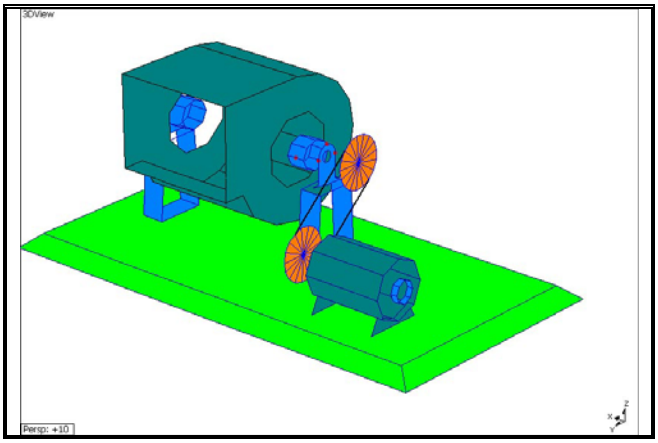
AHU 1 RF – McCormick

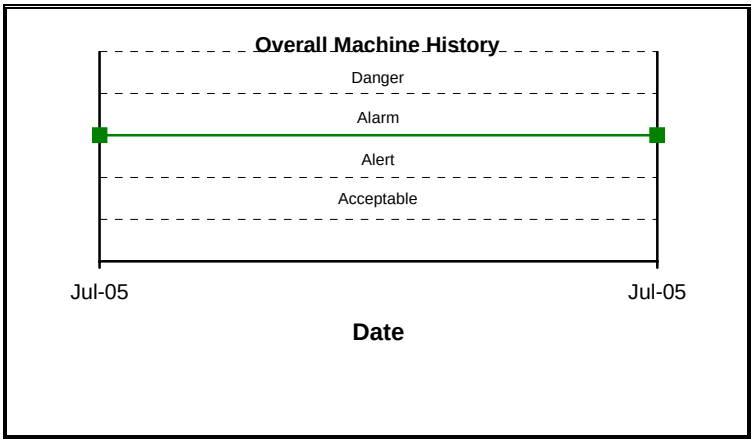
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Replace the motor bearings.**

Condition: **ALARM** **Analyzed By:** Joe Keckeisen





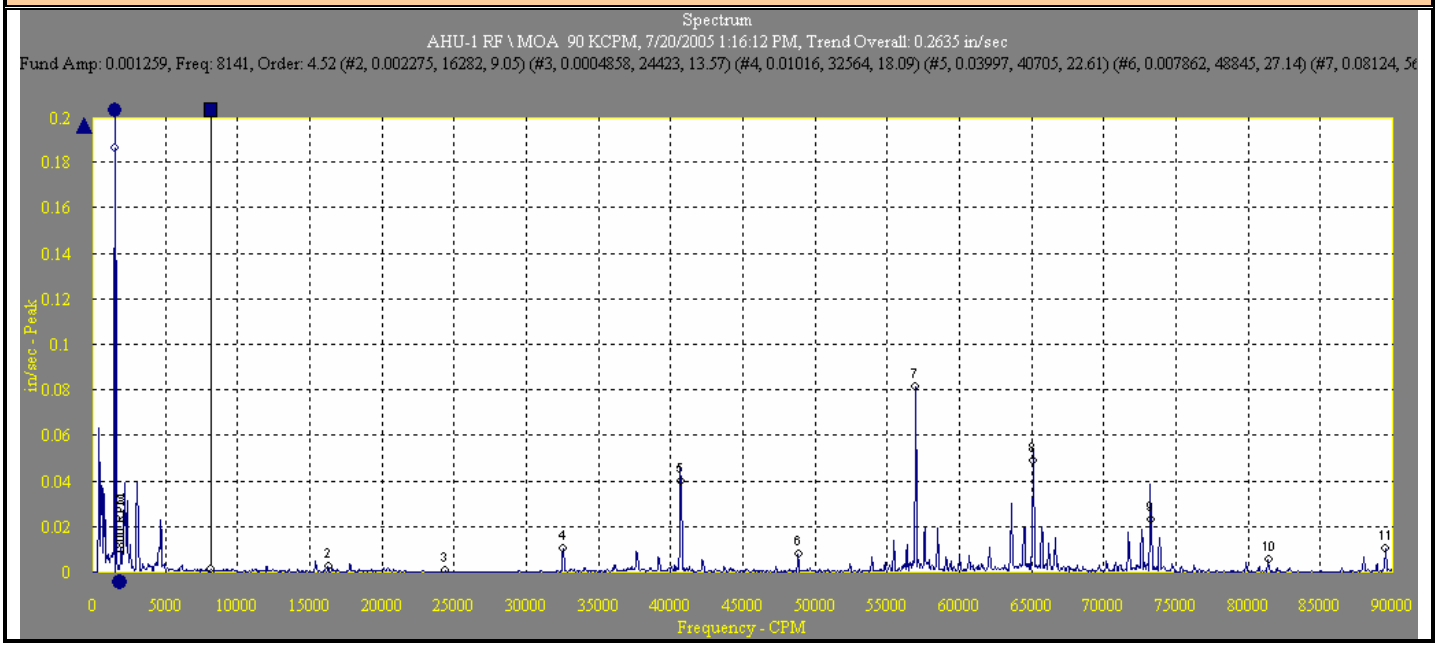
Recommendations

Replace the motor support bearings.

Diagnosis

The vibrations at a ball bearing defect frequencies indicate a problem with the motor support bearings.

Physical Observations



AHU 1 SF – Whitaker

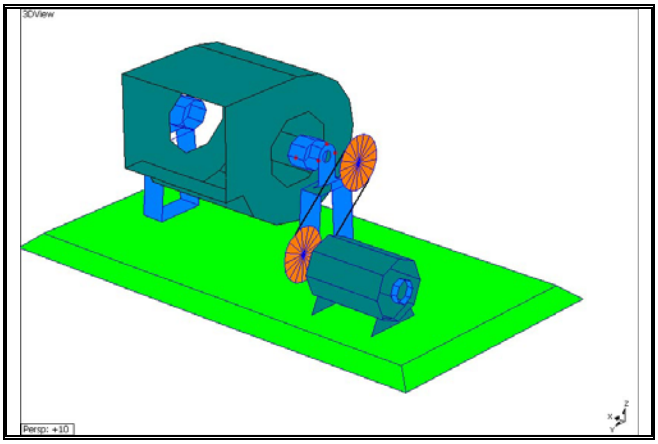
Report Date: August 10, 2005

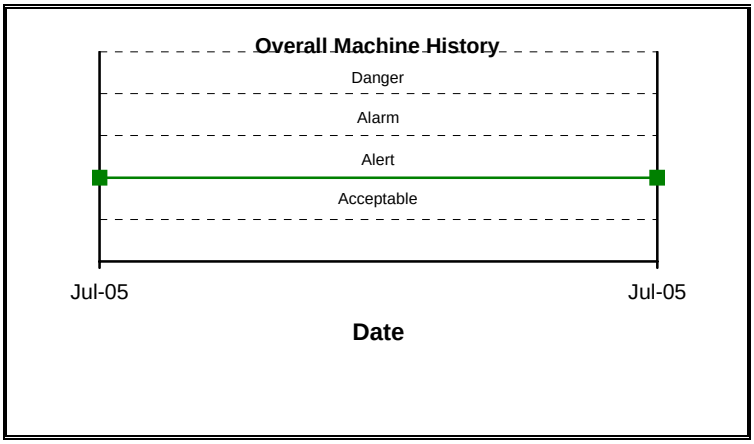
Survey Date: July 20, 2005

Recommendations: **Monitor the motor bearings. Check the sheave alignment and runout.**

Condition: **ALERT**

Analyzed By: Joe Keckeisen





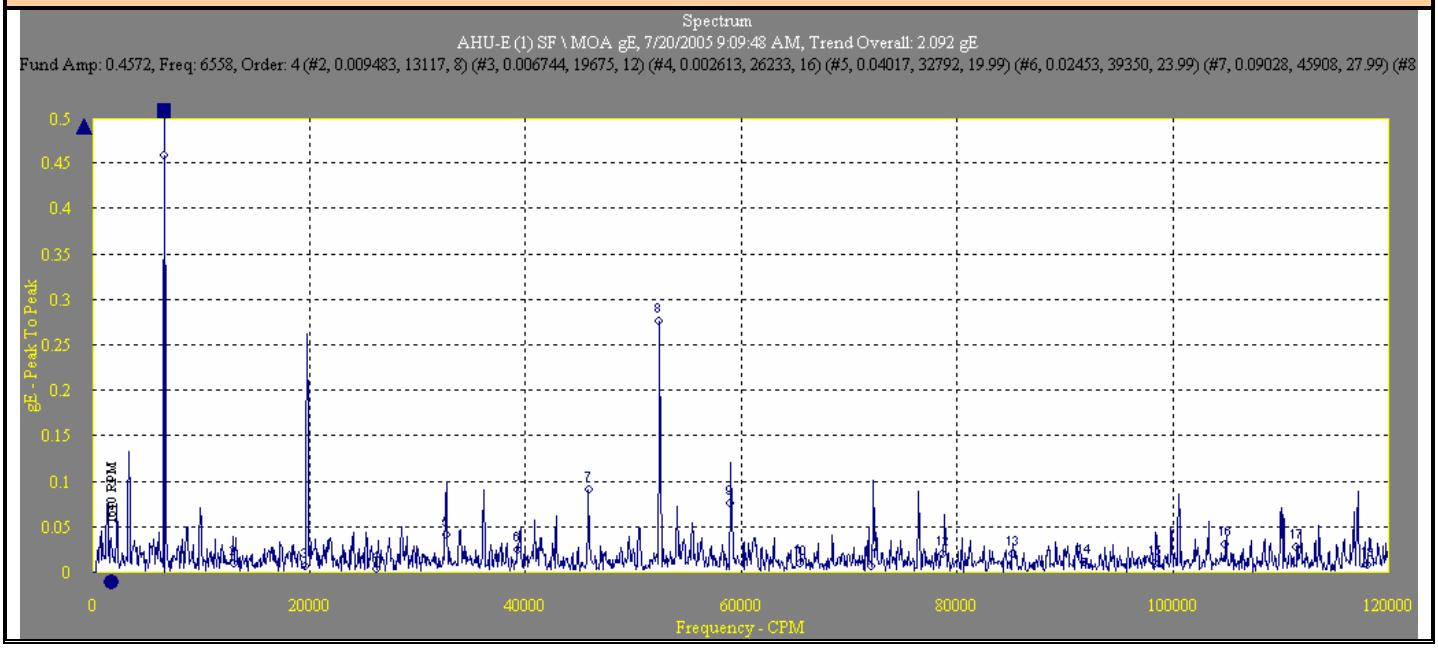
Recommendations

Continue to monitor the possible bearing defect frequencies on the motor bearings.Check the alignment on motor and fan sheaves. Check the fan and motor sheave face and groove runout. The sheave runout should be 0.005 inches or less.

Diagnosis

The vibrations at the ball bearing defect frequencies indicate a possible problem with the motor support bearings. The vibration levels and harmonics of the motor and/or fan turning speed indicate a sheave misalignment. The vibration levels at the motor and/or fan speed in the radial and\or axial direction indicate face or groove runout of the motor and/or fan sheaves.

Physical Observations



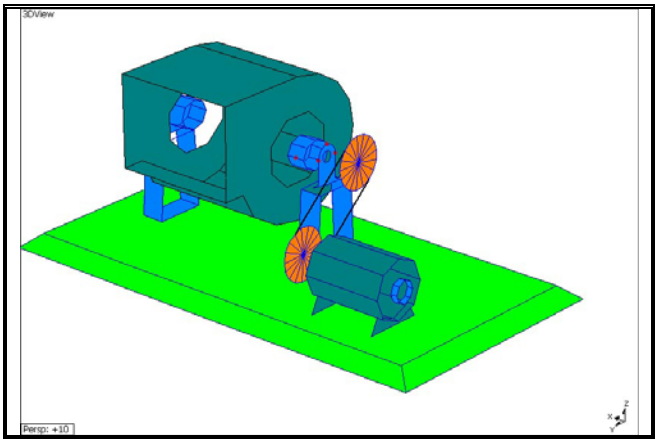
AHU 2 SF – Whitaker

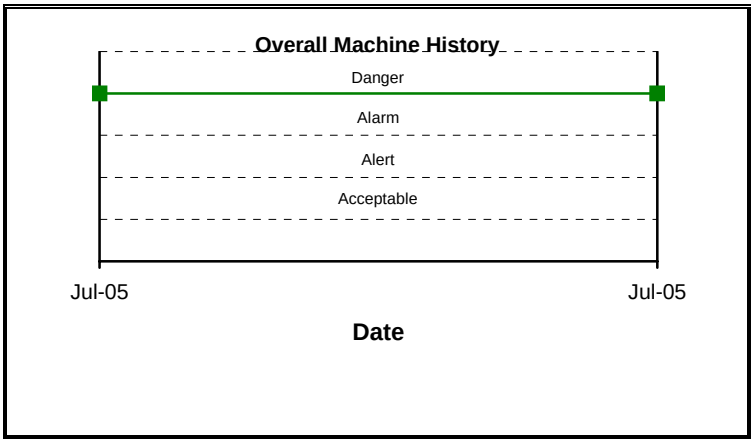
Report Date: August 10, 2005

Survey Date: July 20, 2005

Recommendations: **Perform further test to determine root cause of vibrations problem.**

Condition: **DANGER** **Analyzed By:** Joe Keckeisen





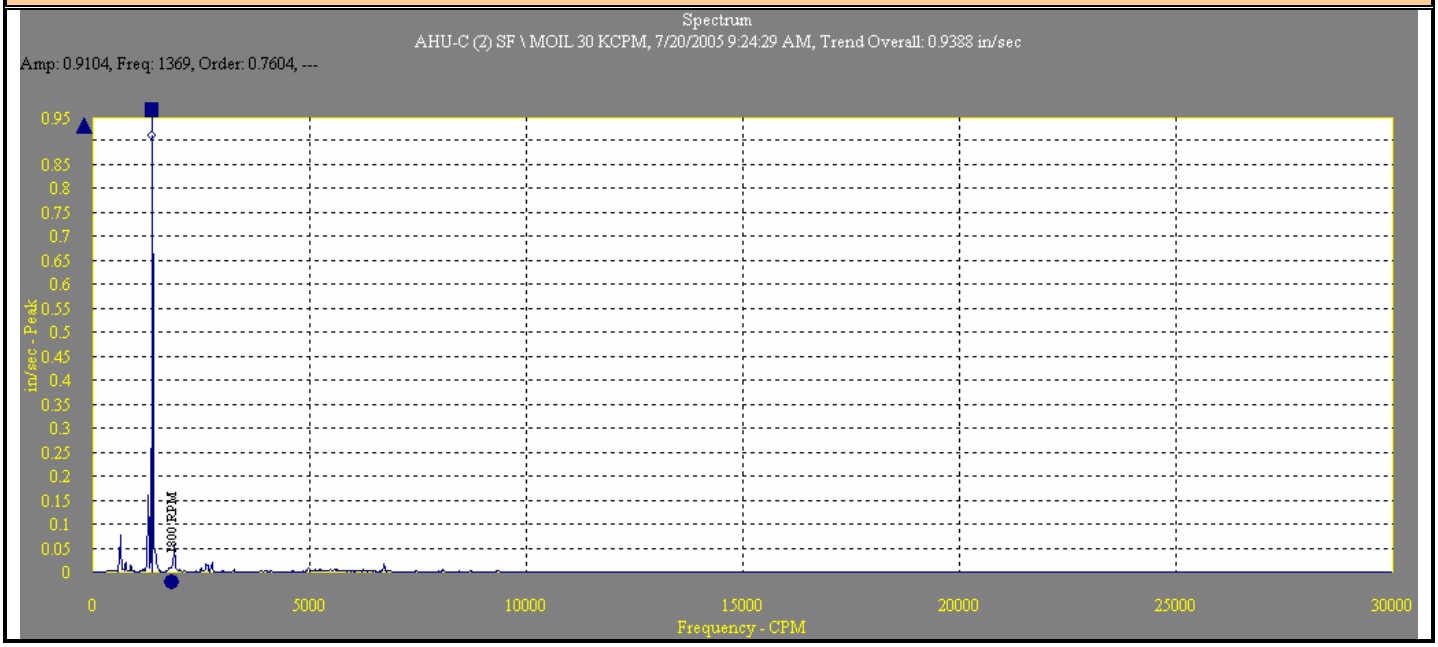
Recommendations

Perform further vibration analysis to determine the source of the problem.

Diagnosis

The vibration at the fan and motor running speed are close in running speed. Less than 100 rpm from one another. This can present several problems in vibration such as a “beat frequency”. The sum of two vibrations close to one another adding both of the amplitudes to create a violent reaction. Performing a more detailed vibration analysis will determine the source of the problem.

Physical Observations



AHU 3 SF – Whitaker

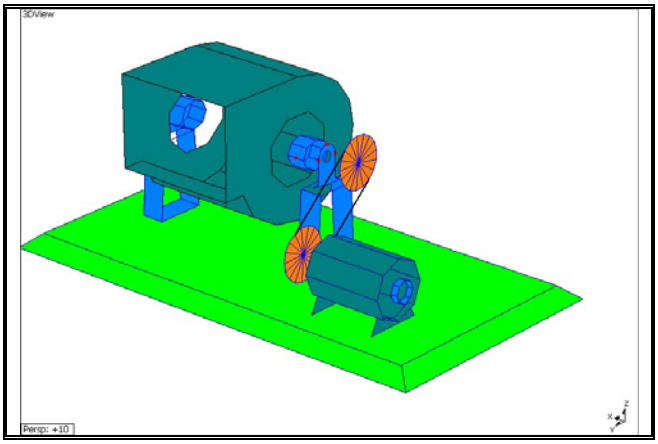
Report Date: August 10, 2005

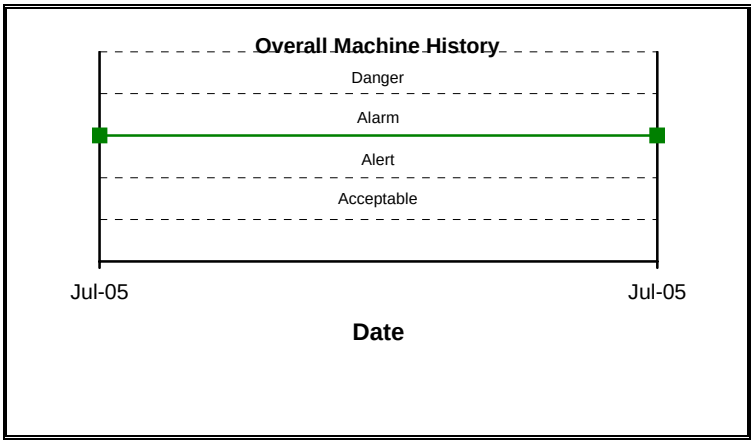
Survey Date: July 20, 2005

Recommendations: **Replace the motor bearings. Correct the fan mechanical looseness. Check the fan bearings for excessive clearance.**

Condition: **ALARM**

Analyzed By: Joe Keckeisen





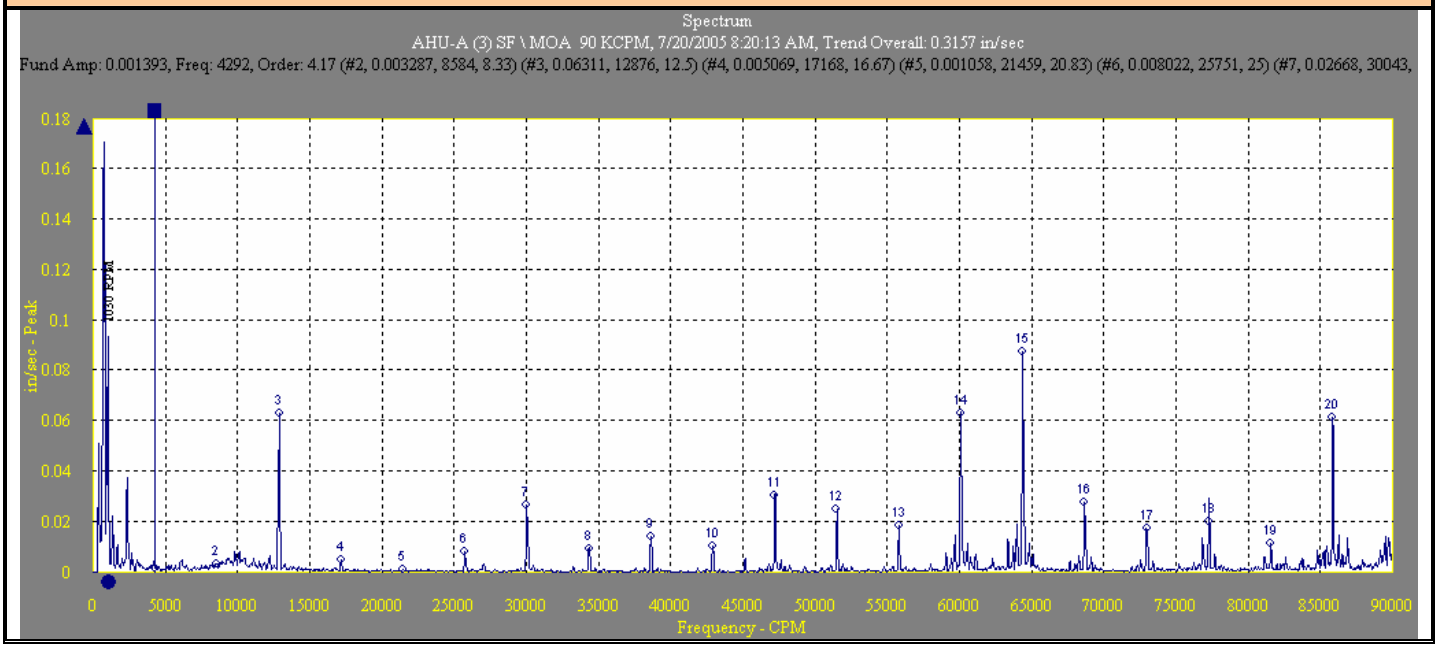
Recommendations

Replace the motor support bearings at the next most convenient opportunity.

Diagnosis

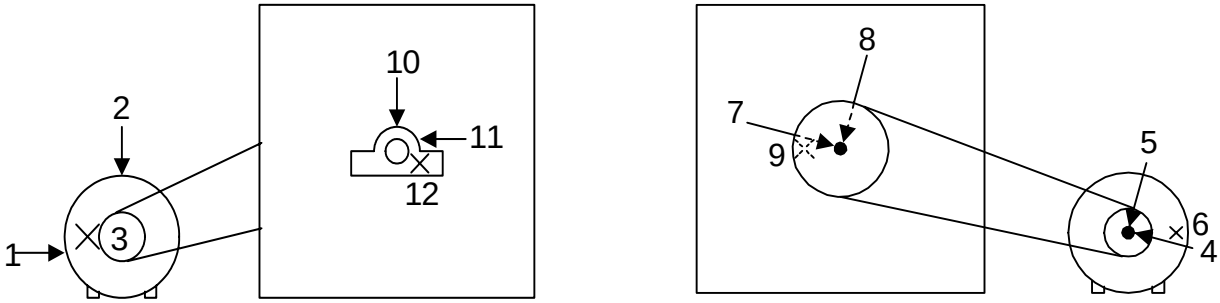
The vibrations at a ball bearing defect frequencies indicate a problem with the motor support bearings.

Physical Observations



VI. MACHINE SCHEMATIC INFORMATION

2 Bearing, Center Hung, Belt Driven, Fan Schematic



1.	MOIL	Motor off end in line
2.	MOP	Motor off end perpendicular
3.	MOA	Motor off end axial
4.	MDIL	Motor drive end in line
5.	MDP	Motor drive end perpendicular
6.	MDA	Motor drive end axial

7.	FIIL	Fan inboard in line
8.	FIP	Fan inboard perpendicular
9.	FIA	Fan inboard axial
10.	FOIL	Fan outboard in line
11.	FOP	Fan outboard perpendicular
12.	FOA	Fan outboard axial

VII. APPENDIX

You can use the Appendix to learn more about the Analysis and Assessment process, and clarify much of the terminology used in this report.

- Analysis and Assessment Process
- Glossary of Vibration, Alignment and Balancing Terms.

ANALYSIS AND ASSESSMENT PROCESS

When analyzing fans and pumps, Johnson Controls categorizes the machines into three conditions called priorities. Categorizing equipment this way allows us to assist you with minimizing downtime and maintenance costs, preventing secondary damage, and increasing operating efficiency. See the section titled "Prioritized Repair Recommendations" for a detailed, prioritized list of your equipment.

To categorize the fans and pumps, Johnson Controls collected vibration data on the machines and analyzed their vibration levels. Using an SKF CMVA10 Microlog data collector, a strobe light, and an accelerometer vibration sensor, Johnson Controls collected vibration spectra on all machines. The following chart identifies our process:

Johnson Controls	To…	How do we do it?	Benefits to you
Collects accurate data Makes visual observations and collects notes Identifies existing problems	Analyze the equipment and determine the condition of each machine. Help us make additional recommendations. Determine the types of repairs that must be completed.	We use the amplitude of a vibration at specific frequencies and compare it to a severity chart based on ISO standards and our own knowledge base. We also observe the machine as it is running, which offers a more precise indication of its condition. To assist with identifying problems, we relate the frequency at the amplitudes to the rotational speed of the machine components.	We can identify those specific machine components requiring repairs. We can help you find problems you may have missed and problems that don't show up in vibration analysis. You can arrange for the parts needed and ensure you have the right skills on hand for repairs.
Provides equipment-specific repair recommendations	Advise you on the proper corrective actions to take.	Our skilled and experienced vibration specialists prepare the recommendations based on their knowledge, the data collected, and physical observations.	You can make quick, effective, and informed decisions about your equipment and operations.
Prioritize equipment repairs	Inform you which repairs are most critical.	We determine which machines are in the worst condition and are most critical to your HVAC system and the areas it serves.	You can target repairs, resources, and your maintenance dollar on the most critical equipment, thus avoiding downtime and costly secondary damage.
Provides recommendations for improving maintenance practices	Inform you of better maintenance practices.	We base our recommendations on common problems we've identified in your facility.	You can train your staff to increase their skills and productivity.
Validates repairs	Verify that repairs were made.	We compare before and after data (spectra).	Your future repair costs and downtime are reduced, and the mean time between failures is increased.

Johnson Controls can also perform repairs. We can collect follow-up vibration data for any repair work to check if any other problems exist, or to provide a baseline for future vibration analysis.

ANALYSIS AND ASSESSMENT PROCESS (continued)

All Johnson Controls mechanics are trained in proper data collection techniques, analysis of common vibration problems, and corrective repairs using predictive techniques. The mechanics themselves are skilled tradesmen in the repair and operation of HVAC mechanical equipment. Johnson Controls mechanics have detailed documentation on the correct processes for performing data collection, analysis, and corrective action techniques.

Our mechanics are supported by five full-time engineers dedicated to supporting predictive technology and specifically vibration analysis. These engineers have been certified as Vibration Analysts by passing tests for different levels of certification from the Vibration Institute or Technical Associates of Charlotte. The Vibration Institute is a professional society dedicated to the science of using machinery vibration to detect developing problems before they cause any unexpected failures. Technical Associates of Charlotte (James E. Berry, vice president) is a consultant and training group for using vibration to detect developing problems.

GLOSSARY OF VIBRATION, ALIGNMENT, AND BALANCING TERMS

1X

The running speed of a machine, or its fundamental frequency. This frequency is most commonly used to assess the amount of imbalance.

2X, 3X

The frequency at 2 or 3 times the running speed of a machine. This frequency is most commonly used to assess misalignment.

acceleration

The change of velocity; measures how a machine's vibration changes speed. Acceleration is typically measured in G's (1G=32.17 ft/s/s=9.81 m/s/s). Measurements are usually made with an accelerometer.

Acceleration is used to assess high frequencies (over 2,000 Hz) such as gear mesh frequencies.

accelerometer

A transducer that collects vibration data; used with a vibration data collector such as the SKF Microlog.

alignment

A procedure used to correct misalignment. The reverse dial indicator method used by Johnson Controls is considered to be one of the most accurate alignment methods available.

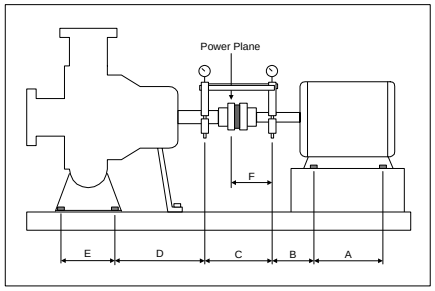


Figure 1: Measurements and setup for the reverse dial indicator method of alignment.

amplitude

The amount (severity) of vibration that a machine exhibits. Amplitude is used to determine the severity of a mechanical equipment problem. Because all machines exhibit vibration, all machines also exhibit amplitude: the greater the amplitude (the severity of the vibration), the greater the problem.

Amplitude is most often measured in IPS (inches per second), but can also be measured in G's or mils. Sometimes referred to as *vibration level*.

averaging

In a vibration analyzer, digitally averaging several measurements improves accuracy.

axial

In the same direction as the shaft centerline.

axial vibration

Vibration which is measured parallel to the shaft's centerline.

axis

The reference plane used in plotting routines. The X-axis is the frequency plane. The Y-axis is the amplitude plane.

balancing

A procedure for adjusting the radial mass distribution on a rotor so that the mass centerline approaches the rotor geometric centerline.

baseline, baseline spectrum

Spectra collected and stored for future comparison. The baseline is taken when a machine is in good operating condition and is used as a reference for future monitoring and analysis.

bearing defect frequencies

The vibration frequencies that are monitored to determine if there are roller or ball bearing defects.

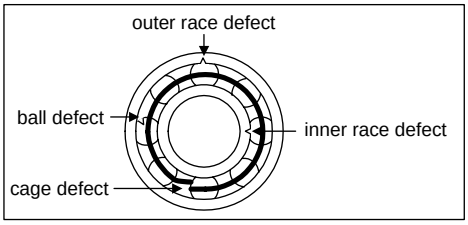


Figure 2: Typical bearing defects.

bent shaft

A shaft condition that is usually caused by excessive force or imbalance; causes excessive vibration.

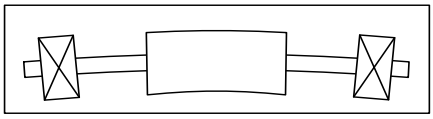


Figure 3: Bent shaft.

blade passing frequency

The vibration frequency used to monitor the condition on any bladed machine (turbine, axial compressor, fan, etc.). Blade pass frequency is represented by multiplying the number of blades by the shaft-rotating frequency.

Example: A 40-blade cage fan rotating at 1,200 RPM has a blade pass frequency of 48,000 RPM.

BPFO, BPFI

The bearing defect frequencies for the outer and inner races of a roller or ball bearing. See also *bearing defect frequencies*.

BSF

The bearing defect frequency created by the spinning of ball bearings or rolling elements.

calibration

A test to ensure that the transducer on the vibration data collector is collecting accurate measurements.

coast up/coast down

The monitoring of machinery conditions (vibration amplitude) during a start-up or shutdown process. See also *run up/run down*.

condition monitoring

A method of determining the condition of a machine by interpreting measurements taken either periodically or continuously while the machine is running. Also referred to as *predictive maintenance*.

CPM

Cycles per minute. A measurement of frequency; frequency is also measured in *CPS and Hz*.

CPS

Cycles per second; also referred to as *Hertz (Hz)*. A measurement of frequency; frequency is also measured in *CPM*.

critical speeds

In general, any rotating speed which is associated with high vibration amplitude. Often, the critical speeds are the rotor speeds which correspond to natural frequencies of the system.

data collector

An instrument, such as the SKF Microlog, use to collect vibration measurements.

diagnostic frequency

The frequency at which a major machine component vibrates, including such components as the motor shaft, compressor shaft, ball bearings, gear mesh, and blade pass.

displacement
Measures the actual distance a machine travels as it vibrates; expressed in mils. The vibration amplitude of displacement frequencies is monitored and used to assess the condition of a machine's components.

Displacement is used to measure amplitude for machines operating below 600 RPM.

download
Transferring information to the data collection device from the host computer.

eccentricity, mechanical
The variation of the outer diameter of a shaft surface when referenced to the true geometric centerline of the shaft. Out-of-roundness.

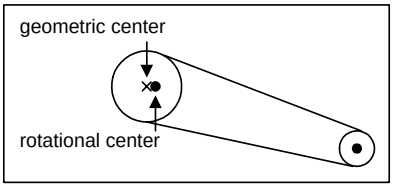


Figure 4: Eccentric sheave.

FIA
Vibration measurement point; stands for Fan Inboard Axial.

FIIL
Vibration measurement point; stands for Fan Inboard In Line.

FIP
Vibration measurement point; stands for Fan Inboard Perpendicular.

FOA
Vibration measurement point; stands for Fan Outboard Axial.

FOIL
Vibration measurement point; stands for Fan Outboard In Line

FOP
Vibration measurement point; stands for Fan Outboard Perpendicular.

Fast Fourier Transform (FFT)
Also known as vibration spectrum. See *spectrum*.

fluid-film bearing
A bearing which supports the shaft on a thin film of oil. The fluid-film layer may be generated by journal rotation (hydrodynamic bearing) or by externally applied pressure (hydrostatic bearing). Also referred to as *journal bearing*.

frequency
How often a repeating event happens in a period of time; for example, one shaft revolution is an event. Frequency is used to identify the source of a vibration because different mechanical problems cause different frequencies.

Frequency is measured in revolutions per minute *(RPM), cycles per minute (CPM), cycles per second (CPS), and Hertz (Hz).*

frequency range
The frequency range (vibration) over which a measurement is collected. Usually refers to upper frequency limit of analysis, considering zero as the lower analysis limit.

Example: A 0-200 Hz measurement is a measurement collected from a range of 0 to 200 Hz.

G's

1 G = 32.2 ft/s/s. Used to express acceleration of vibration.

gear mesh frequency
The frequency generated by two or more gears meshing teeth together. Used to monitor the condition of the gears. Gear mesh frequency is equal to the number of times the gear teeth impact each other in one revolution.

Example: The gear mesh frequency for a large 36-tooth gear running at 10 RPM is 360.

harmonic
A frequency that is an integer multiple of a fundamental frequency. For example, 5400 RPM is the third harmonic of 1800 RPM.

Harmonics often indicate a worsening machinery condition. Harmonics are produced either by an event that occurs multiple times per revolution, or by a distortion of the running speed component's pure sine wave.

heavy spot
The representation of imbalance on a shaft. The heavy spot does not change with rotational speed.

Determining the location of a heavy spot allows for the placement of a counter-weight to correct the imbalance.

Hz
Hertz. Also referred to as cycles per second (CPS): RPM/60. A measurement of frequency; frequency is also measured in CPM.

imbalance (unbalance)
Occurs when a shaft's geometric centerline and mass centerline do not coincide; that is, there is a heavy spot somewhere along the shaft. Imbalance is the second biggest contributor to excessive machinery vibration.

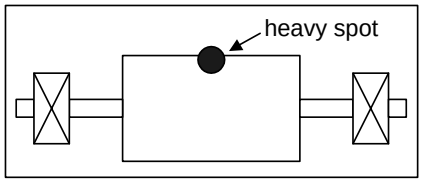


Figure 5: Imbalanced shaft.

IPS
Inches per second. A measurement of vibration.

journal bearing
A plain cylindrical bearing.

line frequency
The frequency of the electrical supply current; 60 Hz in North America, 50 Hz in other parts of the world.

looseness
Occurs when machinery parts are not properly fitted together; causes excessive vibration.

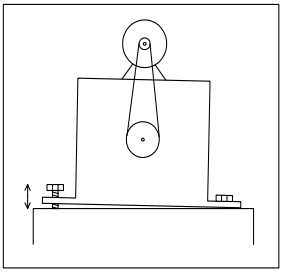


Figure 6: Machine with a loose mounting bolt.

MDA
Vibration measurement point; stands for Motor Drive End Axial.

MDH
Vibration measurement point; stands for Motor Drive End Horizontal.

MDIL
Vibration measurement point; stands for Motor Drive End In Line.

MDP
Vibration measurement point; stands for Motor Drive End Perpendicular.

MDV
Vibration measurement point; stands for Motor Drive End Vertical.

MOA
Vibration measurement point; stands for Motor Outboard Axial.

MOH
Vibration measurement point; stands for Motor Off End Horizontal.

MOIL
Vibration measurement point; stands for Motor Outboard In Line.

MOP
Vibration measurement point; stands for Motor Outboard Perpendicular.

MOV
Vibration measurement point; stands for Motor Off End Vertical.

magnetic base
A magnet used to mount an accelerometer to a machine surface when collecting vibration data.

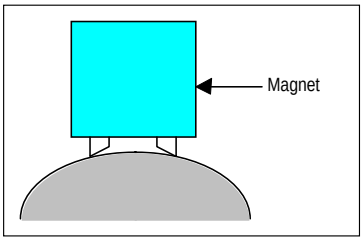


Figure 7: The magnetic base can be mounted to metal surfaces for vibration data collection while a machine is running.

measurement point
The location specified for locating the accelerometer on the machine surface for collecting vibration data.

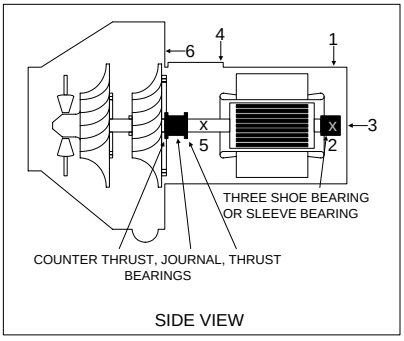


Figure 8: This Carrier 19C chiller requires six measurement points for data collection.

mil
One thousandth (0.001) of an inch. (1 mil = 25.4 microns.) A measurement of vibration's displacement.

misalignment
Occurs when shaft centerlines are not collinear (occupying the same space) during machine operation. Misalignment is the most common contributor to excessive machinery vibration.

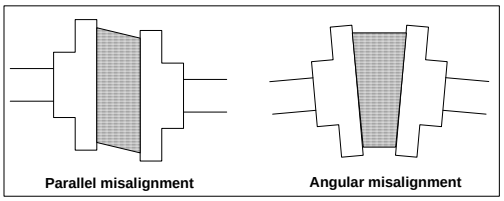


Figure 9: Two types of coupling misalignment.

mounting base, mounting tab
A threaded steel tab that is glued to the surface of a geared chiller; the accelerometer is then mounted to each mounting tab at specified measurement points to collect vibration data.

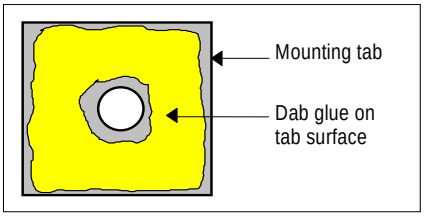


Figure 10: Once glue is applied to the tab, the tab is pressed to the machine surface at defined measurement points and allowed to dry.

natural frequency
The frequency of free vibration of a system. Resonance exists when a machine vibrates at its natural frequency. See also *resonance*.

overall
The sum of all the energy within a specified frequency band. Overall can be calculated by using the root-mean-square (rms) equation.

PIA
Vibration measurement point; stands for Pump Inboard Axial.

PIH
Vibration measurement point; stands for Pump Inboard Horizontal.

PIV
Vibration measurement point; stands for Pump Inboard Vertical.

POA
Vibration measurement point; stands for Pump Outboard Axial.

POH
Vibration measurement point; stands for Pump Outboard Horizontal.

POV
Vibration measurement point; stands for Pump Outboard Vertical.

phase
A measurement of the timing relationship between two signals or between a specific vibration event and a strobe light pulse.

phase reference
The reference signal used in rotating machinery measurements that is generated by a sensor observing a once-per-revolution event. Phase reference is used to measure the phase relationship at other measurement points.

point
The vibration data at a measurement location.

proactive maintenance
A maintenance approach that focuses on identifying and correcting the root causes of machinery problems. Proactive maintenance reduces maintenance and energy costs, downtime, secondary damage, and unnecessary parts replacement.

radial
Vibration measured perpendicular to a shaft's centerline.

radial vibration
Shaft dynamic motion or casing vibration that is in a direction perpendicular to the shaft centerline.

repeatability
The ability of an accelerometer or transducer to reproduce readings when the same input is applied repeatedly. Watching for repeatability ensures that measurements are accurate.

redundancy
A piece of equipment that has a duplicate to be used as a backup. If a non-redundance piece of equipment fails, services cannot continue until the equipment is repaired or replaced.

resonance
Occurs when a machine's vibration frequency is the same as the natural frequency of one of its components. See also *natural frequency*.

RPM
Revolutions per minute. A measurement of frequency.

rolling element bearing

Bearing whose low friction qualities derive from rolling elements (balls or rollers), with little lubrication.

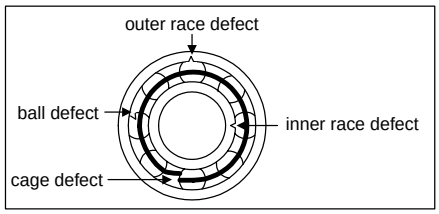


Figure 11: Typical defects on a rolling element bearing.

rotor bar passing frequency

The periodic pulsation in an induction motor equal to the number of rotor bars times the RPM of the rotor. The frequency is used to monitor the condition of the rotor.

route

A list of data collection points and machines for a customer location that the Predictive Diagnostics Team downloads to the SKF Microlog. Data is collected for a route in the order the points are given.

run up/run down

The monitoring of machinery conditions during a start-up or shutdown process. Also referred to as *coast up/coast down*.

sideband

Evenly spaced peaks centered around a major peak in a spectrum. When sidebands have high amplitude and there are many sidebands occurring in a spectrum, the machine condition is worsening.

signature

See *spectrum*.

slip frequency

The difference in frequency or speed between the synchronous speed of the stator and the actual speed of the rotor. Slip frequency is monitored to assess the condition of the rotor.

spectrum

A graphical representation of frequencies and their amplitudes. Created through vibration analysis; it is distinctive and special to a machine or component, system ,or subsystem at a specific point in time, and under specific machine operating conditions.

Spectra can be used to diagnose specific machinery problems and to build an historical comparison of mechanical condition over the operating life of a machine.

Spectra is plural for *spectrum*. Also known as a vibration spectrum, signature, or Fast Fourier Transform (FFT).

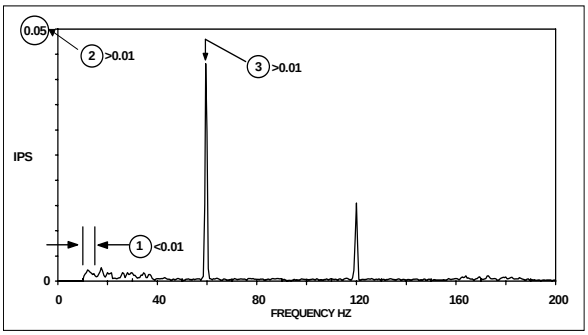


Figure 12: Spectrum showing vibration data collected on a chiller.

stator

The non-rotating component of an induction motor, comprised of a stack of laminated plates that carry two conductors per slot to provide a rotating magnetic field.

transducer

A device that translates a physical quantity into an electrical output.

trend
The measurement of a variable (such as vibration) over time.

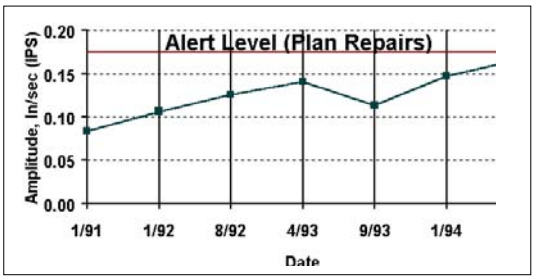


Figure 13: Trend plot.

trigger
Can be used to initiate a measurement so a phase relationship can be established.

unbalance
See *imbalance*.

upload
Transferring data from the data collection device to the host computer.

velocity
The speed of vibration. Velocity is measured in inches per second (IPS) and is one of the most common units used to express amplitude.

vibration
Back and forth motion. Common machinery problems generate forces that change direction as machines rotate. This results in vibration that repeats.

vibration analysis
A method of diagnosing machinery problems, determining the severity of those problems, and forecasting the most appropriate time to correct them. Vibration analysis is a predictive maintenance technology.

vibration level
The magnitude of vibration. Sometimes referred to as *amplitude*, most often measured in IPS.

vibration spectrum
See *spectrum*.

waterfall
A three-dimensional multiple spectra display.

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