Vibration Applications With Vibrating Screens

Article ID:	**NK-1000-0572**
Publish Date:	**04 Mar 2015**
Article Status:	**Approved**
Article Type:	**General Product Technical Information**
Required Action:	**Information Only**

Recent Article Revision History:

Revision/Publish	Description of Revision
04 Mar 2015	**updated affected products**

(See end of article for a complete revision history listing.)

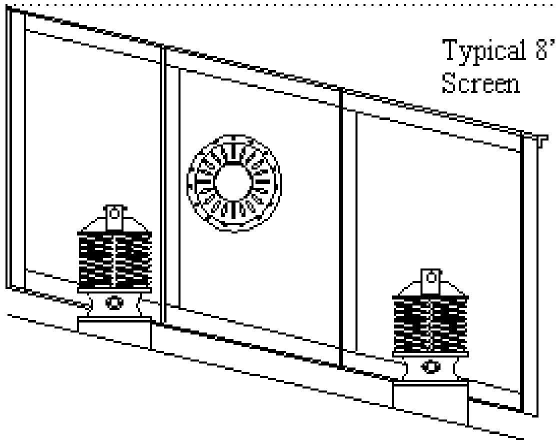
Affected Products:

Product Line	Category	Device	Version
Machinery Health Management	**AMS Machinery Manager Software**	**Data Analysis**	

Vibration analysis is a very powerful and cost effective tool. Put to good use, it can help save thousands of dollars in unplanned downtime and unnecessary maintenance activities.

In most traditional applications of vibration analysis, data is collected on rotating elements, such as motors, pumps, fans, compressors. This data shows the mechanical condition of the equipment. For example: bearing faults, gear faults, misalignment, coupling problems, etc. More advanced uses could include buildings and other structures, where data collected could detect certain design flaws and/or structural degradation.

These applications are certainly appropriate in the material handling industry. They are being implemented throughout the industry and established programs are starting to realize the many benefits of a vibration analysis program. However, there is a piece of equipment indigenous to this industry that escapes the more traditional analysts, the vibrating screen. They are normally passed over on the initial sight assessment due to their large and seemingly violent motion. However, the vibration analyzer is capable of providing a wealth of data that can help both maintenance and production get full utilization out of their screen.



Typical 8' x 24' Inclined Vibrating Screen

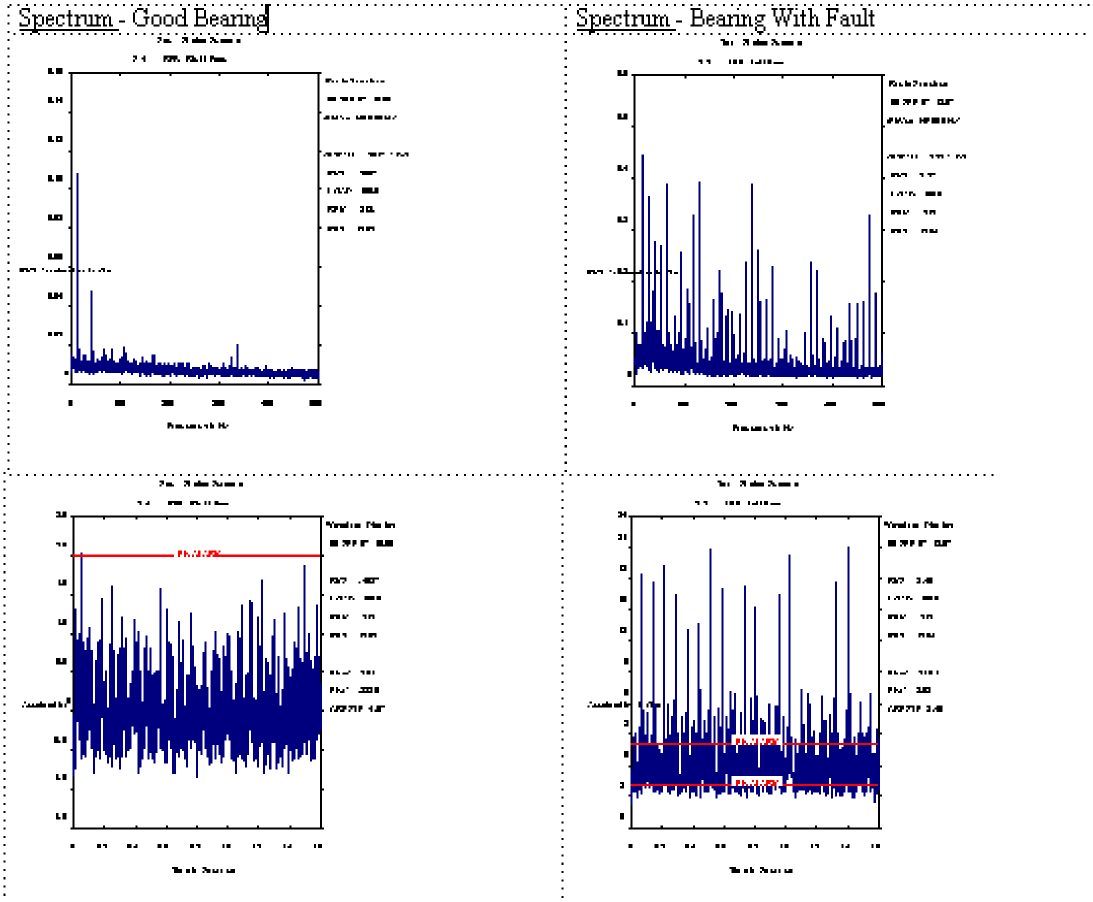
A vibrating screen is a piece of equipment that separates different size material. Separation of material is accomplished by means of screening media, commonly referred to as decks, which act like a filter. The screen deck has certain size opening in it. The smaller material falls through the opening while the larger material remains on top of the screen deck. The entire screen can vibrate at up to 1000 cycles per minute and can have as many as three decks. The decks are arranged above each other, usually with the larger opening screen deck being on top and the lower screens having smaller opening respectively. As material is feed onto the top deck, the screen can vibrate at over 5 G's. The material falls through the openings and is separated. Each deck's overflow is usually directed into a chute and the material that falls completely through is sent to a chute.

The screen is supported on all four corners by either steel springs or rubber "donuts" , and it can either rest on the floor or be suspended by rods or chain. The motion of the screen is provided by an eccentric shaft. This shaft is inside a housing that serves as the mount for the bearing. Screens can have up to three shafts, each in their respective housing.

Signal Modulation

Signal modulation is a problem when trying to get a vibration signature on the drive mechanism. The screen is moving at a speed of up to 1000 cpm and can be producing forces in excess of 5.0 G's. Modulated data provides little useable information about the condition of the bearings or gears in the drive mechanism.

Typical modulated data would only appear as a single peak at turning speed. To get usable information, the modulation would have to be corrected for as it was collected. That means that the carrier frequency would be filtered out, leaving only the higher frequency data (impacting) of the bearings and/or gears. A technique known as PeakVue® is used in the following example.



Spectrum - Good Bearing

Spectrum - Bearing With Fault

The "good" spectrum does contain a once per revolution impact as indicated by the peak at Turning Speed. This is normal in vibrating screens due to the eccentric shaft in the drive mechanism. The "bad" spectrum contains peaks that are non-synchronous to turning speed. These peaks matched the inner race fault frequency of the bearing. Note the difference in amplitudes of the two spectra.

A normal waveform usually shows peaks of over 1 G due to the eccentric shaft, so a peak alarm of 2 G's is chosen as an alarm.

Traditional Screen Troubleshooting Techniques

Traditional techniques for identifying problems would include:

- Measuring spring height
- Checking for level spring mounts
- Checking the level of screen (side to side)

- Checking for evenly distributed flow from feed chute
- Checking for restrictions to motion
- Checking the stroke (trace of the motion)
- Measuring the stroke length
- Measuring screen speed

The traditional analysis of a screen's motion, acceleration and angle is accomplished with a *screen card or screen gauge*. A screen card is a rectangular, magnetic card that has several black circles of varying diameters on it. It also has several straight lines all being at a different angles from the edge of the card. This card is placed squarely on the screen. While the screen is running the circles will appear as an oval. The oval with the most solid center is the correct throw of the screen. The straight line that is clearest is the proper angle of the screen. To get an idea of the orbital motion of the screen a white sticker is applied to each corner of the screen. A pen or pencil, held firmly, lightly applied to the sticker, allows the motion of the screen to be traced onto the sticker. The resulting "plot" is the motion of the screen, and the length of the long axis of the oval is the screen's "throw".

The speed of the screen can be assessed with a contact tachometer or strobe light.

The acceleration of a screen is measured with the following equation:

$$\frac{\text{(Screen Speed in RPM)2 X (Screen Throw in inches)}}{100{,}000} = \text{G's}_{\text{RMS}}$$

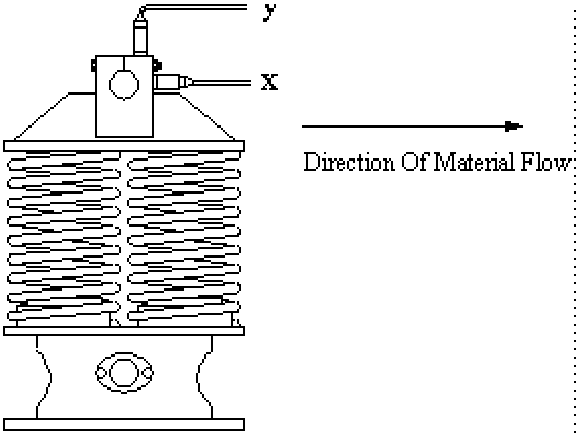
General Screen Acceleration Standards

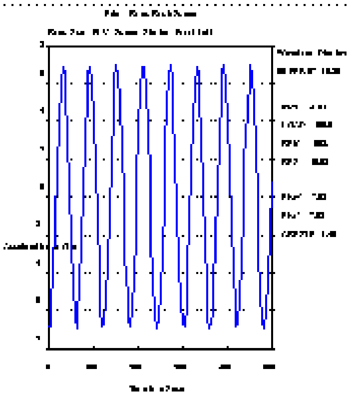
Application	**Nominal Aperture Size (mm) of Screening Elements**	**Stroke (mm) HD ND**	**Speed (rpm) HD ND**	**G Index (target) Loaded**
Scalping	>75	12.0 - 10.5	750 - 800	3.8
Ballast	75 to 32	10.0 - 8.5	850 - 900	4.0
Aggregates	25.4 to 6.7	9.0 - 8.0	900 - 950	4.1
Fines Separation	<6.7	8.0 - 7.0	950 - 1000	4.0

HD - Heavy Duty: Deep bed depth. high % of nearsize particles in feed, plugging or blinding is a problem.
ND - Normal Duty: Nearly optimum bed depth, avg % of nearsize particles in feed, & minimal plugging or blinding.

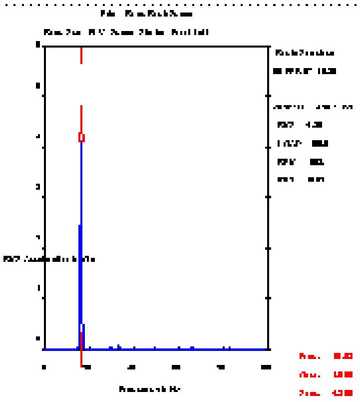
Orbit Analysis On Vibrating Screens

Vibration data is collected at each corner of the screen. Each corner is designated by either Feed (F) or Discharge (D) and Left (L) or (R) . So then FL would be Feed Left, etc.





"Waveform"

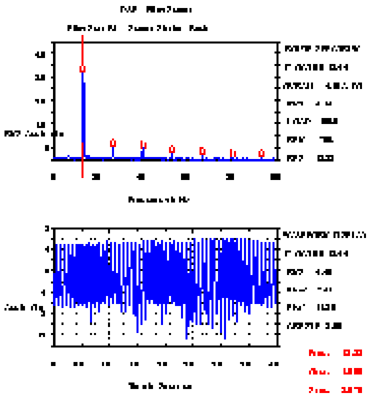


"Spectrum"

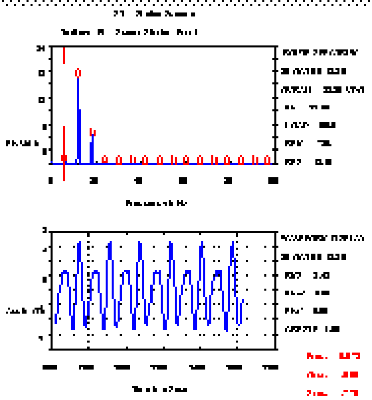
The vibration data also tells us the speed of the screen. Notice in the top right hand corner of this spectrum we see the RPM = 998. This is accomplished through the fact that for each complete rotation of the shaft the screen makes one complete cycle up and down. Therefore by measuring the number of cycles per minute, we know the number of shaft rotations per minute.

Knowing what a "good" screen should look like, we can look at others and deduce that there are problems.

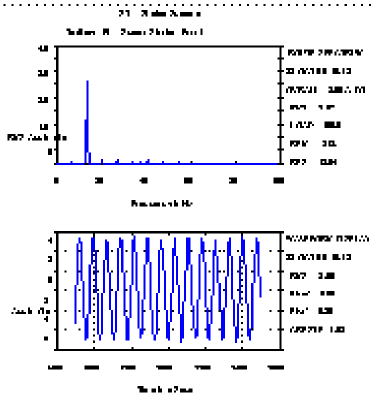
For example:



This screen reflects that something is allowing the screen to travel way too far in the down direction. A weak cross member was suspected. And upon inspection some broken bolts were found and replaced. The new data looked fine.



This particular screen had rubber donuts instead of steel springs. And further inspection revealed that the rubber donuts were supposed to be 10" high but had collapsed and were now only 7" high. The rubber donuts were replaced and the following vibration data was taken.

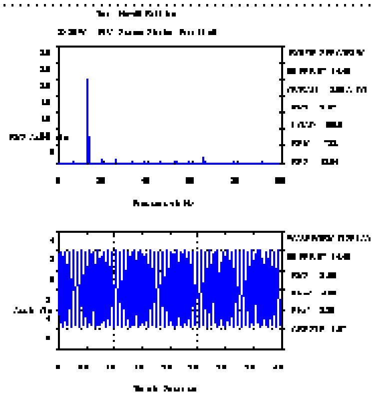
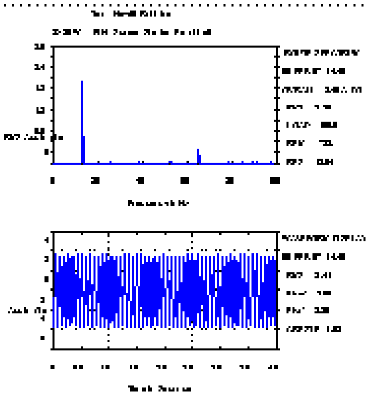


Notice there is now no wasted energy, like in the first picture.

More Advanced Vibration Applications With Screens

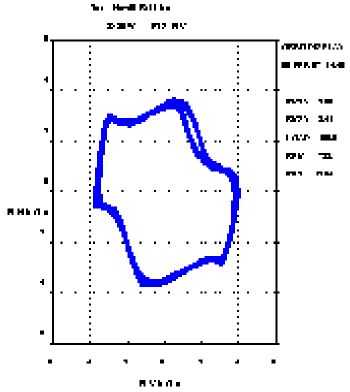
It was mentioned earlier that the data needed to be collected in the vertical and horizontal planes at the same time. And to accomplish this you would need a dual channel analyzer. This is because the data needs to be in phase to provide us with the capability to do an Orbit Plot. An orbit plot is a plot of the relative motion between two transducers. Or in the case of a vibrating screen it would be called the trace of the screen's *Stroke*.

Why is that necessary, when we have the screens waveforms and spectra already? Because the pure waveforms and spectra do not always alert us to everything we want to know about the motion of the screen. For example:

Front Left Vertical	Front Left Horizontal
	

These 4 plots reflect what would be considered a normal screen, with nothing in the spectra or waveforms to alert a problem.

However, if we were to plots the two waveforms simultaneously, we would see a different picture

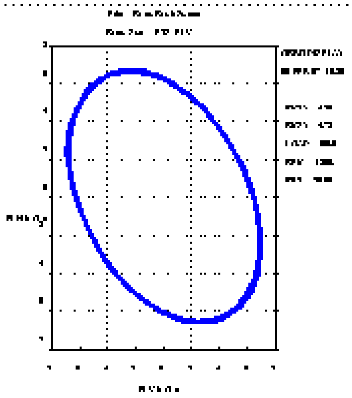
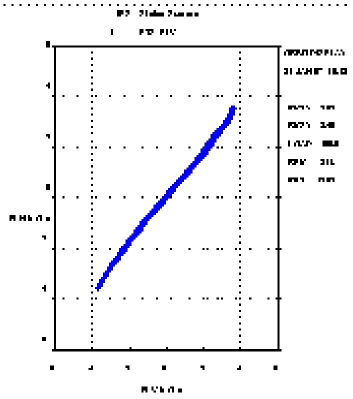


We can see from the plot that the motion has two flat spots, located at about the 4 and 10 o'clock positions. Broken internal cross members were found.

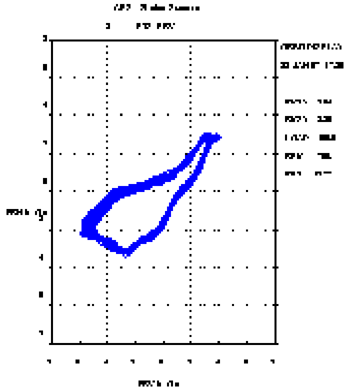
The orbit plot can provide a wealth of data not seen in the spectra and waveforms.

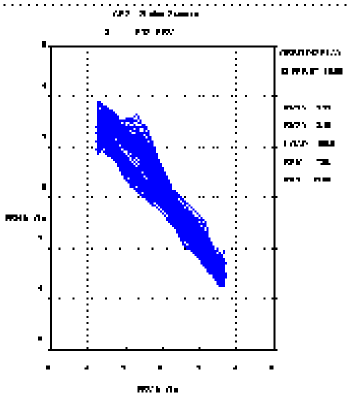
It becomes easier to spot a screen with problems when we compare its orbit plot to that of a good one.

For example:

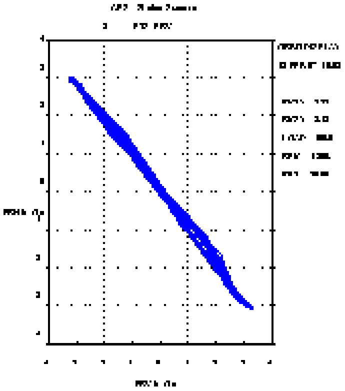
	This would be the perfect orbit plot for an inclined screen.
	Horizontal screens should have an orbit plot like this. Notice the motion is all in a line.

Knowing that makes it easy to spot a bad one when it looks like this:

	This screen had several broken springs.



The springs were replaced and the follow-up data looked like this. Further inspection found that the top screen deck had excessive wear on the right hand side. This condition allowed a large percentage of the material to pass through on the right hand side of the screen and thus overload it on that side.



To verify this condition, additional data was collected on the screen with it running empty. It looked like this. It was deduced that replacement of the worn screening media would correct the rest of the problem.

Linking Traditional Inspections With Vibration Data

There is no doubt that linking the traditional inspections with the vibration data could provide an invaluable tool for troubleshooting and “tuning” screen performance.

The collection of the vibration data in the vertical and horizontal planes at the same time provides us with valuable data.

First - Screen Speed

The frequency of the up and down motion of the screen is the speed of the screen.

Second - Orbit Plot

By graphing the screens vertical and horizontal vibration at the same time we get and actual trace of the motion of the screen.

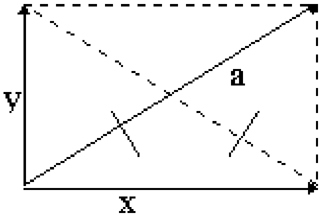
Third - Screen Angle

By treating the vertical and horizontal vibration at the speed of the screen as vectors in the x and y planes, we can use the following equation to calculate the angle of throw of the screen.

Arctangent y/x = Angle of Throw

Fourth - Screen Force At Angle Of Incidence

Again by using the vectors we can solve for the resultant vector. Which would be the actual G’s of acceleration that the material on the screen is seeing.



a is equal to the hypotenuse of the triangle formed by **x** and **y**. Therefore, by solving for **a** we get the resultant vector of **x** and **y**.

Where **a** is equal to the square root of **x** squared plus **y** squared.

$$a = \sqrt{x^2 + y^2}$$

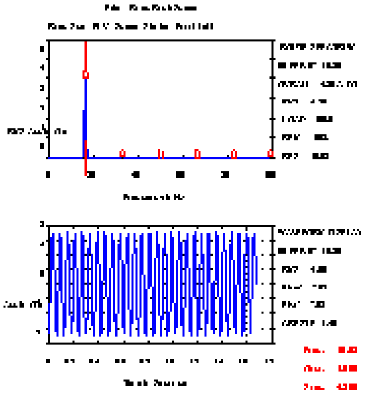
Fifth - Actual Length Of Stroke

By taking the acceleration of the resultant vector **a** in G’s (RMS) and converting it to displacement in Mils (Peak - Peak)) at the speed of the screen, we can calculate the actual length of the stroke.

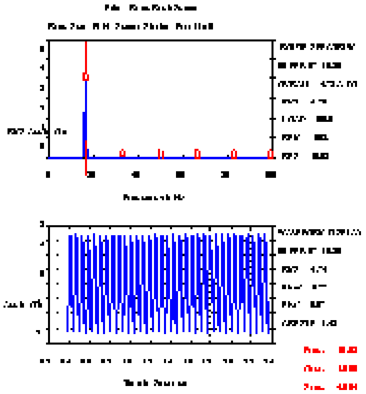
This equation is (G’s RMS 386.4 1.414) (2 (RPM/60))2 2 = Mils Peak - Peak

Full Example Of Screen Information Derived From Vibration Signature

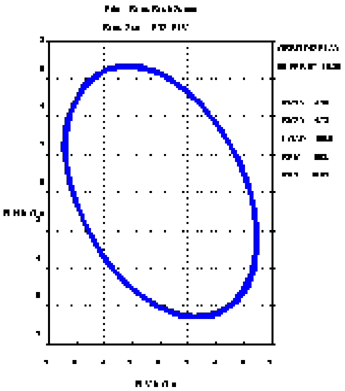
Front Left Corner - Vertical



Front Left Corner - Horizontal



Orbit Plot

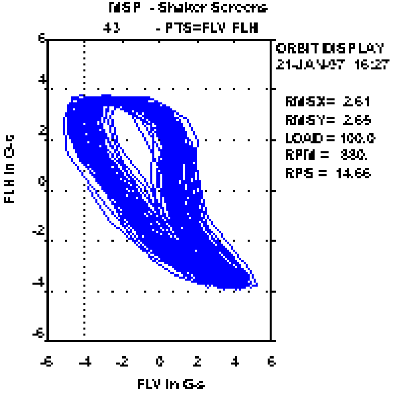


Physical Data:

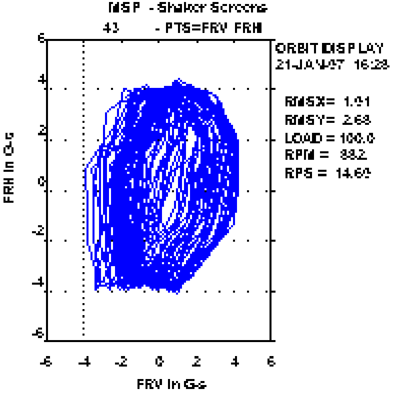
Speed	998 rpm
Horizontal Force	X = 4.694 G's
Vertical Force	Y = 4.859 G's
Angle Of Stroke	45.98°
Force At Angle Of Stroke	6.756 G's
Stroke Length (mils)	675.63
Stroke Length (in)	11/16

Before & After Examples

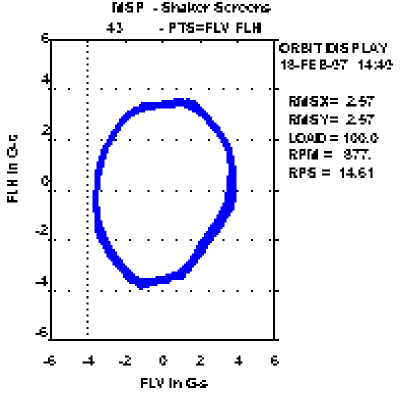
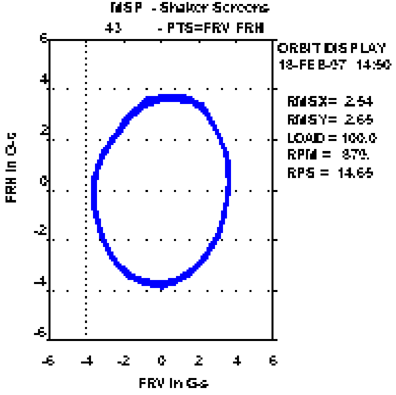
Discharge Left - Orbit *Before*



Discharge Right - Orbit *Before*

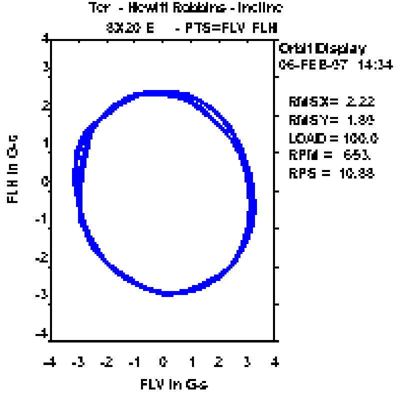
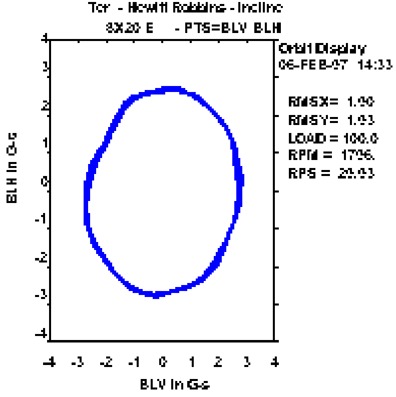


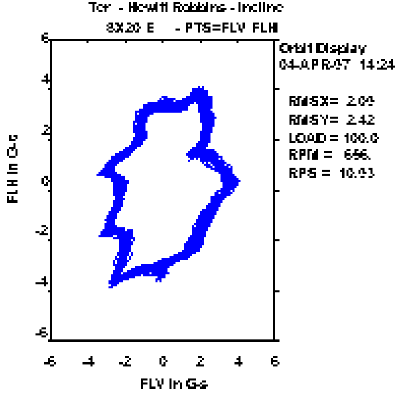
Angle of Throw	45.44°	*Angle of Throw*	54.52°
Force (G's)	3.72	*Force (G's)*	3.29
Stroke (inches)	½	*Stroke (inches)*	7/16

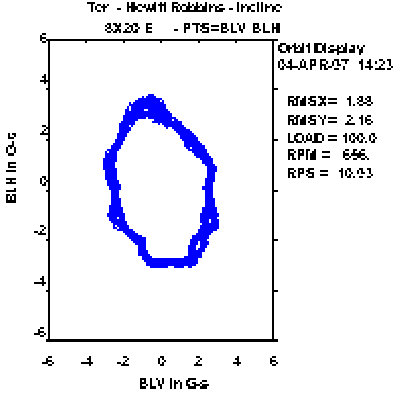
<table>
<tr><td colspan="2">Discharge Left - Orbit <i>After</i></td><td colspan="2">Discharge Right - Orbit <i>After</i></td></tr>
<tr><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td><i>Angle of Throw</i></td><td>45.00°</td><td><i>Angle of Throw</i></td><td>46.21°</td></tr>
<tr><td><i>Force (G's)</i></td><td>3.63</td><td><i>Force (G's)</i></td><td>3.67</td></tr>
<tr><td><i>Stroke (inches)</i></td><td>7/16</td><td><i>Stroke (inches)</i></td><td>½</td></tr>
</table>

Screen Speed = 880 rpm

Degradation Examples

<table>
<tr><td colspan="2">Discharge Left - Orbit <i>Before</i></td><td colspan="2">Discharge Right - Orbit <i>Before</i></td></tr>
<tr><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td><i>Angle of Throw</i></td><td>40.41°</td><td><i>Angle of Throw</i></td><td>45.45°</td></tr>
<tr><td><i>Force (G's)</i></td><td>2.92</td><td><i>Force (G's)</i></td><td>2.71</td></tr>
<tr><td><i>Stroke (inches)</i></td><td>11/16</td><td><i>Stroke (inches)</i></td><td>5/8</td></tr>
</table>

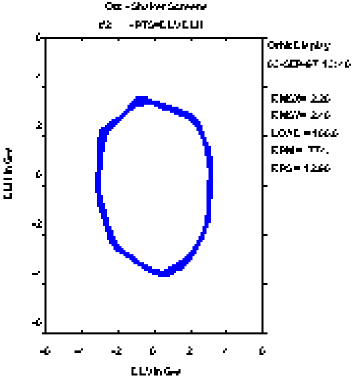


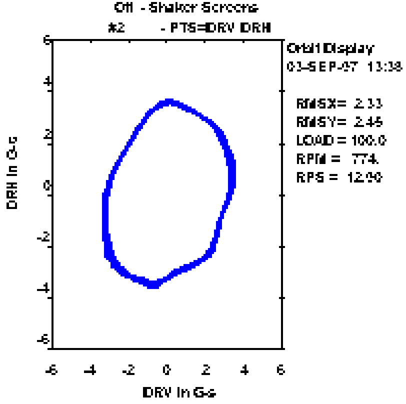


Discharge Left - Orbit *After*		**Discharge Right - Orbit** *After*	
Angle of Throw	49.19°	*Angle of Throw*	48.96°
Force (G's)	3.2	*Force (G's)*	2.86
Stroke (inches)	¾	*Stroke (inches)*	11/16

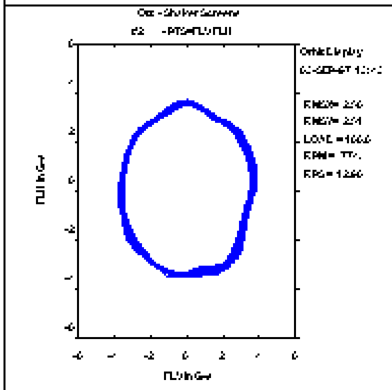
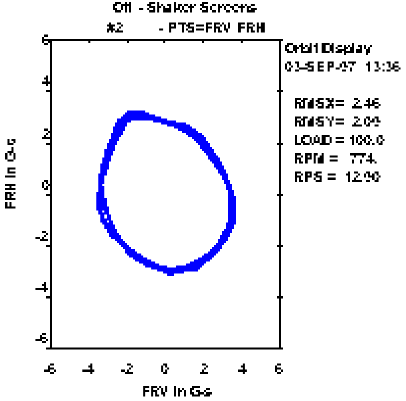
Screen Speed = 656 rpm

Structural Problems



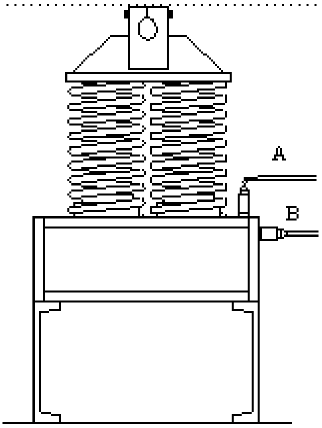


Discharge Left - Orbit		**Discharge Right - Orbit**	
Angle of Throw	42.62°	*Angle of Throw*	43.63°
Force (G's)	3.31	*Force (G's)*	3.36
Stroke (inches)	9/16	*Stroke (inches)*	9/16

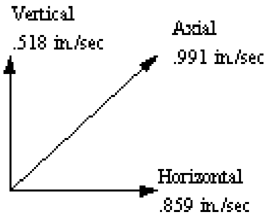
Feed Left - Orbit		**Feed Right - Orbit**	
			
Angle of Throw	45.42°	*Angle of Throw*	49.68°
Force (G's)	3.56	*Force (G's)*	3.2
Stroke (inches)	9/16	*Stroke (inches)*	9/16

Screen Speed = 774 rpm

Structural Problems Continued

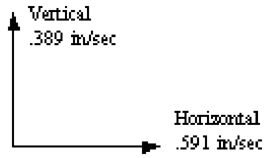


Discharge Right



Vibration readings were taken on the pedestals supporting the springs on several corners. The arrows above represent the vibration amplitudes in all three planes. The vertical reading was collected with the transducer mounted in position A. The horizontal reading was collected with the transducer in position B. And the axial reading was also collected in position B, but with the transducer facing the body of the screen.

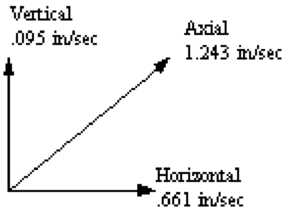
Feed Right



Vibration reading were taken on this corner in the same manner and the amplitudes are noted at the right.

The amplitudes on this corner are lower than the discharge end, but still are above the recommended levels.

Feed Left



Vibration reading were taken on this corner in the same manner and the amplitudes are noted at the right.

The vertical amplitude on this corner are considerably lower than the other corners and within the tolerable limit. This indicates that the structural movement at this corner in the vertical plane is not a problem. However, the horizontal amplitude remains high. The maximum axial movement was noted on this corner.

Discharge Left

No structural readings were collected on this corner. It was surmised that the reading on this corner would be similar to the other corners. And that the other readings were sufficient to display the structural issues.

Things That Cause Bad Orbits

Installation Issues

Pedestals not equidistant from screen body
- Trunion Not Level
- Springs Not Plumb
- Screen Not Level

Weak Column
- Broken Welds
- Weak Beams (Torsional Weakness)
- Structural Resonance

Belts Too Tight

Motor Broke Over Center

Broken Cross Member

Weak or Broken Springs

Uneven Feed

Revision/Publish	Description of Revision
04 Mar 2015	**updated affected products**
16 Dec 2010	**Original release of article**

View Emerson Products and Services: Click This Link