Cutting Analysis Time While Improving Diagnostic Accuracy Through Proper Database Setup

The Importance of the Database Setup

The database for your vibration program, if properly set up, can provide an effective platform from which you can work to guard your equipment against unexpected downtime and catastrophic failure. Improperly set up, it can not only provide you with ongoing headaches and time consuming processes in return for very little real protection but it can actually doom your program right from the start. Improper database setup severely complicates data interpretation, a subject that is extremely complicated and difficult to master to begin with. Even for an experienced data analyst, setting up even a moderately sized database is a task that has numerous traps and pitfalls that, if not negotiated, can cause severe problems down the road.

Switching from DOS to Windows

With that in mind, Vibe-Assist's switch from Emonitor DOS to Emonitor for Windows 5 years or so ago was, to say the least, a bit traumatic. EFW didn't do the same things that the DOS software did and even the similar things it did were done (at least slightly) differently. Much of our difficulty (and other's, I'm sure) was overcoming the "we've always done it this way" mindset. As primarily a service company, we were affected in a number of ways – nearly all negative. We couldn't review the data the way we were accustomed to because the reports we were used to getting in DOS were not available. Analysis time increased as we struggled to overcome these new problems. EFW (and subsequently Odyssey), although very powerful, was very complicated. There were capabilities there to handle our analysis needs – the question was how to make them work with our database setup (which was a fairly traditional setup). Using a database translated from DOS was very cumbersome – the larger the database, the less efficient it was to analyze and the more cumbersome it was to use.

We were fortunate in that we were doing a lot of start-ups for Entek and were able to acclimate ourselves to the new database structure that EFW presented. Setting up databases during these start-ups was time consuming and difficult since each had to be built from scratch. It was only after that period of time during which we got to know EFW that it became apparent that we were NOT going to get EFW to do what we wanted with the database setup we had always used and been successful with. We needed a new approach. We were looking at things backwards. We couldn't make the software capabilities fit the existing database setup – *we needed to create a new database setup that allowed us to utilize the new capabilities of EFW.*

How Vibe-Assist Analyzes Data

Vibe-Assist's service philosophy has always been to actively review the data and not use alarms. Although alarms have their place, they are only as good as how well they are set up <u>and</u> maintained. In my opinion, they should <u>only</u> be used by experienced analysts in well-established programs. The main problem is that they often convey a false sense of security and nearly always will either over-protect or under-protect your equipment. The former tends to reinforce that sense of complacency since machines running normally can be in alarm month after month and the latter has its own obvious problems. Additionally, an inexperienced analyst relying extensively on alarms never actually learns to review and analyze data – they rely on alarms to inform them of 'problems'. Finally, setting up and maintaining band alarms in EFW or Odyssey is very complicated and the alarm reports we could get at the time didn't provide much useful information.

But there is, of course, a need to "weed through" the data and <u>reliably</u> pull out areas of concern (<u>alarm</u> us) – it is not practical to review <u>every</u> piece of data. To accomplish that in the DOS software, there was one report in particular that we used extensively and successfully and sorely missed when starting with EFW. This custom report would list the single highest amplitude on every spectrum and the frequency it occurred at. That amplitude, however, could be worthy of attention (1.1 ips, for instance) or not worthy of attention (0.02 ips) – there was no minimum threshold set by the analyst, the software simply grabbed the highest amplitude for the report no matter what it was.

Along those lines, we saw an extremely powerful tool lurking in EFW's reporting capabilities – the ability to generate a report that listed the frequency and amplitude (among other selected bits of data) of <u>every</u> peak on a spectrum that exceeded an amplitude threshold that was set by the analyst. In fact, EFW's capabilities were <u>far</u> superior to what we were used to with the DOS software – a way to efficiently yet reliably perform a preliminary analysis of the spectral data with a simple to understand text report. The problem was figuring out how to use that capability properly.

The initial problem was setting the threshold amplitude. Although we took – and still take – specialty spectrums based on the specific needs of a machine, we had always concentrated on velocity spectrums as our main analysis tool.

Consider a typical velocity spectrum to 120kcpm. This spectrum is designed to monitor both low frequency vibrations (1x, 2x, 3x rpm, etc.) and high frequency vibrations (primarily bearing defect related). If the amplitude threshold was set at, say, 0.05 ips, the report would be a reasonably safe one for detecting bearing defects developing but overkill for low frequency vibrations (rpm related). The result would be a huge report with a lot of useless garbage showing up – OVER-alarming.

Conversely, consider setting a 0.20 ips threshold for the same spectrum. That would be a good threshold for the low frequency end of the spectrum (rpm related) and it would also keep the report length within reasonable limits. However, that threshold would be very high – and consequently dangerous and unreliable – to use for monitoring early or even intermediate stage bearing defect related vibrations occurring at high frequencies – and bearing monitoring, of course, is of utmost importance. The result would be a report that would be likely to UNDER-alarm the analyst.

Rethinking The 'Old' Ways

The 'New' Database Structure

Our solution to this problem of where to set the threshold required rethinking the entire database structure. It took some creativity and abandonment of the 'old' ways of thinking but in doing so we killed several birds with one stone (bad news for the birds but good news for us). Our 'new' database structure consisted of the following measurements:

Measurement #1: A velocity magnitude. This is used for trending primarily the low frequency end – unbalance, misalignment, looseness, etc. (basically vibration occurring from sub-synchronous up through the to 8x – 12x rpm range).

Measurement #2: A velocity spectrum. The Fmax of the spectrum will depend on the location, the speed and the drive transmission of the machine. For a direct drive, it can be as high as 30kcpm or as low as 6kcpm. For a belt drive, it can be as high as 12kcpm or as low as 6kcpm. In any case, a spectrum with such a low Fmax (and in a few cases up to 1600 lines) gives you anywhere from good to excellent spectrum resolution – a critical spectrum tool. These spectra can then be used to generate a report that includes all amplitude peaks exceeding, say, 0.15 ips (the threshold can be set at any amplitude you like). Since it is only 'watching' the low frequency end of the spectrum, this is adequate.

Measurement #3: An acceleration magnitude. This is used for trending the high frequency end – bearings, gears and high frequency electrical symptoms.

Measurement #4: An acceleration spectrum. The Fmax of this spectrum will be either 60kcm or 120kcpm (excluding special cases such as gear applications) depending on speed. An acceleration spectrum is far more sensitive to high frequency problems developing (i.e. bearings) than a velocity spectrum and very insensitive to low frequency influences such as 1x, 2x & 3x rpm vibrations. This spectrum can then be used to generate a report that includes all the amplitude peaks exceeding, say, 0.8 g's. For those of you not familiar with acceleration amplitudes, at 60,000 cpm 0.8 g's is equivalent to about 0.05 ips. At 120,000 cpm, it is equivalent to about 0.025 ips. Again, that threshold can be adjusted down (or up) to accommodate your (and your machine's) comfort levels. The beauty of this report is that any lines that show up will be (in the absence of gears) either electrically related or bearing related 99.9% of the time. It immediately tips us off to the presence of a bearing defect developing at an early stage. The only thing missing is the bearing defect frequency so the next reading we take is the . . .

Measurement #5: A gSE spectrum (no magnitude). When a line shows up on the acceleration report, we assess the amplitudes and then go to the gSE spectrum to look for the impact frequency related to the defect. We can assess the intensity of the impacts by analyzing the gSE spectrum on a dB scale and assess the severity of the bearing condition from the acceleration spectrum.

Measurement #6: A time domain reading intended to capture 5 – 7 shaft revolutions. Although many people are not comfortable with time domain analysis, it can be an extremely powerful tool that gives you information not available on the spectrum.

The 'Downside'

Now, we *have* noticed that the response to this is often "We don't have time to collect all of that data !!". We can't argue that we've increased the collection time and if that is of critical importance to you, that's fine. But let's examine how much we've really affected it. We'll start with the last reading – the time domain.

- The time domain reading can be made inactive. We use time domain when troubleshooting and normally for slow speed equipment, gear applications and sleeve bearings (especially if we are getting accurate shaft movements) but often do not collect it as part of a periodic route.
- The gSE and acceleration spectra plus the acceleration magnitude are all non-negotiable – they are collected under all circumstances. The time required to collect these 3 readings is minimal (possibly 5 – 8 seconds). Also, we only collect one gSE reading per bearing (even if taking tri-axial readings). The magnitude gives of a good high frequency only (little if any influence from low frequencies) trending tool while the spectrums give valuable bearing related information.
- The velocity spectrum is the killer. That single reading – because of the good to excellent spectrum resolution – is responsible for the lion's share of the collection time. If we get rid of this reading, our collection time is back to normal. But it is too important to get rid of - - - or is it ? Since velocity magnitude allows us to reliably trend low frequency vibration, the spectrum, under the right circumstances, becomes expendable. So what are these 'circumstances'?

How Bad Is The Downside – Really ?

The main 'circumstance' – which applies to most people reading this paper – is that the analyst or technician work at or very close to the plant. As a service company, Vibe-Assist is often an hour or more from the site by the time the data is reviewed. We can't simply return for another spectrum. If you can, however, the approach can be quite different. Once a couple of month's worth of data is collected – a baseline – we can de-activate the velocity spectrum and easily set up some simple statistical alarms based on the velocity magnitude. If they go into alarm, the spectrum can be re-activated and collected. The bearings are still being reliably monitored so the velocity alarms are designed to alert us to low frequency increases – especially sudden increases (the most dangerous of situations).

In addition to that method of 'tweaking' the database to help with collection time, there is something else to consider. During the time spent collecting a route, you are spending your time in three different ways. How much time is spent on each of the following:

1. Walking from machine to machine.
2. Moving the transducer from point to point.
3. Actually collecting & processing the data.

In many cases, collecting and processing data is less – sometimes much less – than 50% of the total time spent. Often the most time is spent walking from machine to machine. So how much does an increase of 5 or 7 seconds per bearing make when the time required for items 1 & 2 above are a constant that are not affected by database setup?

The Upside (Is It Ever !!)

THE argument for utilizing this database structure – something we discovered only after using it for awhile – is actually two-fold. In a nutshell, we achieved a decrease in analysis time (from the DOS software days) of, on average, ***75% with an improvement in accuracy and machinery protection*****.**

The reasons for that rather astounding claim are simple. The first report being generated – the velocity spectrum - will alert us to any peaks above a certain threshold – let's say 0.15 ips (what we normally use). This is the report we 'get to know' because there will be peaks showing up month after month. A level of judgement is used to look over the report and check on the peaks of interest. Here again the software capabilities come into play. With a spectrum open, you can click on the line on the report and not only will the spectrum change to that location id but the cursor will be placed on the peak of interest.

The second report being generated – the acceleration report – will alert us to any high frequency peaks developing. This report is reviewed carefully and every line is investigated. After all, bearing failure is the real bottom line we are guarding against. The gSE spectrum provides valuable insights that help in the analysis and the two together create a powerful line of defense against any bearings deteriorating unexpectedly.

Alarms That Provide Useful Information And Are Easy to Set Up & Use

Let's step back and ask: "What have we really done here?". We have set up a simple, 2-band alarm. The low frequency band is monitored with velocity. The high frequency band is monitored with acceleration. There is no set up involved in these alarms – the threshold is set up in the report and to change it (assuming proper mouse control and a decent computer) takes (we timed it) 11.4 seconds. You don't have to update the alarms – ever. You get a text report that is simple to review and interpret and that is tied directly to the pertinent spectrum.

Let's compare this method to actual band alarms. If you have 6 bands set up and the 4th goes into alarm, what do you do? You go look at the spectrum. How much work was involved in setting up those alarms? Hours? Days? Weeks? Are they statistical? Do they involve 'categories'? *Are they set up to properly protect your equipment?* Each of those involves periodic updating of the alarm values. Even if it is not that time consuming, you still need to remember to do it.

Now let's look at the reports we generate. Can a machine fail without any indication on either report we run? Sure – the same way it can fail without your alarms picking it up. It can fail due to a sudden event that is not caught for one reason or another (loss of lube, component failure, human error, etc.). A vibration program (short of protection systems) has never been and will never be a guarantee against failures. But in the absence of such an event, is there any way for a problem to develop that would trigger an alarm without showing up on one of the reports we use? No. It is as simple as that. It can't slip through the cracks unless it is allowed to by human error. If the vibration goes up on the low frequency end, it will show up on the velocity report and trend. If it goes up on the high frequency end, it will show up on the acceleration report.

Back in the DOS days, we had confidence that between our reports and our experience, we would catch nearly every problem. There were the occasional misses but they were few and far between. With our new database set up, we are confident that we will not only be alerted to catch every problem that lends itself to being detected through vibration analysis but that we will also accomplish it in a fraction of the time – 25% or even less – that it previously took us with our DOS software methods. We felt that we were 'vaccinated' against unexpected failures and that lead we use for our database structure – Vaccine.

Sharing the Information

Creating the Vaccine Templates

Our next step was to use this structure and what we had learned to create comprehensive templates with which a database can be easily created. There were two reasons we wanted this capability. First, we wanted to be able to set up our service (contract) customer's databases easily (in fact, we eventually gutted every database we had and built a new one using the Vaccine structure). Second, we wanted to be able to provide the templates for start-ups we performed. Often, 3-day start-ups are done with beginners – future analysts that may not have even been to a basic theory class yet. We knew that the less we gave them to think about at that point, the better chance they would have of being successful. Since the initial database set up was so crucial to future success, we felt this would give them a fighting chance. The only decisions necessary to create a database from the Vaccine templates are rolling element or sleeve bearings and > 1200 rpm or < 1200 rpm. That's it.

The result of our work was the Vaccine Database Templates that covered fans, pumps, ac & dc motors of different sizes, compressors, slow speed rollers and more. The bearings are set up to be tri-axial and comprehensive – all of the readings we've discussed are included. Unless you are fairly experienced in database setups, it is far easier to remove items or de-activate them than it is to add them in later. We would also provide the custom reports we use to analyze the data and any custom collection specs that we use (including time domain collection specs set up properly).

The Database Setup

Samples of the database structure we discussed above is illustrated here in Figures 1-3:

DATA TYPE	UNITS	COLLECTION	FILTER	STORAGE	ACTIVE
Magnitude	ips	STD-HI (KCPM) 12	318 CPM HP	Always/S026	Yes
Spectrum	ips	STD-HI (KCPM) 12	318 CPM HP	Always/All	Yes
Magnitude	g's	STD (KCPM) 120	Overall	Always/S026	Yes
Spectrum	g's	STD (KCPM) 120	318 CPM HP	Always/All	Yes
Spectrum	g's	gSE STD(KCPM) 60	5kHz gSE	Always/S052	Yes
Time	g's	TW 0000 Select	Overall	Always/3 Year	No

Figure 1
Sample Measurements for Pos. 3 on a belt driven fan running > 1200 rpm
The 'STD-HI' collection spec uses 800 lines of resolution

DATA TYPE	UNITS	COLLECTION	FILTER	STORAGE	ACTIVE
Magnitude	ips	STD (KCPM) 30	318 CPM HP	Always/S026	Yes
Spectrum	ips	STD (KCPM) 30	318 CPM HP	Always/All	Yes
Magnitude	g's	STD (KCPM) 120	Overall	Always/S026	Yes
Spectrum	g's	STD (KCPM) 120	318 CPM HP	Always/All	Yes
Spectrum	g's	gSE STD(KCPM) 60	5kHz gSE	Always/S052	Yes
Time	g's	TW 0000 Select	Overall	Always/3 Year	No

Figure 2
Sample Measurements for Pos. 3 on a direct drive fan running > 1200 rpm

DATA TYPE	UNITS	COLLECTION	FILTER	STORAGE	ACTIVE
Magnitude	ips	STD (KCPM) 12	318 CPM HP	Always/S026	Yes
Spectrum	ips	STD (KCPM) 12	318 CPM HP	Always/All	Yes
Magnitude	g's	STD (KCPM) 60	Overall	Always/S026	Yes
Spectrum	g's	STD (KCPM) 60	318 CPM HP	Always/All	Yes
Spectrum	g's	gSE STD(KCPM) 30	5kHz gSE	Always/S052	Yes
Time	ips	TW 0000 Select	Overall	Always/3 Year	No

Figure 3
Sample Measurements for Pos. 3 on a direct drive pump running < 1200 rpm

These are just a few examples to provide the general structure for people interested. There are additional spectra taken on >10 HP motors, for instance, that are either high resolution (12kcpm, 1600 lines – to separate electrical and mechanical frequencies) or high frequency (200x rpm to monitor winding slot pass and rotor bar pass frequencies). Furthermore, special readings are set up for gear trains, slow speed equipment, sleeve bearings and other specific applications to numerous to include here.

The Key to Vaccine – The Custom Reports

Since the reports we are able to utilize are so crucial to the success of the database structure, samples of the reports are provided here along with some of the important report set up information.

Spectral Data Review
Velocity Data

Location ID	Pos	Dir	Fmax	PkAmpl	PkFreq	RPM	Date / Time
Line-O-Flame BL							
MTR-IB-AXIAL	2	Axial	12000.	.456	3540.	3550.	3/4/99 11:42 AM

Figure 4
The "Velocity" report

The Velocity Report

The velocity report shown here has a threshold of 0.15 ips. The columns are:

- Location ID – Self explanatory
- Pos – Position (number or letter) of measurement
- Dir – Direction of measurement
- Fmax – The Fmax of the spectrum in cpm
- Pk Ampl – The amplitude of the spectrum peak being reported on
- Pk Freq – The frequency of spectrum peak being reported on
- RPM – The rpm listed in the 'RPM' field of the database's location id pane
- Date / Time – Self explanatory

Only a single line shows up on this particular report but it tells us a lot. It tells us that on this entire machine, there is only a single position – #2 bearing – and direction – axial – that generates a velocity peak in excess of 0.15 ips. That peak is at 3540 cpm and the amplitude is 0.456 ips (and in case you forgot, the nameplate rpm is 3550).

If we concurrently have a spectrum plot open and click on this line on the report, the open spectrum will switch to this measurement and the cursor will be placed at 3540 cpm.– the peak of interest. The report can be date sorted (as can all Odyssey reports) to eliminate old data from showing up (or allowing it to in the case of machines that haven't had data collected on them for a while).

The strategy for reviewing the velocity report is to apply your judgement. As you get comfortable with reviewing the report and get familiar with the 'normal' amplitudes your machines generate, you will learn when to take a look and when to just dismiss a line. As an example, a machine may have 0.25 ips @ 1x rpm month after month after month but you don't have the time or resources to balance such a moderately unbalanced fan. You learn to basically 'ignore' that line. But if suddenly one month that same machine were to show a 1x amplitude of 0.46 ips plus the appearance of peaks at 2x and 3x that show up on the report (exceeding the threshold amplitude) – now its time to check it out ! The rpm column allows you to make a judgement on what frequency (relative to rpm) the peak is occurring at.

The Acceleration Report

The acceleration report is identical to the velocity report in appearance. Differences occur only in how the report is generated. It looks for acceleration data only (and not gSE or ESP data) and has a different threshold. Aside from that, it is identical.

The *analysis* strategy for the acceleration report, however, is much different than that for the velocity report. Under ordinary circumstances, a machine with no bearing defects will not generate any report lines unless the motor has vibration occurring at rotor bar pass (RBPF) or winding slot pass frequency (WSPF). If the motor does have RBPF or WSPF, you can tell from the spectrum or even the report that the sidebands are at 2x line frequency. That is, in fact, the first thing you should suspect and look for. In either case, however, the appearance of a line on the report – any line – should be handled by switching to that plot (again, via clicking the line on the report) and analyzing the spectrum. The gSE or ESP spectrum, at this point, becomes an additional important analysis tool by revealing the impact frequency and intensity.

Basically, the acceleration report is analyzed carefully each and every time. After all, our number one job is the prevention of failures and bearings are the #1 suspect for these occurrences so this report is THE critical piece of information.

Creating The Reports

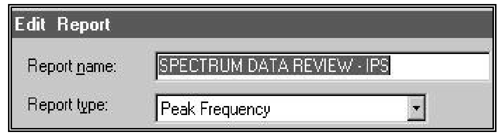

Figure 5

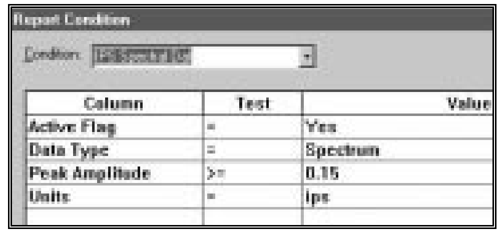

Figure 6

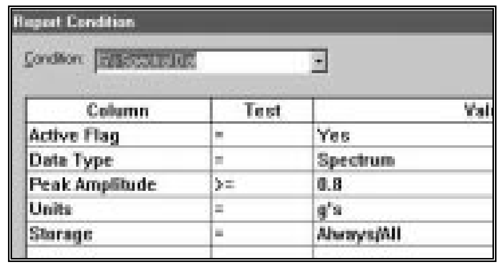

Figure 7

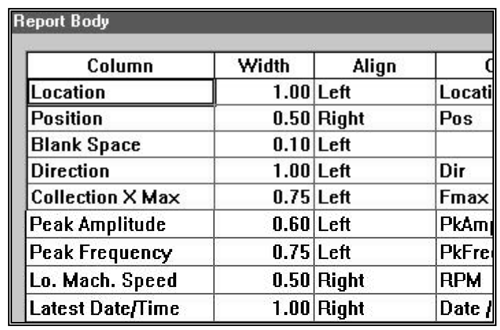

Figure 8

Shown here are some of the critical fields necessary to properly set up the custom reports discussed above. The first (and most important) requirement is the ability to access Odyssey's "Report Builder" feature (under the 'Tools' drop-down menu). After clicking on 'New', you will get a 'New Report' box (clicking on 'Edit' will get you the 'Edit Report' box shown in Figure 5). You can also set margins in this box but the defaults of 1.0" on each side are sufficient (they can be less).

The first of the buttons to access will be 'Condition'. When you click on that button, you will get the box shown in Figure 6 (for the velocity report) and Figure 7 (for the acceleration report). In the acceleration report, note the additional line referencing the 'Storage' field. If you refer back to the database setup, you'll notice that the gSE or ESP spectra have a somewhat different storage specification than the other measurements. This is solely to be able to somehow eliminate the gSE or ESP spectra from consideration when running this report. The software cannot differentiate between the units used for gSE / ESP and the conventional g's measurement so this sorting capability became necessary and this was the easiest field to use.

Also note the Condition names. Once you have set these up properly, you will need to save the condition. You can use the names shown here or any other you like but you will need to name them.

To touch on each button on the right side of the 'New Report' box:

- **Header** – refers to the information at the top corner of the page – for instance, the date and page number.
- **Page Title** – Whatever title you like. The report shown in Figure 4 is titled: Spectral Data Review / Velocity Data
- **Grouping** – Our reports use Grandparent / Parent / Name
- **Body** – This box, along with 'Condition', is the key. Here you will select which fields and bits of data will show up in your report. The setup is shown in Figure 8. The fields under 'Column' are accessed by double-clicking on the field. Using the first letter of the field selected (Location, Position, etc.) will eventually get you to that selection. The width is manually programmed in. The alignment is accessed by double-clicking on the field and the final column – mostly cut off in Figure 8 – is the name you want to appear at the top of each column and is manually inputted.
- **Footer** – We don't use one.
- **Plots** – We don't display any.
- **Sorting** – This will dictate in what order the report contents will be listed. The setup we use is shown in Figure 9 and is the most convenient.

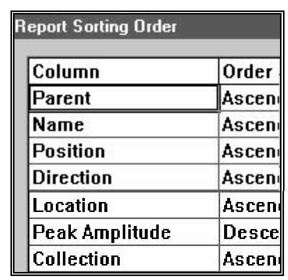

Figure 9

Summary

The database setup here – which includes the custom reports and collection specs – has dramatically decreased our analysis time and improved our accuracy. The one downside – a moderate increase in collection time – is more than offset by the upsides. The key was fitting our database structure to the abilities of the software – not endlessly trying to fit the software to our database structure or just complaining that the software won't do what we want it to. The fact is, Odyssey has some extremely useful tools available. The trick is in finding them and creating a database structure that utilizes them to the fullest extent possible. The problem is that they are often discovered after the database has been signed, sealed and delivered.

One thing I've been fortunate enough to learn in my years of training and doing startups at various plants is that there is any number of ways to skin the 'cat' we call a 'successful vibration program'. This database structure accomplishes that goal with flying colors for Vibe-Assist and it might for you as well.