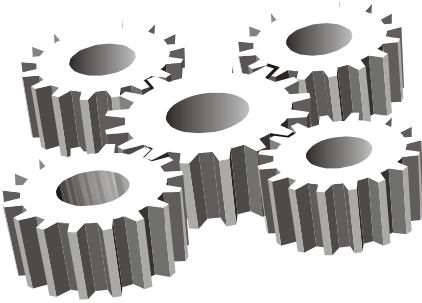


THE BETA BULLETIN



MACHINERY ANALYSIS



Profiling – A Data Enhancement Method

Vibration Profiling is a powerful, fast and accurate diagnostic tool. It condenses complex problems and a large mass of data to a manageable size. Profiling makes quick work of simpler studies. The easy to understand graphical presentation allows Beta Machinery Analysis to explain recommendations to any plant personnel quickly and effectively.

The key concept in Profiling is population-based comparisons; a very simple concept, but extremely powerful. If we have spectra from a population of equipment test points, comparison of vibration attributes across the population will readily portray anomalous behavior patterns without analyzing individual spectra. For example, we might compare the vibration at twice rotational frequency from all bearings in a pump, or series of pumps, to assess alignment.

For any machine geometry and speed, it is possible to predict frequencies at which vibration components will increase if certain machine faults develop. These “fault frequencies” cover the known sources of vibration energy for the test point such as rotational harmonics, bearing defect frequencies, pulsation harmonics, oil whirl, gear mesh harmonics and side bands, etc. This grouping of fault frequencies into “fault groups” is the same approach an analyst would employ in evaluating a spectrum. Procedurally:

- For each test point, the vibration level at each fault frequency is extracted from the spectrum.
- Extracted fault levels are sorted into fault groups associated with rotational harmonics, bearing faults, gear faults, etc.; see table below for examples.
- Graphical presentation of fault levels for each fault group is made in a simple, easily understood bar graph format; see description below and examples on the following pages.
- The initial Profile for each fault group is a “dominant” profile. On the bar graph, each test point has a bar of height equal to the largest level for the fault group being profiled. Annotation is placed above each bar to indicate which fault frequency is dominant; this annotation is an important part of the Profile.

Before using Profiling on plant equipment, a setup procedure is required to define the fault groups and fault frequencies associated with each test point. Examples of fault groups and fault frequencies are listed in the table below.

Fault Group	Fault Freq.	Description
Rotational	1R	Rotational frequency
	2R	Twice rotational frequency
	3R	Three times rotational frequency
Bearing	O	Outer race passing frequency
	2O	Twice outer race passing frequency
	I	Inner race passing frequency
Gear	G	Gear mesh frequency
	2G	Twice gear mesh frequency
	-M	Lower side band; G-R
	+M	Upper side band; G+R
Vane	V	Impellor vane passing

In practice there may be more fault groups than shown in the table, and many more fault frequencies. As learning about failure modes takes place, windows are added, removed or modified.

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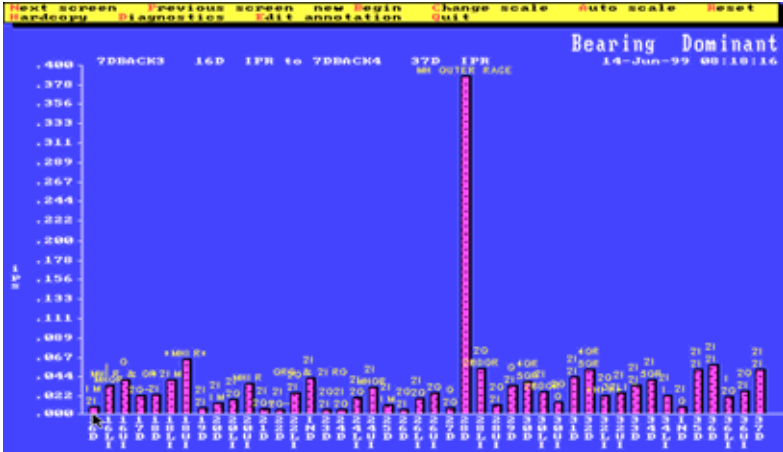
Profile graph format:

Bar locations on the x axis corresponds to test points; at each test point there are one, two or three bars corresponding to vibration measured in one, two or three directions. The y axis is vibration amplitude, usually in velocity units. The height of each bar is equal to the amplitude at the profiled fault frequency. For the *dominant* profile, the profiled fault frequency is the member of the fault group with the largest amplitude. Annotation immediately above the bar indicates which fault frequency is dominant. If this annotation is absent, then the “default” fault frequency is dominant; e.g. “R” in the rotation fault group is omitted if dominant, simply to reduce clutter. There may be a second annotation placed above the first; this indicates that there is a “sub-dominant” component in the group that is greater than 50% of the amplitude of the dominant. Profiles of specific fault frequencies, such as 2R, draw bars equal to the spectrum amplitude at that fault frequency. No annotation is required, since the fault frequency is stated in the graph title.

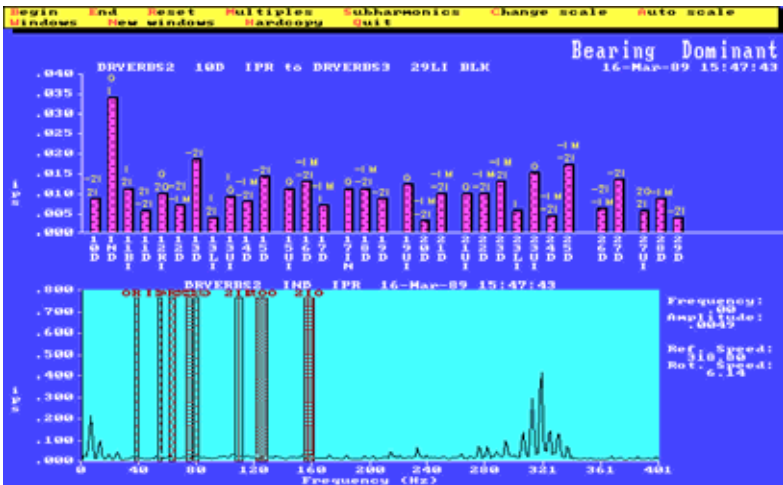


The example to the left helps to demonstrate that Profiling is a powerful diagnostic tool for *any* plant or mill machinery; it is not specifically a paper machine tool. These Profiles show improved rotational vibration in a boiler feed water pump resulting from a change to an improved coupling followed by re-alignment. The Profiles are far clearer than the 12 spectra from which they are derived.

“A picture is worth a thousand words.”

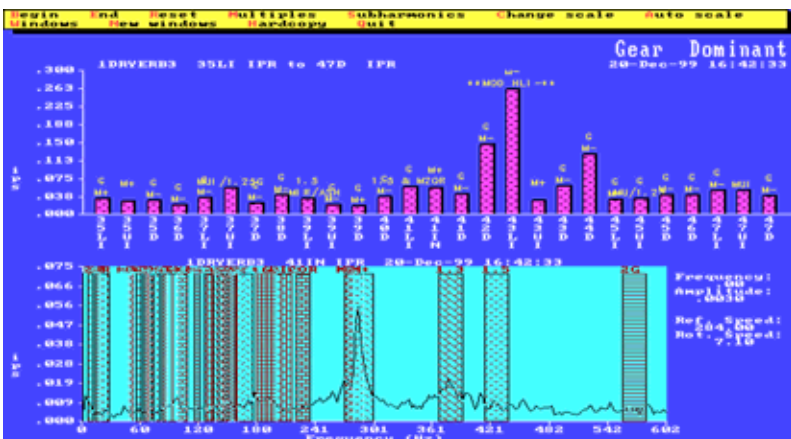


This is a Profile of dominant bearing fault levels from two sections of a paper machine dryer gear train, highlighting a damaged bearing at 28 Dryer (28D). The Profile is derived from a minimum of nine bearing fault frequencies specific to each bearing and from 88 spectra. Note the large data reduction achieved. Instead of reviewing those 88 spectra, we see bearing condition in this one graph.

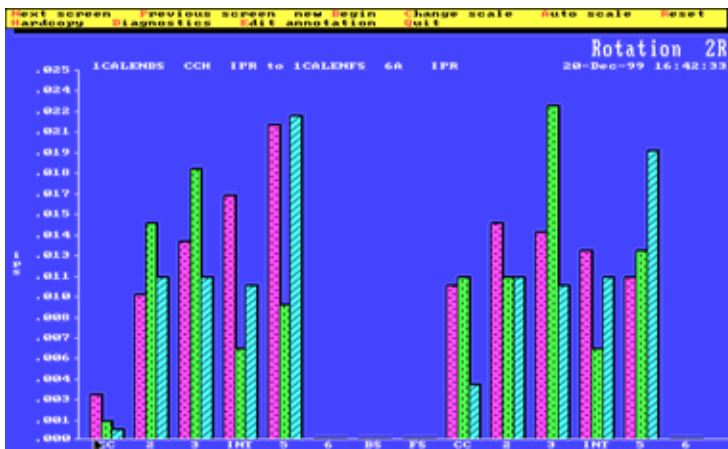


The Profile in the upper part of this figure is a “bearing dominant” profile for a section of a paper machine dryer. Note that at the test point marked “IND”, there is a relatively high level of inner race passing energy, with a significant level of outer race passing energy. This is a bearing in trauma.

The spectrum from which this result was obtained is shown in the lower part of the figure. The bearing fault windows are shown. Note that the bearing fault energy seems insignificant when we look at the spectrum. Without Profiling, this fault probably would have been missed.

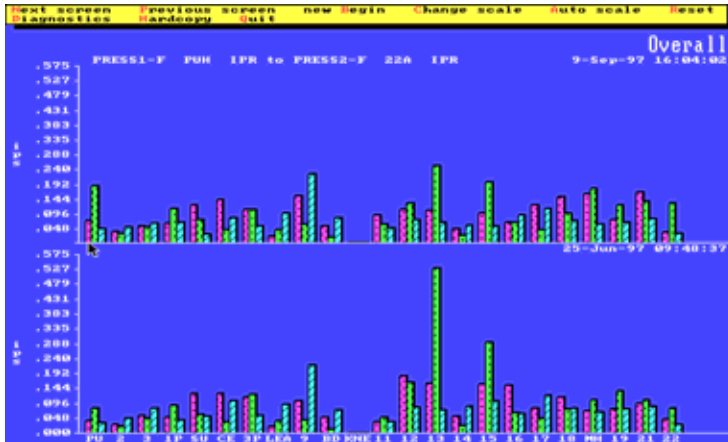


Detecting anomalies in gear train vibration spectra is a difficult task, particularly if we work with the spectra one-by-one. With Profiling, the job is much less difficult. Here we show the gear dominant profile of a paper machine dryer section in the upper part of the figure. At each test point, a minimum of 14 custom fault windows has been defined. There are 54 spectra involved. The lower part of the figure shows a spectrum sample with all group windows overlaid. The process is equally powerful for gearboxes in general.



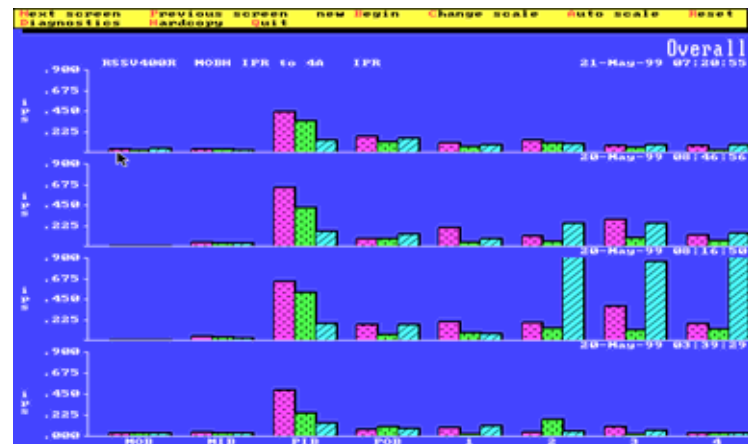
This example shows the use of a Profile of a specific fault window, rather than the dominant fault profiles shown previously. Here we have a twice rotational frequency Profile to analyze calender stack roll alignment.

This 2R Profile works well for evaluating alignment in a series of similar pumps, for example, all profiled together.



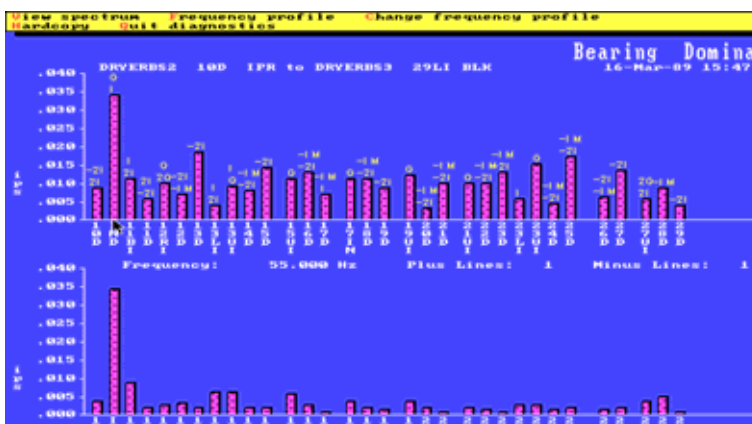
Profiles can be compared with baseline or reference patterns to reveal degradation or other changes in behavior, perhaps due to design changes or maintenance. In this example, overall Profiles of a complete paper machine press section are shown, before (lower) and after (upper) a small speed decrease. This picture summarizes data from 156 spectra. Note the reduction in vibration at rolls 12, 13 and 15; this occurred because rotational harmonics moved away from a frame resonant frequency.

This is an excellent tool for studying process or speed changes on any equipment.



Here we see a series of Profiles showing the overall energy pattern of a clarifier pump (MOB to POB) and piping system (1-4), taken over a period of two days. The unit had excessive vibration due to resonance. The various Profiles correspond to certain trial modifications. This picture summarizes data from 90 spectra. It guides the user concerning the best permanent modifications.

Profiling is by no means just a paper machine diagnostic tool; it is useful for any type of equipment.



This figure shows a different type of Profile comparison. The upper, bearing dominant Profile shows high inner race defect energy at a paper machine dryer section Indrive (IND). The lower Profile is a picture of vibration across the machine section at the IND inner race passing frequency of 55 Hz. This indicates that the high vibration does not originate from another source; i.e. is not crosstalk.

... More about Profiling:

Where can I learn more about Profiling?

If you have questions or just want more detail, call us on our toll-free number or send us an e-mail. Ask for Bryan Long, Brian Howes, or Bill Eckert. If we can't help you, Steve Lawn, our associate from Powell River, B.C, almost certainly can.

How can I utilize Profiling?

Beta Machinery Analysis offers Profiling as a service.

Can Beta provide Profiling for data that I collect?

We are working on this. Right now, we can provide "Remote Profiling" for users of the DATA-TRAP vibration data collector. In the future we plan to interface to data from other popular collectors. We encourage readers to talk to us about interfacing to your data collector.

The world *is* getting smaller...

We all read and hear about "globalization" of business, the erosion of international barriers to trade and the like. At Beta, we have been experiencing a steady growth in our international work (i.e. outside Canada and USA) over the past few years. But I was reminded about the scale of globalization through the players involved in a large job Beta was recently awarded.

The project is a large compressor facility to be built in Syria. The owner is a joint venture by Elf (France) and Conoco (USA). Compressor packaging is by Gas Services International in Singapore. And the pulsation/vibration, torsional and skid design work is being done by our staff in Calgary, Canada.

This is truly cool.

Bryan Long,
President

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