Volume 14 #1

the BETA BULLETIN

Keeping it running smoothly

Monitor/Analyze/Optimize for Increased Production and Profit

If you own or operate machinery, you are well aware of the many challenges that present themselves; challenges that could mean costly downtime. This article explains how Beta's new monitoring, analysis and optimization program is an affordable, easy to implement alternative.

Many companies monitor production machinery by collecting operating data such as pressures, temperatures, flow rates, and the like. This data is often collected in connection with process data as part of a control system. It is also very common to manually collect machinery operating data on paper log sheets or sometimes with hand held data collectors.

These programs can provide a front line of protection against machinery failure and consequent production interruption. In practice, there are major problems with these programs. The very large amount of raw data becomes overwhelming; it becomes impractical and even impossible to detect subtle deterioration in machine performance or condition. It's a situation of "data rich – information poor."


Many companies are assessing the effectiveness of their monitoring programs.

It is often possible to increase availability, optimize throughput and reduce maintenance through a well designed and executed program. **An effective program involves three components: Monitor, Analyze and Optimize; we call it "MAO."**

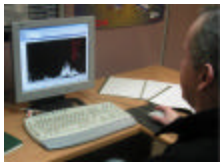
MONITOR

Monitor, the first component, refers to the complete and consistent collection of the type of operating data mentioned above. By complete, we mean making sure the functional aspects of the machinery that would reveal significant machine degradation and performance problems are covered. Much of this data is already collected in the form of log sheets, SCADA & DCS data. Some additional sensors and readouts may be needed. At this point you have data, not information, which is why the second component is needed.

ANALYZE

Analyze refers to performing the required steps to turn data into information. It involves manipulation of the raw data to produce a small number of key indicators. Mathematically, the processes involve steps such as:

- Regression analyses to develop baseline relationships.
- Models of machine and process.
- Calculation of efficiencies.
- Ratios, differences and similar calculations that normalize the indicator.



Machine experts and proprietary software used to analyze machine health.

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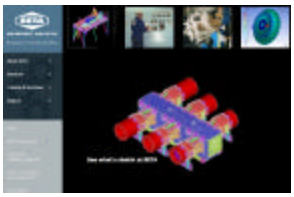
What's Inside

Technical Information on New Website

Exciting new Website with Valuable Features

During mid 2005, Beta unveiled its new website. This site includes many new features for our engineering customers and provides a wealth of technical and application information.



Beta's new website.

People interested in reciprocating or rotating equipment can now access more information including:

Risk Rating Chart.

- Presentations and technical bulletins on API 618 (4th edition and the new 5th edition) and how it applies to reciprocating compressors.
- Case studies illustrating design issues, troubleshooting problems, and machinery inspections.
- Downloadable past Beta Bulletins (PDFs).
- Engineering formulae for design engineers.
- Expanded list of technical articles.
- Animations illustrating different design/application studies.
- Specifications for performing vibration, torsional, thermal, and other studies – particularly useful for owners/EPCs wanting to specify the right design approach and ensure suppliers deliver useful recommendations.
- Risk rating charts which quantify the level of vibration risk associated with different compressor packages.
- And much more.

Beta continues to update the site with content for our different customer groups (Beta Communities):

- Compressor packagers and OEMs.
- Engineering Procurement and Construction engineers.
- Owner/operators of machinery systems.

Please send me your ideas for additional topics, case studies, or other information you want added to the site.

Jackie Walters
Marketing Communications
info@BetaMachinery.com

Vibro-Meter Appoints Beta as Distributor

Vibro-Meter, owned by Meggitt Corporation, is a global leader in providing rotating measuring components and condition monitoring systems. The Company has over 90% market share of transducers for jet engines and a high share for industrial turbines. In addition to Vibro-Meter, Meggitt also owns **Endevco** and **Wilcoxon** – respected names in the transducer market.

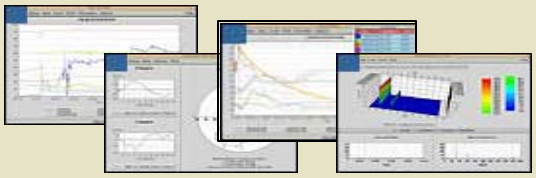
Beta is pleased to be selected as Vibro-Meter's exclusive distributor in Alberta and British Columbia. According to Bernard Gauthier (Vibro-Meter General Manager, Canada), "Beta's leadership in vibration, respected field service capabilities, and its rotating experts, makes this the best technical group in Western Canada and an ideal partner for us."

Vibro-Meter has a large installed base of high performance proximity probes, accelerometers, velocity probes and many other components used on rotating equipment. As the OEM supplier to many turbine manufacturers, Vibro-Meter can support customers with aftermarket products.

The Company also offers **VMS-600**, a comprehensive offering of machine protection systems and condition monitoring solutions. These systems are ideal for those facilities planning to upgrade their older systems or building a new facility. Advantages of the VMS-600 system include:

- Easy to install, adapt and expand.
- Machine protection, condition and performance monitoring within a single framework.
- "One card does it all" – revolutionary design reduces the complexity and inventory requirements associated with other systems.
- Modular, scalable, and configurable using standard operating systems.

Beta can answer Vibro-Meter application questions and support customers with our range of rotating/ reciprocating field services. For more information of Vibro-Meter capabilities, visit our website, www.betamachinery.com, or call us at 800-561-2382.



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Example 1: Analyze

Monitoring reciprocating compressor discharge temperature provides an example of the need for a normalized key indicator. Discharge temperature varies with compression ratio, gas properties, and suction temperature, but is also affected by problems like ring leaks and valve leaks. The increase in temperature due to a developing valve leak can be undetectable in the normal variations due to the other factors mentioned. However, a "normalized" measure can be developed by monitoring the difference between measured discharge temperature and a theoretical, or expected discharge temperature. The expected discharge temperature is calculated based on current suction temperature, compression ratio, and gas properties; so, now when we see a significant increase in the key measure, we can be confident we are seeing a machine problem, as is the case illustrated in Figure 1.

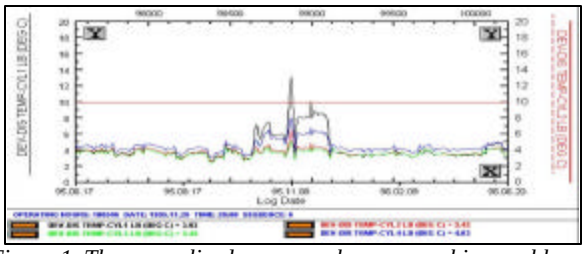

Figure 1 The normalized measure shows a machine problem.

Example 2: Analyze

A second example was encountered in monitoring the temperature of a centrifugal compressor thrust bearing. The historical trend of the measured temperature looked roughly like that shown in Figure 2. Temperature variations seen in the raw data were much larger than that which would indicate a subtle overload condition. So, steps were taken to develop a normalized measure.

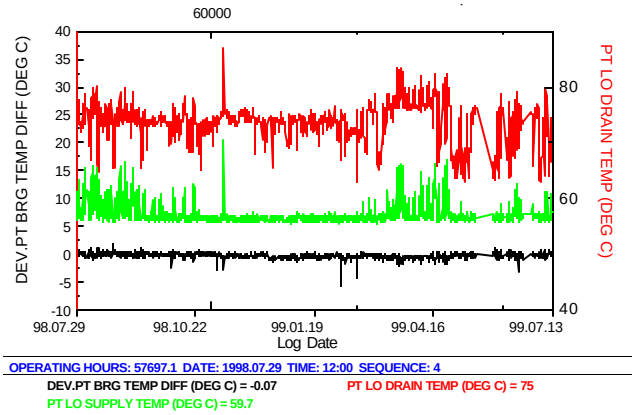

Figure 2 Trending thrust bearing oil temperature (red) often shows wide fluctuations. When the difference between the supply (green) and drain temperatures is graphed against speed, a baseline becomes evident. The bottom trend line shows the deviation from this baseline, which is a much more sensitive indication of bearing temperature problems.

OPTIMIZE

Optimize is the third aspect of the MAO program. This means making use of the key indicators, supported by the intermediate measures and raw data, to make decisions and take action (or not) on an informed basis. Examples include:

- Identifying and removing throughput bottlenecks or inefficiencies.
- Improving machine deployment to increase throughput.
- Taking maintenance action prior to a machine failure.
- Detecting and correcting conditions that lead to premature failure.
- Supporting condition based maintenance and turnaround planning; doing only what needs to be done.

For example, as part of a MAO analysis, it was found that a compressor was being operated with a much higher compression ratio on first stage than on second stage, see Figure 3. This is an inefficient mode of operation. The customer was advised to adjust the compressor loading to equalize the ratios. This simple change had a direct economic impact by increasing compressor throughput and decreasing HP/MM.

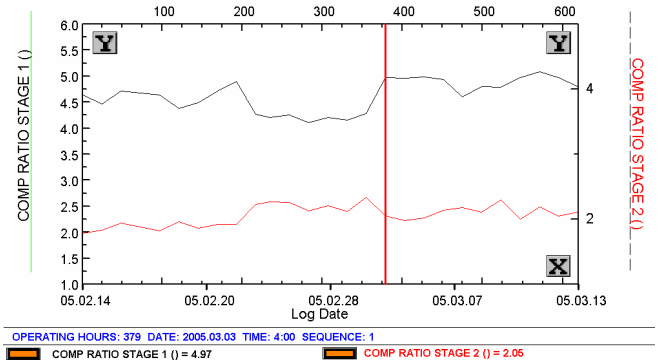

Figure 3 Monitoring revealed inefficient compressor loading.

MAO PROGRAM

So, how is a MAO program implemented? The main requirements are:

- Machinery specialist knowledge.
- Appropriate tools, mostly software, to support the MAO process.
- Adequate and dedicated manpower.

For many companies, these requirements are difficult or impossible to meet. Operations staff can't afford to hire and train additional machinery specialists and many of their senior experienced staff are approaching retirement age.

Continued on page 4

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In addition, front line operators are busy and lack the time to do additional analysis work. While a large in-house program is desired, it is often difficult to justify and implement.

An attractive alternative is to outsource part of the program. The Operating Company takes the lead in the front end (providing the raw data) and in the back end (making final decisions) of the process. A specialist service provider (Beta) takes responsibility for the central part of the program including data analysis, recommendations and following up with operations/reliability staff.

For the Operating Company, there are a number of advantages to outsourcing the data analysis:

- More cost effective to outsource the machine analysis activities than to add specialists in each operating region.
- The above activities, while necessary, are not core to their business.
- The program will remain consistent, even as operating staff change roles or turnover occurs.

Additionally, the scope and scale of the outsourced program can easily be adjusted as experience and circumstances indicate. Unless the program is very large, an outsourced program is likely to be much more cost-effective when all costs of an in-house program are considered.

Example 1: Optimize
Oil consumption: An illustration of the value of carefully logging and trending basic operating data, in this case, oil consumption in an engine, is shown in Figure 4.

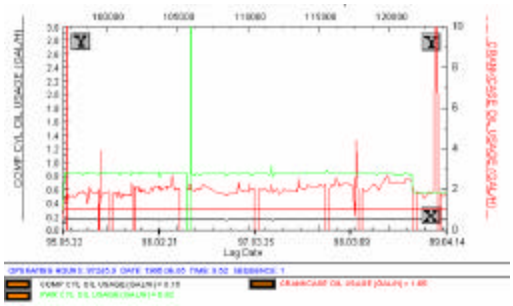

Figure 4 Note the slow upward trend in crankcase oil usage. Without this presentation, the change would likely not be noticed. An overhaul performed at about 122,000 operating hours reduced the oil usage to previous levels.

This information was used in conjunction with other key indicators, to determine the optimum time to perform an overhaul and to determine what maintenance to perform during that overhaul.

Example 2: Optimize
Compressor blade washing: Monitoring gas turbine parameters can indicate the need for blade washing of the compressor section when the performance has degraded to some level, based on economic impacts. See Figure 5.

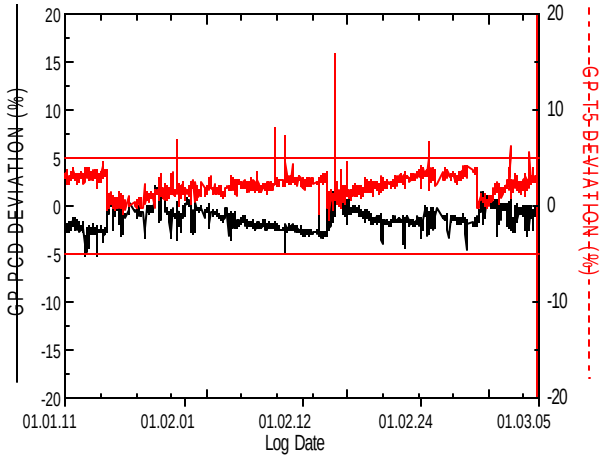

Figure 5 In this case, trends of operating parameters show degradation of performance due to fouling of a gas turbine compressor section and restoration of pressure (black) and temperature (red) through blade washing.

How an outsourced MAO program works:

- Operating Company and Beta agree on scope, timeline, and objectives.
- Operating Company and Beta determine what, and how, data is to be collected.
- Beta takes the lead in implementing the program and working with direct operating staff.
- Beta performs data archiving, analysis, trending, etc.
- Beta provides periodic reporting, including recommendations.
- Beta monitors program, implements improvements, and provides training updates.

Beta charges a low monthly fee for the MAO service, based on the number and types of machines included in program.

A number of different customers have adopted the MAO approach. The following list illustrates the types of facilities that can benefit from the program:

- Gas plants that include pumps, reciprocating compressors and other equipment.
- Gas production operators with a fleet of field compressors.
- Petroleum operating companies with a blend of water disposal equipment, oil production, and gas compression assets.

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Case Study

High Pressure CO_2 Compressor

Internal Bottle Failure

One of North America's largest gas producers operates high pressure CO_2 compressors (2200 psi) in an enhanced oil recovery process. A loud noise was heard, emanating from a 4th stage discharge bottle. Inspection of the bottle found the choke tube supports had failed – a costly and potentially unsafe condition for the process.

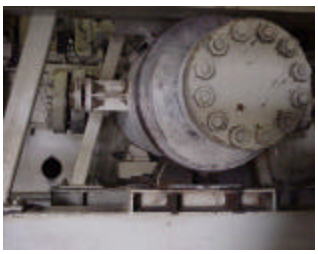
Beta was retained to investigate the system and recommend necessary modifications. To solve this problem, Beta conducted field vibration and pulsation measurements, one dimensional and three dimensional acoustical modeling of the bottle, and three dimensional structural modeling.

The following figures illustrate the field measurements and modeling used to assess forces acting on bottle components.

Further modeling was conducted to:

- find a modified bottle design with reduced forces,
- improve the choke tube support design,
- modify the bottle support, and
- modify the cylinder support.

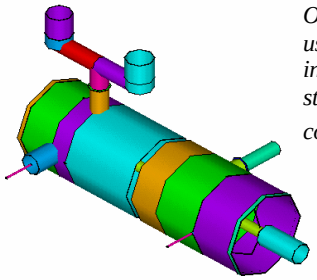
It was recommended that periodic vibration inspections be performed to ensure system integrity.



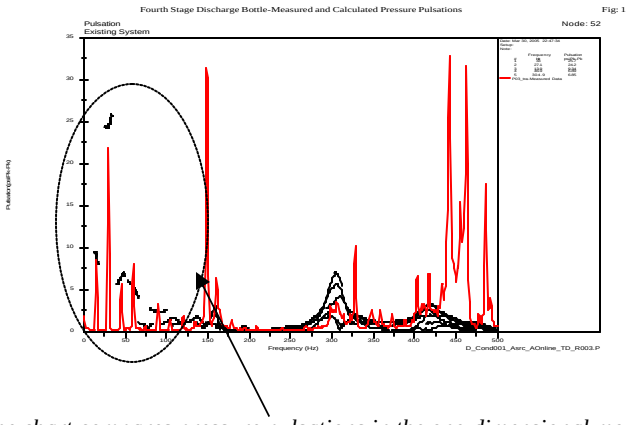
End view of 4th stage discharge bottle which experienced internal failure (broken choke tube supports); creating a serious safety and operational hazard.

This illustrates that appropriate modeling can be the most cost effective approach to equipment modifications. Without this approach, the customer would have invested significantly more time and money in a trial and error approach to structural modifications.

Installing pressure transducer into discharge bottle nozzle.



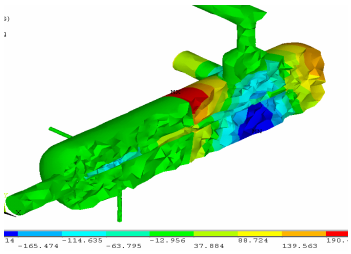
One-dimensional acoustical model used to calculate the forces on the internal baffles/choke tube in the 4th stage discharge bottle. The model confirmed the cause of failure.



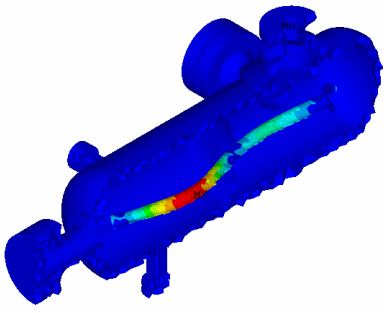
The chart compares pressure pulsations in the one-dimensional model to measured field data.
Red = measured data, Black = 1-D model results

Note: Model is accurate for these low frequency pulsations.

A 3-D model is required for higher frequency pulsations.



3D Acoustical model illustrates pressure gradients in transverse acoustical mode (sectional view of 4th stage discharge bottle).



3D Structural Model is used to avoid overlap of acoustical forces with structural (mechanical) resonances. This figure illustrates a vibration mode shape for a choke tube.

2005 Upcoming Courses

For more information and to register, please visit our website at www.BetaMachinery.com.

COURSE	DATE & TIME	WHERE	LENGTH	COST
Pulsation/Vibration For Recip Compressors – Level 1	Nov. 2nd 8AM-Noon	Calgary	4 hrs	$100
Pulsation/Vibration For Recip Compressors – Level 1	Nov. 2nd 8AM-Noon	Houston	4 hrs	$100
Torque Talk	Nov. 23rd 8AM-Noon	Calgary	4 hrs	$100
Pulsation/Vibration, Mechanical and Structural Analysis for Reciprocating Compressor Reliability	Nov. 29th 3PM-5:30PM	Singapore	2.5 hrs	$30 SGD
Online Condition Monitoring – Level 1 (Vibro-Meter)	Nov. 30th 8:30AM-11:30AM	Calgary	3 hrs	$100
Pulsation/Vibration for Recip Compressors – Level 1	Dec. 7th 8AM-Noon	Calgary	4 hrs	$100
Pulsation/Vibration for Recip Compressors – Level 1	Dec. 7th 8AM-Noon	Houston	4 hrs	$100
How to get more value from your Monitoring Program (Monitoring, Analysis & Optimization)	Dec. 14th 8:30AM-11:30AM	Calgary	3 hrs	$100

News and Notes

Beta Machinery Analysis is pleased to announce the following appointments:

Shelley D. Greenfield is promoted to **Vice President, Design Services**. Shelley received her P.Eng. in Calgary, Alberta, and has worked with Beta for the past 20 years, primarily in design and business development. She was a member of the pulsation and vibration control task force that developed the 5th edition, API 618 guidelines and RP-688 recommended practice, and has authored, or co-authored several technical papers.

Chris Harper is promoted to **Principal Engineer**. Chris graduated from the University of Alberta with his B.Sc. in Mechanical Engineering and received his P.Eng. in 2003. With Beta for 6 years, he has been a team leader and has technical experience in design and field services. Chris has co-authored two papers presented at the Gas Machinery Conference.

Tom Van Hardeveld, M.Sc. Mech.Eng., P.Eng., has joined Beta as **Senior Associate** to support our Optimization Services team. Tom has more than 30 years experience in all aspects of the operation and maintenance of turbines, compressors, and other gas transmission and process equipment. He has had assignments worldwide and specializes in Reliability Centered Maintenance, and Condition Monitoring.

William Amenyah is promoted to **Team Leader, Design Services**. William has a post-graduate degree in Computer Aided Engineering from the University of Strathclyde in Scotland and his M.Sc. in Mechanical Engineering from the University of Alberta. He received his P.Eng. designation this year. William has been with Beta for 4 years and his background is primarily in mechanical design and acoustics.

As a result of the company's growth, Beta is pleased to welcome **Anthony Nguyen, Nils Joergensen, and Sukhpreet Sandhu** as **Analysts**.

Congratulations to the winners

of the web contest to launch Beta's new corporate web site, www.betamachinery.com.

Winners of $100 restaurant gift certificates are **Will Martin**, **Lauren M. Tushim**, Sr. Mechanical Projects Engineer, Albert-Garaudy & Associates; and **Paul D. Altpeter**, Sr. Principal Machinery Engineer, Air Products and Chemicals, Inc.

Winner of the bonus $150 gift certificate is **Doug Goodreau**, Plant Engineer, Union Gas.

Again, congratulations to the winners, and our thanks to every one who took the time to enter and play along!

News and Notes continued

New Brochures

Beta's expanded engineering and design, field and optimization services for reciprocating and rotating machinery are highlighted in this new corporate brochure.
Find out why clients worldwide use Beta Machinery Analysis.

Monitor, Analyze, and Optimize any equipment for improved performance, decreased costs, and increased reliability. This new service has clients realizing substantial cost savings and enjoying Beta's cost-effective solution to their monitoring headaches.

Vibration and reliability issues in reciprocating and screw compressors are addressed in Beta's one-day start up service. Whether your unit is stock, rental, or custom, this service is a wise investment.

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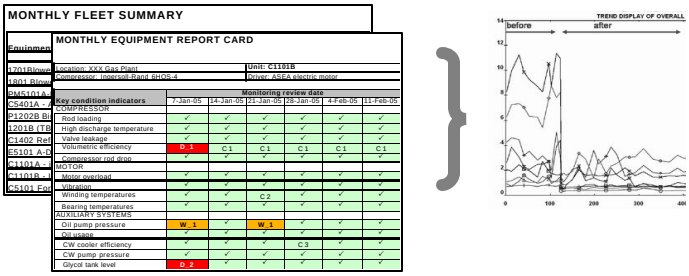
- Midstream operating companies with liquid extraction and large compression facilities.
- Refineries.
- Fertilizer facilities.

In summary, the right analysis of machinery operating parameters is a vital aspect of a good machinery monitoring program. There are significant challenges to implementing an effective program, including the required skills and experience, building and maintaining the required manpower, and the ongoing investment in hardware and software. Outsourcing parts of the program to experienced professionals addresses these issues and more – and in a very cost effective way.

For further information, please contact our MAO Service team (800-561-2382).



Recommendations via easy-to-use fleet and equipment report cards lead to equipment optimization ,for reduced maintenance costs and increased reliability.

To contact
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Trade Shows

May 18-19
Beta was an exhibitor at the Peace Region Petroleum Show in Grande Prairie, AB.

September 14-15
Bill Eckert and Brian Howes manned our booth at the Oil Sands Trade Show and Conference, Ft. McMurray, AB.

October 3-5
Shelley Greenfield, Luis De la Roche, Kelly Eberle and Rich Bennekemper were at the GMC, Covington, KY at booth #35. Beta presented Technical Papers - "Introduction to Vibration & Pulsation in Reciprocating Compressors," "Lateral & Torsional Vibration," and "Acoustical Modeling of Reciprocating Compressors with Stepless Valve Unloaders."

October 26-28
At the CMVA in Edmonton, AB, Beta presented two Technical Papers, "Observations About Rotating and Reciprocating Equipment" and "Industrial Engine Reliability and Maintenance – Data That Should Be Collected and Analyzed On Every Engine."

Beta Will Be There . . .
December 12-15
34th Turbomachinery Symposium, Houston, TX has been rescheduled to December due to Hurricane Katrina. We invite you to stop by our booth 1029. For more information, click on http://turbolab.tamu.edu.

We're updating our database at Beta Machinery Analysis.
To provide uninterrupted delivery of your BETA BULLETIN, please check off and make corrections wherever applicable and **fax this page to BETA BULLETIN UPDATES 403-245-3257** OR **email info@betamachinery.com**

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