Machinery Analysis

35th Anniversary Edition
THE BETA BULLETIN

VOLUME 11 #2

From the President …

On the occasion of the 35th anniversary of Beta Machinery Analysis, I would like to share a few miscellaneous ramblings and reflections. Maybe we can even find a lesson or two.

The world has changed a lot in 35 years. In 1967, gasoline was forty cents a gallon and beer was $3 a dozen. Computers were main frames in University or government labs for the most part. There were six teams in the National Hockey League though it was set to expand to twelve. In January, the first Super Bowl was played as the Green Bay Packers of the National Football League defeated the Kansas City Chiefs of the American Football League, 35-10. New cars - maybe $4000 to $5000.

Dave Schuh - 1974

In Calgary, a young engineer named Dave Schuh was dreaming of launching his own company to solve machinery problems. Dave was employed at a machine and fabrication shop called Barber Industries where he frequently saw the same broken parts coming in for repair. This observation led him and his wife Nellie to sell the new Chrysler and start Beta Machinery Analysis in June of 1967. My understanding is that the proceeds from the Chrysler along with some hard earned savings were spent on buying some analysis equipment fundamental to the undertaking.

Most notably, they purchased an engine/compressor analyzer called a Beta II. This is believed to have been the first such piece of equipment in Canada. Of course, it was all analog, difficult to use, but very powerful at a time when there was very little analytical instrumentation in use in industry. Problems in performance or reliability were mostly attacked by trial-and-error, as there was little alternative.

Dave and Nel experienced some very lean times in the early days. This is not surprising, in my opinion. They were not just starting up a new business - that's difficult enough. But they started a new *type of business. They survived those lean times because they had identified a real need in the marketplace, offered a valuable solution and executed well - Marketing 101.*

Brian Howes - 1978

Along with Brian Howes who joined Beta in 1972, Dave identified opportunities for additional services. It was the pursuit of one of these that resulted in my joining the Company in November, 1973. The way this came about was by far the most significant coincidence of my business life. At the time, I was working at the Defence Research Establishment near Medicine Hat, Alberta and was looking for a career change. With a sense of obligation, rather than an expectation of results, I submitted my professional resume to the national government agency that dealt with employment matters.

At that same time, Dave and Brian started to look for someone to develop a computer program to simulate pulsations in reciprocating compressor piping systems. They believed that this could be the basis of a valuable, new design service. They also submitted their need to the same government agency, albeit with the same expectation that that route was unlikely to produce results. Well, the unexpected happened and, as the saying goes, the rest is history. This life experience has always suggested to me that we should not overlook any possible avenue in the quest for our goals.

We launched this new design service called "MAPAK' in the 1974-75 time frame. (By this time beer cost just a little more, but gas was way up thanks to the Arab oil embargo of 1973.) The new MAPAK service became very successful. It is still the largest service area for the Company. To date BMA has been awarded and has executed some 1500 MAPAK assignments.

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INSIDE:

Case Study - Residue Gas Service on Six Throw Separable Compressor

Machine Description

- Six throw separable compressor (4 identical)
- 2650 hp engine driver
- 800 to 900 rpm speed range
- Five compressor cylinders, two services
- Two cylinders for two-stage propane service
- Three cylinders for one stage residue service
- Level of Acoustical Design: Another vendor acoustical model to API 618 Third Edition, Design Approach 3.

Figure 1: Residue Gas System

Vibration Problems and Nozzle Failures

The first field analysis of this machine was requested by the owner and the packager because of vibration problems on primarily the propane service side of this compressor. After a thorough vibration analysis, the field representative not only diagnosed and recommended solutions to the problems on the propane service, but also revealed a vibration concern on the residue side of the compressor at about 71 Hz (5 times compressor speed at 842 RPM.) This vibration was attributed to high pulsation-induced unbalanced forces in the residue systems. An acoustical analysis of the residue systems was recommended.

The recommended solutions for the propane service were implemented and those problems were solved. The acoustical analysis of the residue systems was not completed by the choice of the customer.

About three years later after several nozzle failures on the residue system pulsation bottles, Beta Machinery Analysis was asked to evaluate these machines again. The cylinder #5 suction and cylinder #1 discharge nozzles had failed several times. Again the 71 Hz problem was identified and an acoustical analysis was recommended. A detailed operating deflected shape (O.D.S.) was measured to help identify the "shape" of the vibration on the residue system. This type of analysis is useful in identifying the forces involved and identifying stressed components. Figure 2 is a graphical representation of the O.D.S. for the 71 Hz vibration. It was noted that all of the components were vibrating around cylinder # 3. System geometry and constraints along with high vibration produced large stresses in the cylinder nozzles.

There was a system natural frequency measured at around 70 Hz. High forces coincident with this system natural frequency led to unacceptable vibration and stress levels.

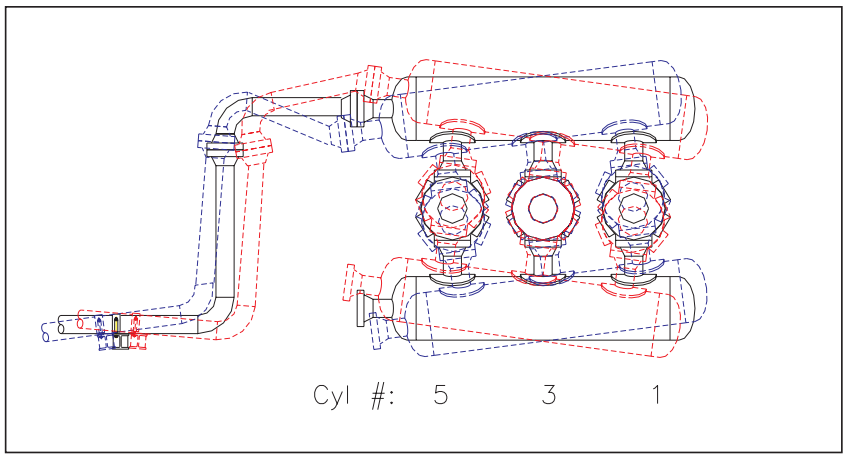

Figure 2: Operating Deflected Shape (O.D.S.) of residue system at 71Hz. The dashed images represent the envelope of the vibration. Note that cylinder #3 is relatively motionless.

Design Analysis and Solution

An acoustical simulation was done for both the suction and discharge of the residue system using Beta's proprietary acoustic modeling software. Predicted pulsation levels in the piping past the pulsation bottles were well within API 618 guidelines. However, the forces in the bottles and in the cylinder nozzles were above guidelines used by the authors. This, however, did not explain why there was such high vibration in the vertical direction on cylinders #1 and 5 and not on cylinder #3.

Further analysis revealed that the phase relationship between the forces in the suction and discharge systems created a strong alternating couple about cylinder #3. This couple matched very well with the measured O.D.S. Figure 3 illustrates the 5X compressor speed resultant couple for the "as-found" and modified system. It was noted that modifying the discharge bottle would have the most impact on the resultant couple and therefore the vibration levels. Modification of the suction bottle was predicted to have little benefit.

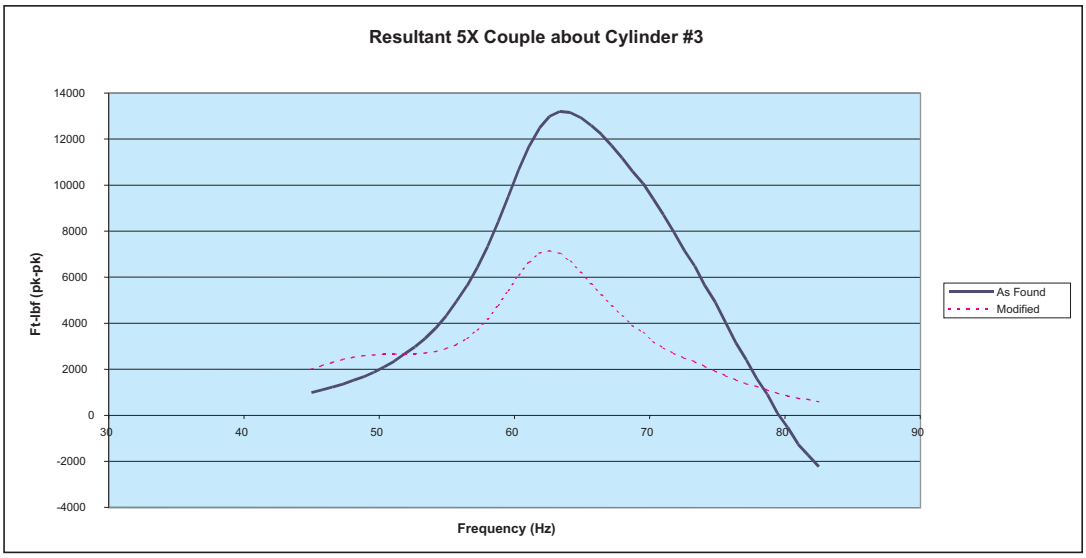

Figure 3: Resultant Couple about Cylinder #3. This plot shows that modifying the discharge bottle should reduce the couple at 70 Hz by 66%.

A modification to the existing discharge bottle was recommended and implemented on one unit. Vibration measurements were taken for comparison. Figure 4 demonstrates the typical improvement in vibration levels on the modified unit. Approximately an 80% reduction in peak vibration levels was realized. Modification of the remaining units was to be completed at the client's earliest opportunity.

Conclusions

It is insufficient to control line-side (outside the bottles) and cylinder flange pulsation levels when completing an acoustical analysis.

Consideration of pulsation-induced unbalanced forces and moments within the pulsation bottles and piping is critical to a sound pulsation control design.

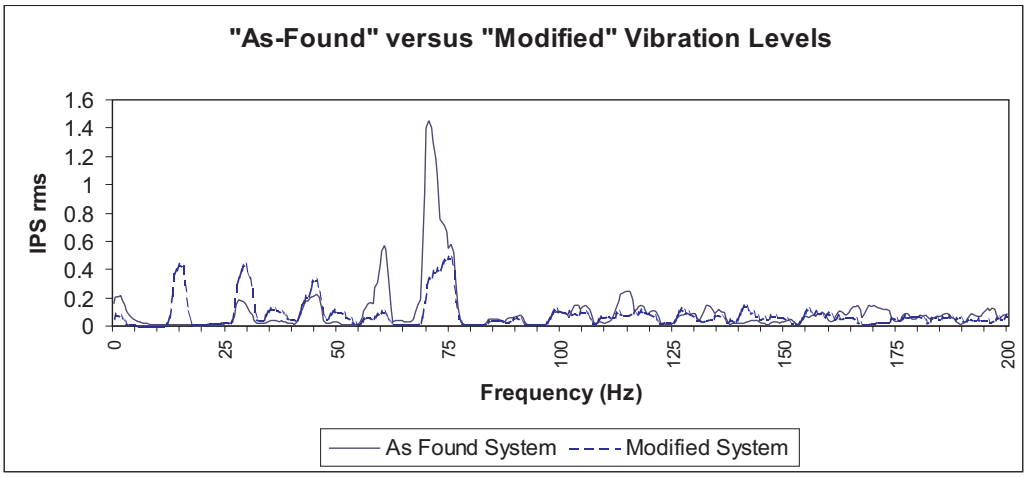

Figure 4: Typical vibration improvement with modified discharge bottle. Vibration level in inches-per-second rms versus frequency in Hz (speed sweep from 800 to 900 RPM.) The "as found" spectrum is the vibration in the vertical direction of cylinder #5 without the discharge bottle modification and the "modified" spectrum is the same measurement with the bottle modified. The reduction in peak vibration at 71Hz is approximately 80%.

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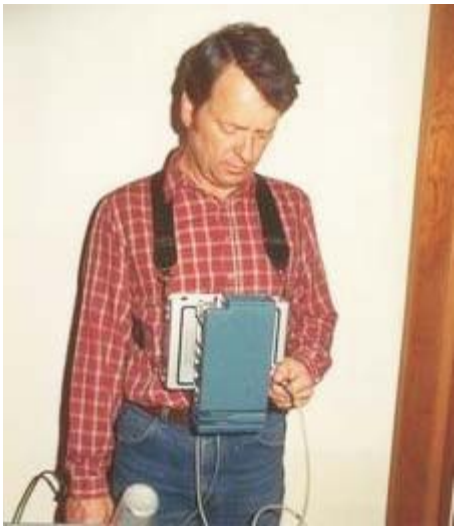
In 1979 (the "good old days" in the oil industry just prior to the bust of the early 80's) we launched a second company called Beta Monitors & Controls. The charter of BMC was to develop, manufacture and sell diagnostic instruments for machinery analysis. Our first product was a microprocessor-based instrument to be used in balancing power cylinders on large bore, slow speed engines. I will never forget the occasion when an early (irate) customer called me to say that "*This @#&* balancer is the best tool I have when it works!!"* The concept was very good, but the execution was very bad. We should have involved people who knew how to design reliable instruments. This did ultimately become a successful product when the reliability problems were sorted out.

In 1985 we introduced a new product called "RECIP-TRAP; a portable, microprocessor based engine/compressor analyzer. In 1988 a BMC office was opened in Houston to provide sales and service. This innovative new product had many advantages over the then industry leading analyzer. But it was outstanding customer service that really led to RECIP-TRAP becoming dominant in its market segment. Conclusion: a brilliant product is not enough; the service, support, training, etc. must also be outstanding for long term success.

The year 1991 was very important for Beta Machinery Analysis. The decision was made to establish a BMA presence in Houston to aggressively grow our design service (MAPAK) business. Frank Fifer moved from Calgary to Houston to take on that role. This undertaking has been very successful, thanks to outstanding customer service backed by world class competence.

Suddenly we arrive at the year 2002. Gasoline is now $1.50 per gallon in the USA and beer is about $15 per dozen in Canada. Everybody has a computer on their desk at work and another one at home. There are now 30 teams in the NHL, including two in Florida (Florida???). The New England Patriots won Super Bowl XXXVI. The cost of a new car? Don't think about it. Beta Machinery Analysis is alive and well in Calgary and Houston, thanks to our customers and to our 34 employees who continue to solve and to prevent machinery problems.

As I reflect on my involvement with Beta during most of its history, I have a strong sense that I have been very fortunate in a number of ways: very interesting work; the opportunity to learn and grow personally and professionally; the chance to do something that makes a difference; working with many customers and BMA personnel. In your working life, what else could one ask for?



Bryan Long - 1980

Bryan Long

News & Notes

Beta was there.....

- The 67th Spring Refining Meeting, April, 2002, was attended by Brian Howes and Shelley Greenfield. They are working on the API Task Force looking at API 618, 674 and RP 688. Next session this group will be tackling API 619.
- Frank Fifer and Bryan Long attended the 2002 Offshore Technology Conference in Houston as part of Beta's increasing involvement in offshore projects.
- Beta was at the Petroleum Technology Alliance of Canada Environmental Conference and Tradeshow. The program focused on economical climate change technology solutions for the oil and gas, oil sands, coal, mining, pipeline and petrochemical industries.

Beta will be there.....

- "Improving the Bottom Line Results Through Asset Management of Production Machinery" will be presented by Bryan Long at the Canadian International Petroleum Conference June 11 - 13, 2002. The Conference coincides with the Global Petroleum Show 2002 in Calgary.
- Beta Engineers have presentations scheduled for the CMVA Annual Meeting and Trade Show to be held in Quebec City in August. Please contact Val Zacharias at cmvaed@shaw.ca for further information.
- Bryan Long, John Harvey and Frank Fifer will be presenting "Improving the Reliability & Performance of Reciprocating Compressors" for the GMRC Workshop in Houston, September 10 and 11, 2002. Anyone who is responsible for the efficient design, operation and/or maintenance of reciprocating compressor systems can benefit from this course. For further information please contact Marsha Short at mshort@southerngas.org.
- Beta will be at the annual Gas Machinery Conference planned for Nasvhille in October. Please drop by our booth as we celebrate Beta's 35th Anniversary.
- The 4th International Pipeline Conference will be held in Calgary from September 29 - October 3, 2002. Brian Howes and Shelley Greenfield will be presenting "Guidelines in Pulsation Studies for Reciprocating Compressors".

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