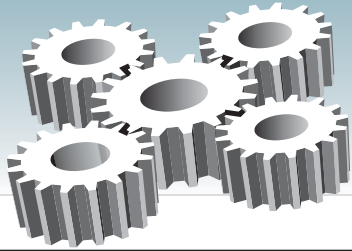




Machinery Analysis

# THE BETA BULLETIN



VOLUME 13 #2

## New Ownership Team Positions Beta for Growth

Beta Machinery Analysis is poised for aggressive growth through expanded services as a result of a new ownership and management team. **Russell Barss** has joined Beta as President and Chairman of the Board. He brings over 20 years of experience in engineering, marketing and leadership of technology based businesses in Canada and the USA. Russ and the existing directors/executives, Bryan Long, Brian Howes, and Tom Klein, are expanding the Company's capabilities and resources in its two locations (Calgary, Alberta and Houston, Texas).



The new ownership team is committed to building on Beta's success in the marketplace through the delivery of high quality services that ensure safe, efficient and reliable performance of industrial machinery. Beta will invest in additional manpower, equipment, and R&D to enhance its technology leadership. As well, plans are to develop new services to assist Beta's customers in getting the best return on their investment.

One of our primary goals is to expand US capabilities and presence, starting with growth in the Houston office. To lead this initiative, we are pleased to announce that **Luis De la Roche** has been appointed as our US Operations Manager. Luis is an experienced engineer who has worked with Beta in design and troubleshooting in the past. He already has a good working relationship with many of our customers. Luis is relocating to Houston and will be directly involved in marketing and operations activities. Contact Luis at [ldelaroc@betamachinery.com](mailto:ldelaroc@betamachinery.com).

Of course a great deal of credit for getting this company to where it presently is on the world stage must go to retiring Chairman of the Board, Dave Schuh and Nel Schuh, also retiring, who together founded the Company in 1967 (see accompanying article).

Both the retiring owners and the new ownership team wish to express appreciation for loyal support of our many customers over the years. We look forward to maintaining and growing those relationships in the future.

### The story 'til now...

In June of 1967, Dave and Nel Schuh sold the new Chrysler (shown below) and bet it all on a new undertaking they called Beta Machinery Analysis (see "From the President" in Beta Bulletin Volume 11 #2). Equipped with a new fangled gadget called an engine analyzer and a lot of energy, Dave set out to solve machinery problems in western Canada and, hopefully, make a decent living in the process.



It was difficult in the early days. Prospective customers were skeptical. This was not just a new service offering, but really a new type of service. Marketing experts would not have given much chance of success. But succeed they did, though it was very tough at times. By the early 1970's business was picking up. Brian Howes was recruited, fresh from the University of Calgary with a Master of Sciences in Mechanical Engineering. Shortly thereafter Bryan Long joined the team to develop computer software for the design of pulsation control in compressors and other systems. The rest, as the saying goes, is history...

1967 Beta Machinery Analysis founded to provide machinery troubleshooting and diagnostic services to industrial equipment users in western Canada.

1967 BMA provided engine and compressor analysis with the first commercially available engine/compressor analyzer in Canada.  
1971 Beta first to use a spectrum analyzer to solve machinery problems in Canada.  
1972 Brian Howes joined the staff, adding significant technical expertise.  
1972 Beta first used finite element modelling to solve vibration problems.  
1972 BMA purchased four function calculators to replace slide rule.  
1973 Bryan Long joined the company to develop a computer simulation of pulsation in reciprocating compressor systems.

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# Evolving Industry Calls for Advancements in Technology and Processes Part 2

Design of reliable compressor installations has become much more difficult and demanding over the years. Part 1 of this article, published in Beta Bulletin Volume 13 #1, discussed the evolution of equipment and standards, and the changing needs of the various stakeholders. In Part 1 we focused on our technological and process advancements in the area of acoustical modelling. Here we will focus on the mechanical aspects of a reciprocating compressor installation.

## Mechanical Analysis

As with acoustical modelling, our mechanical modelling tools and techniques have evolved over the years. It is apparent there are many commercially available software packages for finite element modelling, however not all are capable of accurately modelling dynamic characteristics. Even the packages that are geared toward dynamic modelling are only as good as the boundary conditions and modelling techniques used in the models. Additionally, as the reciprocating compressor industry evolved the nature of the problems and the accuracy of the models needed to predict those problems also changed.

Early reciprocating compressor installations were typically large, slow speed integral compressors, usually operating to a maximum speed of 360 rpm. The industry moved next toward using separable compressors with typical maximum operating speeds of 900 rpm. This increase in compressor speed significantly raised the design

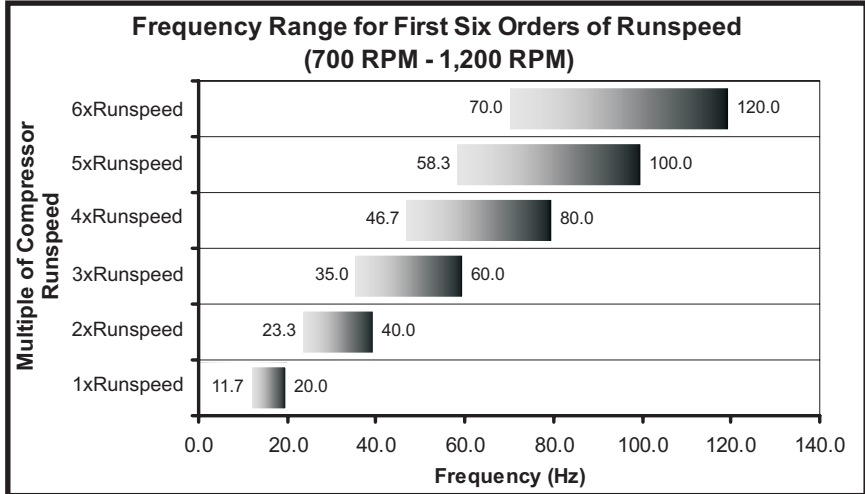


Figure 1 Frequency Range for a High Speed Reciprocating Compressor

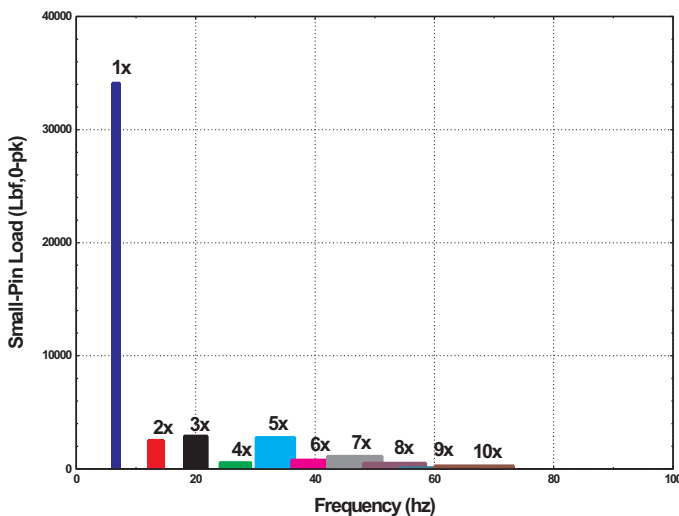
challenge. In recent years, larger compressors operating at higher speeds (1200 rpm to 1800 rpm) have become common.

In mechanical modelling, one of the main design goals is to have all mechanical natural frequencies above two times runspeed (due to the inherent unbalanced forces and moments). As the reciprocating compressor industry has evolved this guideline has gone from above 12 Hz (2 x 360 rpm/60) to above 30 Hz (2 x 900 rpm/60) to above 40 Hz (2 x 1200 rpm/60). A speed change from 360 to 900 rpm (2.5 times) means the stiffness of a component must increase by more than six times (assuming the modal mass is constant) to achieve the same mechanical natural frequency-to-speed ratio and vibration level (assuming the same mass and

dynamic force). The change from 900 to 1200 rpm means the system must have an increased stiffness of 1.8 times to achieve the same vibration, assuming a fixed mass and dynamic force. However, the assumption that dynamic force remains constant as the speed increases is not accurate with respect to the compressor mechanical unbalanced forces and moments. These dynamic forces increase with the square of the compressor speed. Therefore, to achieve the same vibration, the stiffness must increase by more than 3 times for a compressor operating at 1200 rpm compared to a compressor operating at 900 rpm.

Other characteristics of high speed compressors also affect the mechanical design. These compressors are frequently designed to operate over a

400 RPM (+/- 10%) Double Acting Compressor



1200 RPM (+/- 10%) Double Acting Compressor

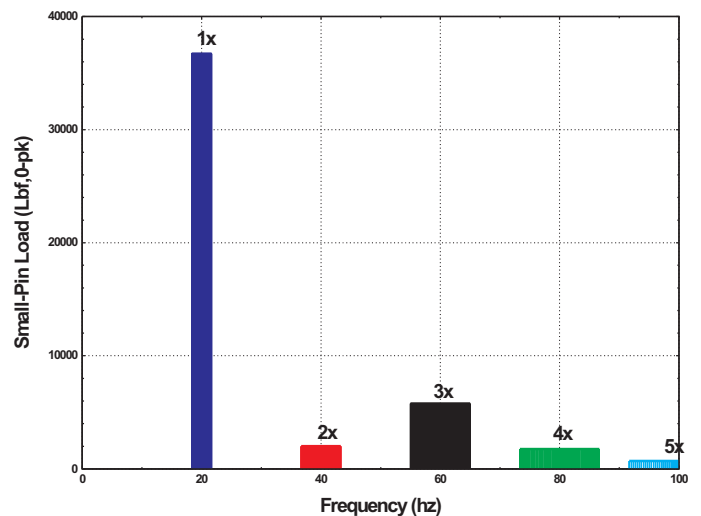


Figure 2 Rod Load vs Frequency for Low Speed and High Speed Reciprocating Compressors

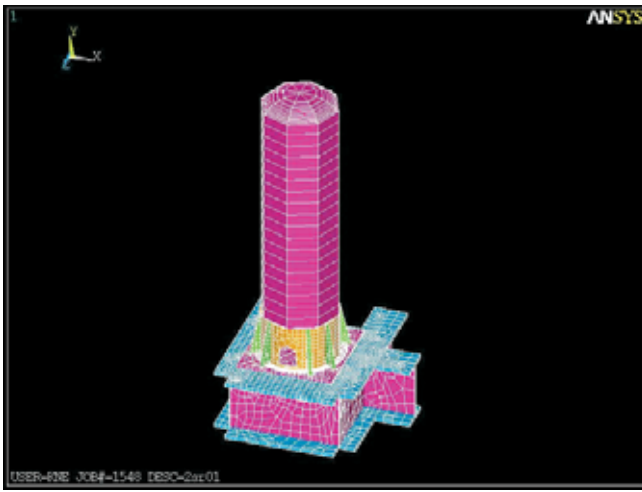


Figure 3 Parametric Model of Scrubber Base

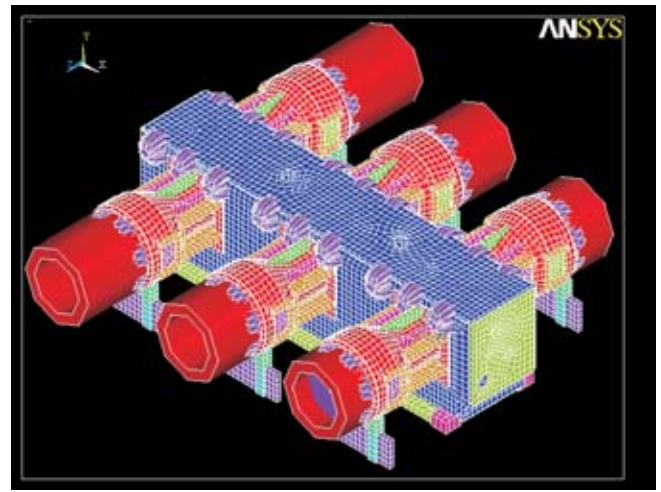


Figure 4 Compressor Frame and Cylinder Model

larger speed range. When a compressor operates over a large speed range, there are limited frequencies to tune a resonance so that it will not be excited by forces at the compressor speed (fundamental speed) or two times the compressor speed (second order speed). See Figure 1. Additionally, a reciprocating compressor causes forces at all the orders of compressor speed, not just one and two times. These forces generally decrease as the order increases.

A mechanical natural frequency that is at a high frequency (above 70 Hz) may not be excited in the case of a low speed compressor since the magnitude of the force tends to decrease with order of run speed. For a high speed compressor, a lower order with a higher force may be resonant with that mechanical natural frequency. See Figure 2. Determining solutions to vibration problems at high frequencies is typically much more difficult than solving vibrations at the compressor fundamental and second order speed.

Beta Machinery Analysis has taken advantage of our field service department and the MAPAK Start-up Check we offer to help fine tune boundary conditions and direct the modelling techniques we use. The development of parametric models and a database of compressor cylinder assembly stiffnesses have allowed us to turn very detailed finite element models into commercially viable processes. Figures 3 and 4 above demonstrate two of the detailed finite element models we have developed to advance our mechanical modelling capabilities.

Modelling a scrubber base as rigidly fixed will usually result in significant

error in predicted MNF, vibration, and dynamic stress.

The same comment applies to assuming that compressor cylinders, or worse yet, the attached bottles are rigid at their bases.

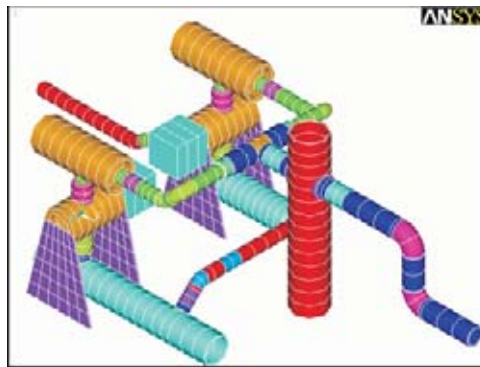


Figure 5 Finite Element Model of an Ariel JGK/2 Compressor

Figure 5 illustrates a model of an Ariel JGK/2, single stage compressor. Beta's standard modelling technique includes a model of the compressor cylinder assembly (at least back to the frame on smaller units and including the frame on larger units), distance piece supports, outboard supports (if applicable), suction and discharge pulsation bottles, close coupled piping and scrubbers. As noted above, the scrubber base stiffness is derived from a detailed model of the scrubber base and skid.

If the mechanical model is terminated too soon, or simplified boundary conditions are used, the calculated mechanical natural frequencies will be less accurate (depending on mode shape).

Table 1 shows a comparison of field measured mechanical natural frequencies versus predicted values for the Ariel JGK/2 model. The predicted values are calculated using Beta's standard modelling technique as well as a simplified model.

The simple model does not include the compressor cylinders and uses an anchored connection at the base of the scrubber. The scrubber mode is significantly affected by the base boundary conditions, while in this case the bottle modes are not significantly affected by either the cylinder or scrubber base stiffnesses.

## Summary

The reciprocating compression industry is an exciting and dynamic industry. The evolution that has taken place has presented many challenges from a design consultant point of view. With a dedicated Research and Development Department and a constant feedback loop between that department, the design group, and field services, Beta Machinery Analysis has been able to evolve with the industry.

Mode	Field Measured	FEA Complete Model	FEA Simple Model
Scrubber Horizontal	15	15.6	37.2
RHS Suction Bottle Horizontal	55	55.7	57.4
LHS Suction Bottle Horizontal	56	55.9	57.5

Table 1 Field vs Predicted MNF's (Hz)

continued from page 1...

1973 First use of a digital computer to predict acoustical natural frequencies of piping systems.

1974 Beta developed a digital model for predicting pulsation and unbalanced forces in a reciprocating compressor. This digital computer simulation was the first of its kind in the world.

1975 First commercial use of "MAPAK" digital computer program to model pulsations generated by reciprocating compressors.



1977 BMA developed and patented the *Aquaprobe*, a water cooled engine pressure indicator probe. Prior to this device transducers in engine service had to be cooled with forced air.

1978 Beta developed the world's first digital firing pressure indicator to balance engine cylinders.

1979 Beta founded Beta Monitors & Controls Ltd. to manufacture and market electronic instruments.

1980 BMA developed DATA-TRAP, the world's first portable digital data collector for vibration.

1980 BMA provided computerized predictive maintenance services. Beta analysts performed periodic checks on running machinery to identify potential problems.

1986 Beta developed and patented *B-Probe*, the world's first non-intrusive inspection tool to evaluate the condition of power cylinders, wrist pins and con rod bearings.

1986 BMA expanded Predictive Maintenance Program service to include reciprocating equipment with the world's first battery operated, digital, hand-held reciprocating compressor analyzer (RECIP-TRAP).

1989 Beta developed comprehensive scoring methodology for engines

enabling reliable life extension decisions (MARS).

1991 BMA opened Houston Sales and Service Office.

1995 Beta celebrated the 1000<sup>th</sup> acoustical (MAPAK) job.



2001 Beta developed a time domain acoustical model to deal with modelling high speed, high horsepower compressors.

2004 More than 6000 field assignments and over 2000 design projects executed to date.

2004 June 15th. After 37 years, Dave & Nel Schuh officially retire; new ownership team takes over.

2004 June 16th. Dave and Nel Schuh buy a new Chrysler!!!! (OK, we just made that up.)

## News & Notes

### *Beta will be there...*

The annual Gas Machinery Conference will be in Albuquerque from October 4 - 6, 2004. Beta will present two papers: "Torsional Vibration: The Value of Field Verification," and "Vibration & Performance Design Considerations for Gas Storage Facilities". Plan to drop by our booth. Visit the conference site at [www.gmrc.org](http://www.gmrc.org) or email Martha Short at [mshort@southerngas.org](mailto:mshort@southerngas.org) for further information.

The CMVA Annual Meeting and Trade Show will be held in Ottawa from October 27 - 29, 2004. For further information, contact Val Zacharias at [val.zacharias@cmva.com](mailto:val.zacharias@cmva.com) or visit the website at [www.cmva.com](http://www.cmva.com).

### *Bigger and better...*

In June a team of five Beta field engineers led by Bill Eckert and Brian Howes carried out one of the largest field assignments in the Company's history. The project was a speed up trial on a paper machine. Ninety four channels of data were collected as the paper machine speed was increased progressively to a new, almost world record level. It was a very demanding job, but most interesting for our engineers. The massive amount of data collected has not yet been fully analyzed, but it appears that the owner will be able to increase the speed and therefore the output with few design changes. A full article will appear in the Bulletin in the future.

### *Moving in...*

Luis De la Roche is busy finding a new home in Houston for his family. Please call to welcome Luis to the US.



*Beta offers best-in-class technical solutions for optimizing reciprocating and rotating equipment. The company is recognized as the global leader in this specialized field due to its:*

- capabilities in preventing machinery vibration and pulsation problems, including its MAPAK software package for modelling machinery systems;
- highly trained staff of machinery experts located in the US and Canada;
- proprietary testing/analysis methodologies and patents that are used to assess machine performance, solve field problems, or advise on new facility designs; and
- over 35 years experience working on challenging projects in the petroleum, pipeline, pulp and paper and manufacturing industries.

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