August, 2009 Volume 18-1

the BETA BULLETIN

BETA
MACHINERY ANALYSIS

ENGINEERING & DESIGN SERVICES
FIELD SERVICES
OPTIMIZATION SERVICES

This Issue in Brief

- Application and technical articles to help you design, operate, and maintain your rotating equipment.
- For reciprocating compressors, we have published a free, practical, easy to read Primer on vibration control strategies. It addresses many of the questions received from packagers, Engineering Consultants and end users about design approaches to avoid pulsation and vibration problems.
- Five short examples to improve performance and reliability for Centrifugal Compressors and Gas Turbines.
- Piping flexibility studies can create challenges, especially for determining skid edge loads. This Application Note identifies the issues for Engineering Consultants when evaluating flexibility of piping connecting to compression equipment.
- Check out Beta's new website for new articles and application information, plus animations, and more.
- Beta has expanded its office in Malaysia giving additional Design, Field and Optimization services support for customers throughout SE Asia.

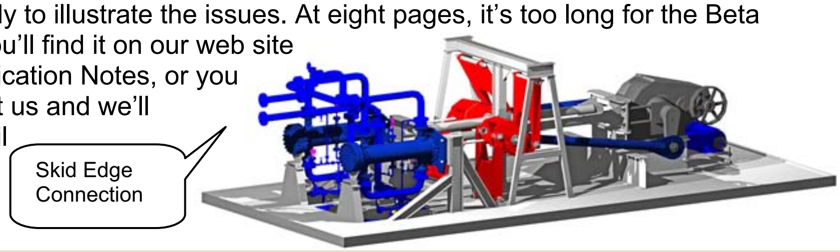
In This Issue

Ask the Expert

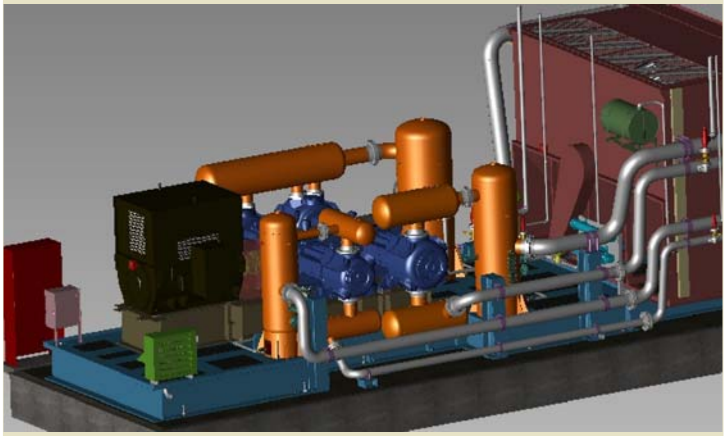
Send in your questions about machinery analysis and we'll answer them in future issues of the Beta Bulletin.

Q – For piping flexibility studies, who is responsible for ensuring the pipe design at the package limit is acceptable...the packager? The EPC?

A - Piping flexibility studies (thermal analyses) are commonly done on piping systems to ensure the stress, force, and deflection due to loads from pressure, temperature, and weight are within safe limits. A problem arises, because the design of a particular facility is often a shared responsibility of several different companies. For example, the compressor packager designs the piping and vessels within their package limit (also referred to as skid edge) and the EPC company designs the interconnecting piping from the compressor package limit to the rest of the facility. We've had this question so many times that we put together an Application Note to cover this very situation. It discusses the commonly referred to specification of allowable skid edge loads and provides practical design practices to ensure the pipe design is acceptable and presents a case study to illustrate the issues. At eight pages, it's too long for the Beta Bulletin. You'll find it on our web site under Application Notes, or you can contact us and we'll gladly email it to you.



Vibration Control Primer for Reciprocating Equipment



Vibration problems are very costly to owners – especially when including the downtime and repair costs.

Our new technical Primer has valuable information to help you mitigate pulsation and vibration on reciprocating compressor/pumps, piping, vessels, skid, and foundation.

This easy to read manual is intended to help the industry prevent pulsation and vibration problems on the compressor and driver, piping, vessels, skid, and foundation. Since the pulsation control solution affects overall compressor performance, a discussion on compressor performance is included.

The Primer addresses many of the common questions, such as, "How do I read a pulsation study?" and, "What is the difference between (API 618, 5th edition) DA2 and DA3 scope of analysis?"

API 618, 5th edition, specifies vibration control strategies for the compressor package. The Primer explains how this Standard should be applied to new or retrofit compressor packages, and identifies design tips to ensure a successful project.

The issues directly relate to the specifications and design processes undertaken by EPCs, compressor packagers, and owners (including facility engineers, rotating engineers, and other staff directly affected by the design or modification of compressors).

Please send us an email to request a free copy, or see the form on our web site, www.BetaMachinery.com.

Case Study: Centrifugal Compressor and Gas Turbine

Performance and Reliability Improvement Examples

These examples are from our monitoring and field services, where we assisted with performance assessments for rotating equipment, such as, gas turbine and centrifugal compressor trains. This Case Study has five optimization examples:

1. Centrifugal performance assessment: changing operating conditions

2. Does the turbo expander need to be rebuilt?

3. Centrifugal compressor has performance degradation.

4. Impact of improved blade wash cycle on a gas turbine.

5. Performance monitoring on a gas turbine.

The end result was increased performance and cost savings for our customers.

1. Centrifugal Performance Assessment: Changing Operating Conditions

A gas plant was planning to increase the inlet gas supply volume. BETA was retained to evaluate the compressor and gas turbine performance to determine whether the unit could handle a 35% increase in gas throughput. As discussed, below, the issue becomes complex due to the impact of ambient temperatures.

Historical and current operating data were used in BETA's performance model to predict throughput and power requirements. It was found that the available engine power could handle the additional volume at certain operating conditions and not at others. The key variables in the analysis were suction pressure and ambient temperatures.

As shown in the example, there is a gap between required power (for the compressor) and available power. The graph shows compressor input power vs. suction pressure for three different ambient temperatures.

At higher suction pressures and low ambient temperatures, the unit can handle the increased

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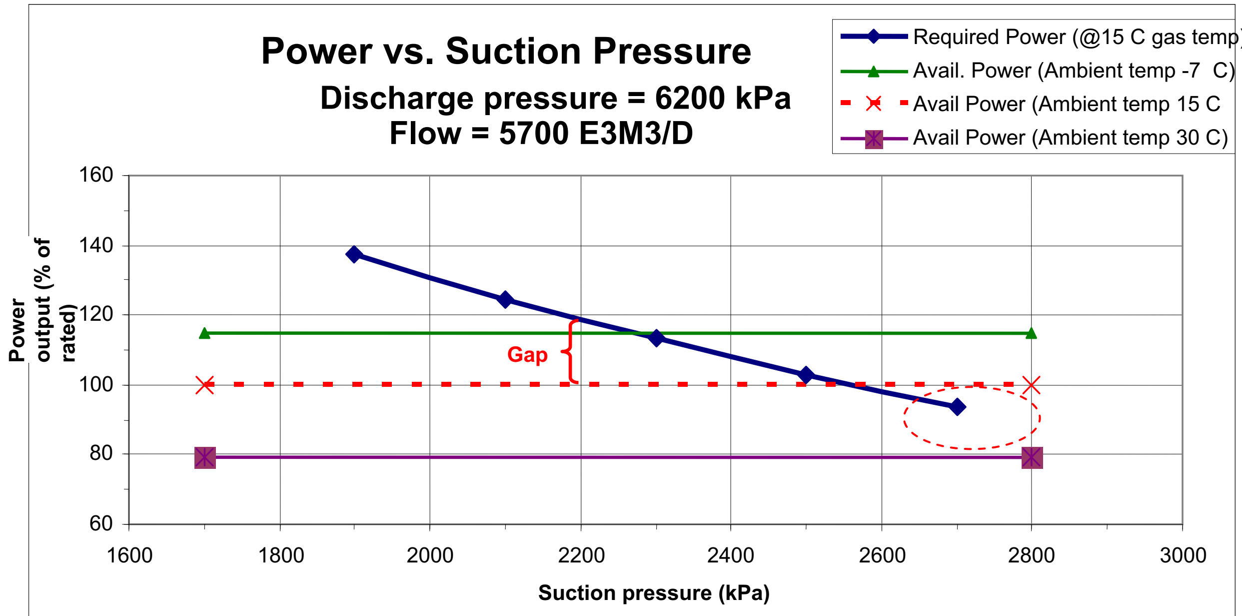
throughput (power output exceeds the required power. For example, at 15 C operation is possible above a suction pressure of 2550 kPa, in the area highlighted below (red oval).

At lower suction pressures there is insufficient power for the required load. This is illustrated by the gap between required power and compressor power output (see example at 15 C and 2200 kPa).



Example: Performance Gap at 15C and 2200 kPa (Available Power < Required Power)

These results were used to investigate various power upgrade possibilities for the gas turbine – an ongoing analysis.

2. Should Turbo Expander Be Rebuilt? (Turbo Expander and Centrifugal Compressor Example)

For this midstream pipeline company, the customer was unsure if the turbo expander should be rebuilt. Would the improved performance (and economics) support the associated repair cost?

The process involves a turbo expander that compresses low pressure gas, which then feeds the centrifugal compressor. The turbo expander currently has a discharge pressure of 2100 kPa. A major overhaul of the turbo expander would increase the discharge pressure to 2460 KPA (which is the suction pressure for the centrifugal compressor). The benefit of this higher suction pressure is to improve the performance of the centrifugal compressor - decreasing the load and fuel requirements. The cost for this overhaul is $150,000.

BETA predicted the reduced power requirements and reduced fuel consumption and evaluated the economics. As shown here, the overhaul would payout in 65 to 87 days – a very good investment.

This table shows the centrifugal compressor performance results, including fuel savings ($) for the typical discharge pressure (Pd), two flow rates (Q) – before and after the change in suction pressures (Ps).

	Pd = 6200 kPa	
	Q= 4250 e^3m^3/d	Q= 5700 e^3m^3/d
Before overhaul: Power (Bhp) at Ps = 2100 kPa:	11640	15611
After overhaul: Power (Bhp) at Ps = 2460 kPa:	9795	13136
Power Savings from overhaul (Bhp):	1845.0	2474.1
Fuel Savings (MSCF/day):	344.1	461.5
Fuel Savings: ($/day):	$1,720.55	$2,307.25
Fuel Savings ($/year):	**$627,999.69**	**$842,147.58**
Payback on Investment (days):	**87**	**65**

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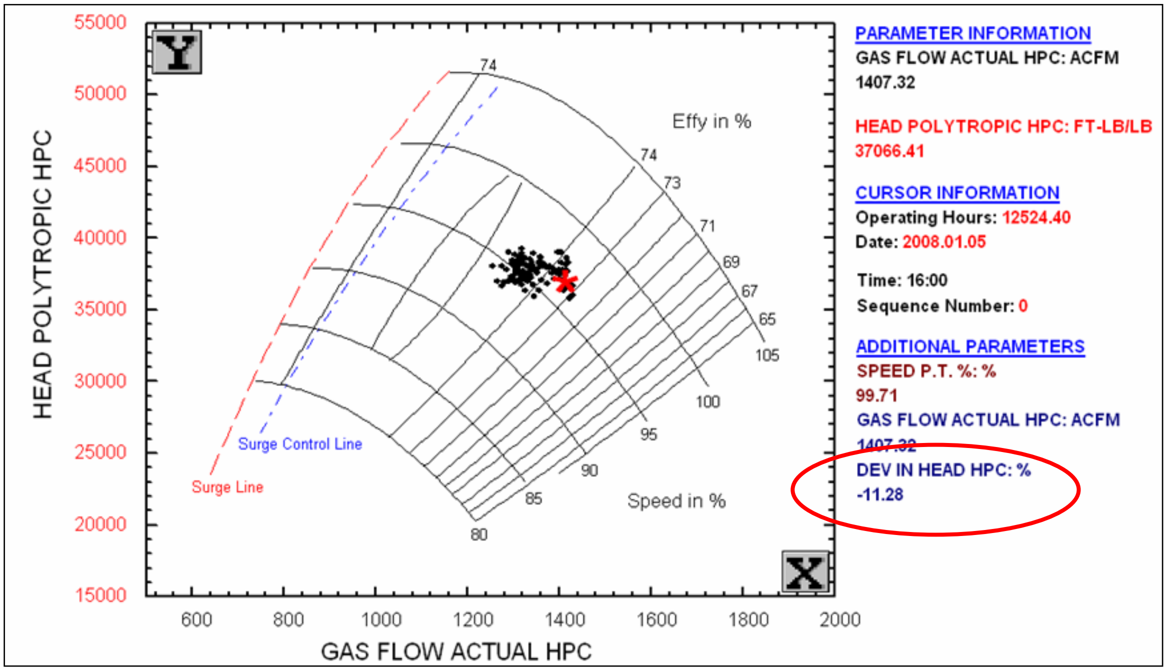
3. Centrifugal Compressor Performance Degradation

The performance of a centrifugal compressor is evaluated against the wheel curve baseline for this particular unit. As show, this unit had an 11% deviation in head at the point shown, likely due to impellor fouling, impellor wear, and/or increased clearances.

BETA monitors the compressor's performance to detect changes in performance. The wheel curve is one of our analytical tools that is tracked regularly.

Cash Flow Impact of Performance Deviation is about $142,500/year. This is based on 63 MMSCFD throughput and 325 BHP of extra power is required because of the stage performance degradation (measured as head deviation). Fuel gas costs are based on engine BSFC of 10,000 BTU/BHP-hr and fuel gas valued at $5/MCF.



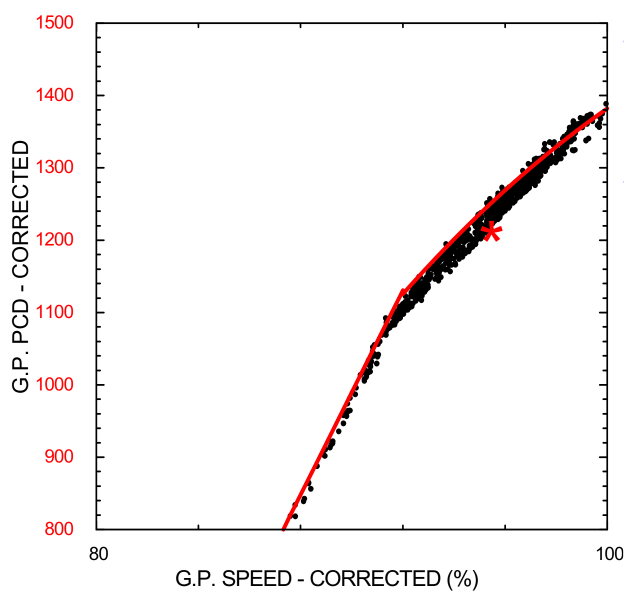
4. Gas Turbine: Impact of Improved Blade Wash

Turbine blade wash is a required maintenance activity. However, the operator will realize improved cash flow by optimizing the maintenance cycle for blade washing. Avoiding unnecessary blade washing improves capacity throughput, yet excessive delays will result in pressure deviation (lower performance).

BETA's monitoring identifies optimal maintenance cycles. Operating data from the turbine is collected daily and converted into normalized baseline curves (see figure at right). This baseline consists of normalized gas producer speed (horizontal) versus normalized compressor pressure deviation.

Deviations between current operating condition and the baseline curves are trended (see figure, next page).

The pressure and temperature deviation is used to determine the optimal maintenance interval. The next figure illustrates multiple blade washing activities. In each case the pressure and temperature is reduced. The deviation starts to increase until the next wash cycle.



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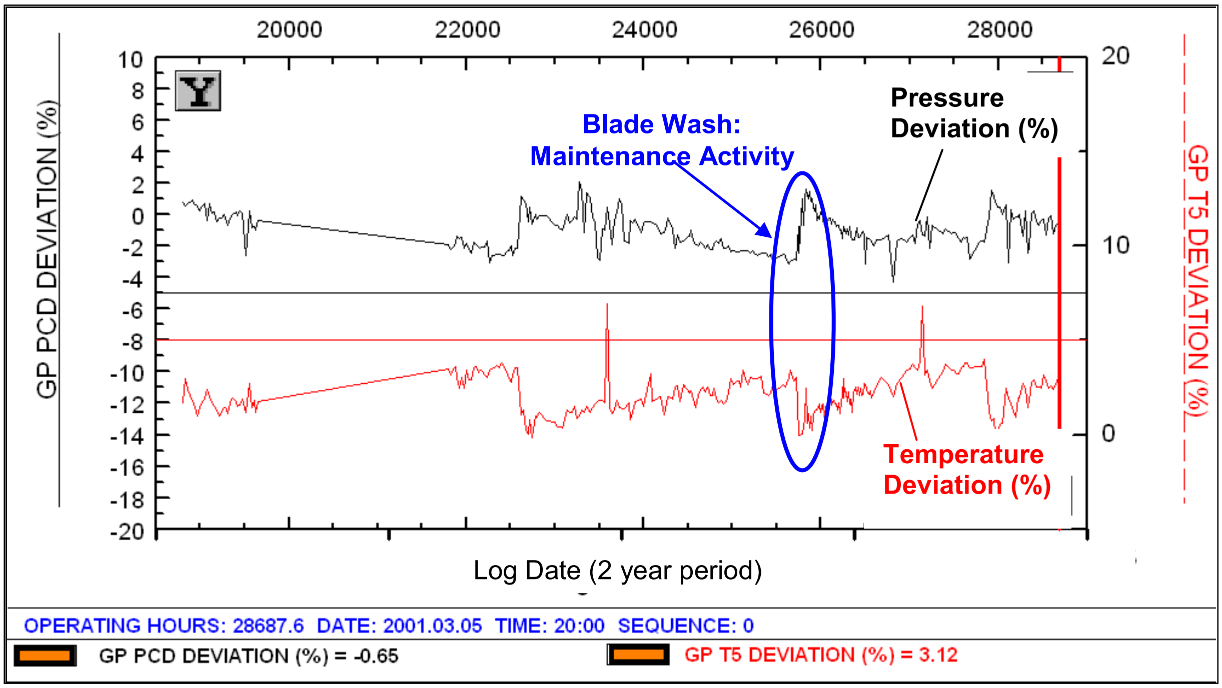
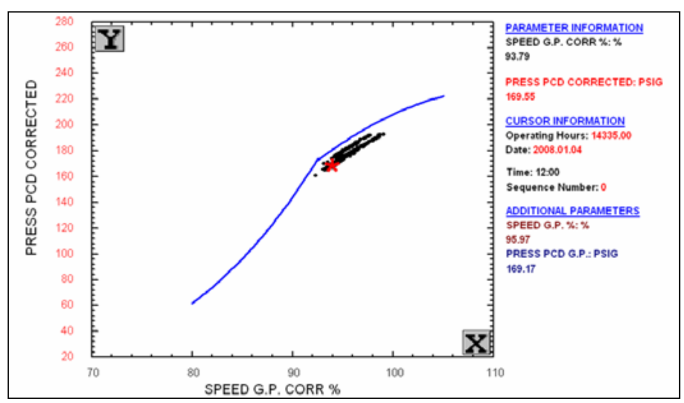
Impact

- Avoiding an unnecessary blade wash will result in reduced downtime and operating costs. The preserved production can represent hundreds of thousands of dollars in cash flow.
- On the other hand, decreased compressor efficiency causes increased fuel consumption and the resulting increased T5 temperatures can shorten component life. These factors also represent very large economic impacts.



5. Gas Turbine: Performance Monitoring (Identifies $250,000 per Year Cost Saving)

Compressor discharge pressure (PCD) is a key factor in gas turbine performance. Beta's MAO service determines the deviation in PCD from a baseline relationship with gas producer speed, N1. In the case shown here, PCD looks unremarkable, but the deviation in PCD tends to jump between -7% and -3%.



The performance graph below shows the same behavior, with the operating points falling either 3% or 7% below the baseline.

The most likely cause of this problem is inlet guide vane linkage malfunction (looseness or "hanging up").

Impact

Measured fuel flow rate was about 10% higher at the increased PCD deviation condition. Under typical operating conditions for this unit, this represents incremental fuel valued at about $250,000 per year, assuming $8/MCF.

For more performance and condition monitoring examples, contact BETA's application support team.

Beta News

Our web site has a new look

Our web site has had more than a face lift. We listened and have responded with a more intuitive layout and easier navigation, plus we have updated and expanded on the technical content.

The animations on our home page tell the story about BETA and demonstrate why more customers trust their challenging machinery problems to us.

Jargon and terms are explained, and the Knowledge Center is a fountain of information, including free downloads of technical articles and papers, Application Notes, interactive calculation tools and converters, and specifications for ordering API 618 studies. Check us out at www.BetaMachinery.com.

Is there anything you'd like to see added to our web site? Please send your input to jwalters@betamachinery.com.

BETA and ACI Services, Inc. announce a new compressor station design optimization service

Beta Machinery Analysis (Beta) and ACI Services, Inc (ACI) have developed a new service to support the design optimization process for reciprocating compressor packages. This service is ideal for pipeline or midstream applications where owners require better performance, flexibility, reliability, and safety across the entire operating envelope.

One of the features of this new service, the System Performance Model™ (SPM™) program, evaluates alternative capacity control schemes, pulsation control solutions, and other factors in the package, over the entire operating envelope.

Here are a few of the tangible benefits to owners; owners can select the optimal design to meet the specified performance prior to fabrication, resulting in higher flow/efficiency, better operating flexibility, and accurate predictions of forces, rod load limits, and other key parameters. The SPM can be integrated in the automated control system, enabling operations to more accurately run the machines and achieve higher efficiency/safety. The Service has been proven to significantly improve profitability and reliability of the compressor package design. Contact either BETA or ACI for more information or for application support.

Additional BETA Support for Southeast Asia Customers

To support our ongoing field, design, and monitoring projects in SE Asia, and to provide even better support to our customers in Malaysia, Singapore, Indonesia, Thailand, and other countries in the region, we have added to our staff in Kuala Lumpur, Malaysia. This means a faster response and expanded coverage.

Jordan Grose is BETA's SE Asia Development Manager, and can be contacted at jgrose@betamachinery.com to get application support for your land-based or offshore compression projects.

Jordan is a mechanical engineer with a wide range of domestic and international design and field experience with compressors, pumps, and other production machinery. He has specialized skills in vibration, performance, troubleshooting, condition monitoring, and machinery design. Jordan has led many performance and condition monitoring assignments, where he implemented new monitoring approaches for critical oil and gas production equipment. He also has experience in pulsation, mechanical and structural analysis for production facilities (offshore) and has authored and technical papers.

If you want support on a project in the area, contact Jordan.

Training Options

Check out our ‘vibration on reciprocating compressors’ training videos on http://www.YouTube.com!

Customized vibration training is available – in most cases, at your site. Ask about our lunch and learns and seminar options. Topics cover issues such as, Pulsation and Vibration in Reciprocating and Rotating Equipment, Understanding API 618, Torsional Analysis, Remote Monitoring, Troubleshooting Tips, and more.

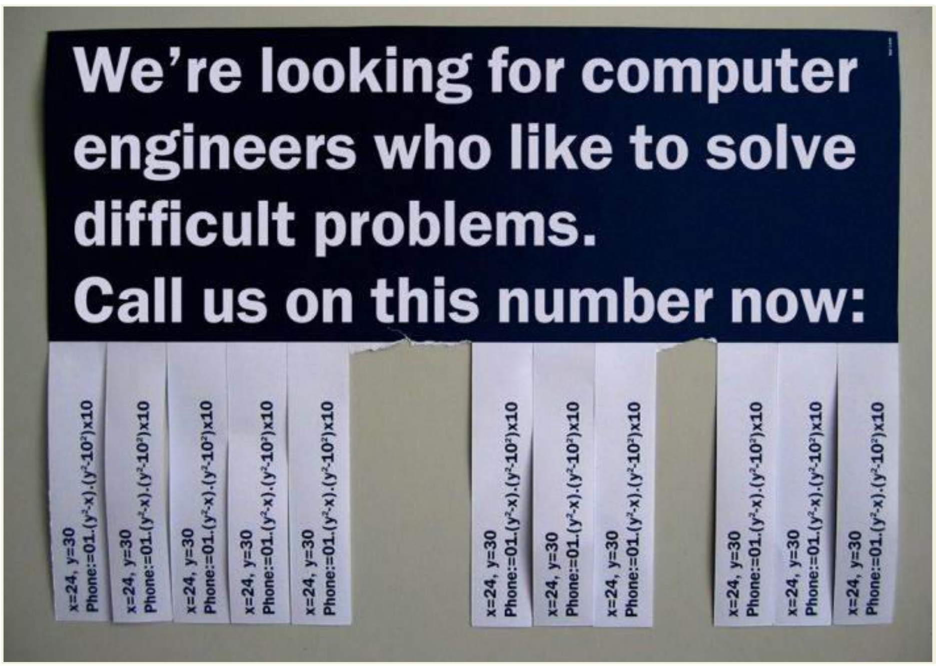
Do you have comments or questions about any of this material? Do you have topics you'd like to see covered in the Beta Bulletin? If so, send an email to: jwalters@betamachinery.com.

Upcoming 2009 Trade Shows and Conferences

Sep 13-17 **TurboMachinery Symposium**, Houston, TX. Booth #1322.

Oct 5-7, **GMC**, Atlanta, GA. Booth 222. Presenting technical papers, *Improved Performance of a Pipeline Compressor Station* and *Vibration Due to Gas Forces*, as well as a short course, *Resolving Common Vibration Problems.*

Humor



You might be an engineer if ...

You think in math.

You know the second law of thermodynamics...but not your own shirt size.

You consider yourself well dressed if your socks match.

You know how all the buttons on your calculator work.

You know vector calculus but you can’t remember how to do long division.

How to Contact Beta

CANADA
300, 1615 – 10th Avenue SW
Calgary, AB T3C 0J7
Canada
Tel +1 403 245-5666

USA
919 Park Meadow Drive
Katy (Houston) TX 77450-4015
USA
Tel +1 281 920-4441

MALAYSIA
No. 22-2, 2nd Floor
Jalan Sri Hartamas 8, Sri Hartamas
50480 Kuala Lumpur, Malaysia
Tel +603 6201 4130

www.BetaMachinery.com **info@BetaMachinery.com**