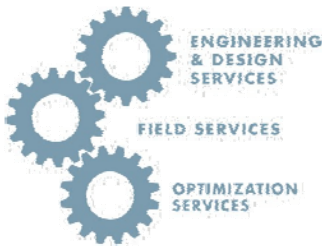


# the BETA BULLETIN

*Season's Greetings*



**MACHINERY ANALYSIS**



## In this Issue

In this issue of the Beta Bulletin you'll find news and tips for your reciprocating and rotating equipment, including:

- Ask the Expert Why important changes to API 618 5th Edition are a big deal.
- Transient Events Why you need to know about them and what studies are recommended.
- Effects of Dynamic Pressure Drop on Reciprocating Compressor Performance Surprising findings from a paper Beta delivered at the 2008 GMC.
- And more...



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## Ask the Expert

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

*Q - Does the new 5th Edition of API 618 have important changes regarding pulsation and vibration studies for compressor packagers and owners?*

*A - Glad you asked. YES. This Standard was updated last December. We've made ourselves familiar with the Standard and asked some hard questions of the committee. Our findings have been published in three parts in CompressorTech Two magazine (June, July, and August/September, 2008) and we have been invited to speak on the subject at several Lunch and Learn events for customers - packagers and owners.*

The article starts in the June issue with an introduction and overview of the new changes to the pulsation and vibration studies required by the 5th Edition of API 618. This includes details on pulsation guidelines and mechanical design issues.

The second part of the article, in the July issue, highlights issues that affect the specification of studies - an important issue for packagers and owners.

The authors of the Standard stress that it is a guide to the minimum requirements only and they advise packagers and owners to 'aggressively pursue performance optimization.' This is the topic covered in the August/September issue.

Visit our web site to download a free pdf of the complete series:  
[www.BetaMachinery.com](http://www.BetaMachinery.com) > Support > Articles > API 618 5<sup>th</sup> Edition.

## In This Issue

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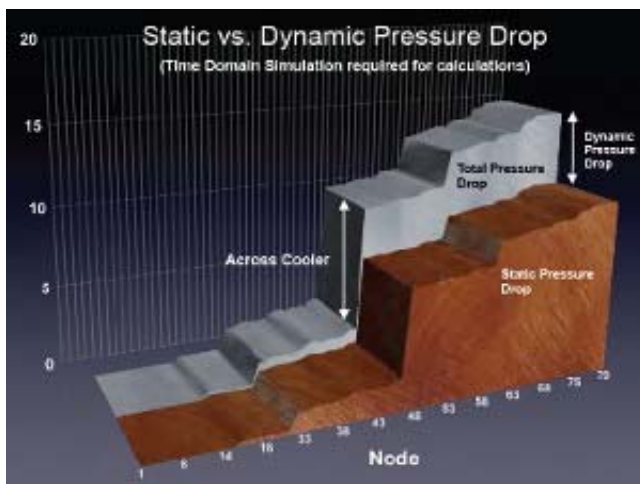
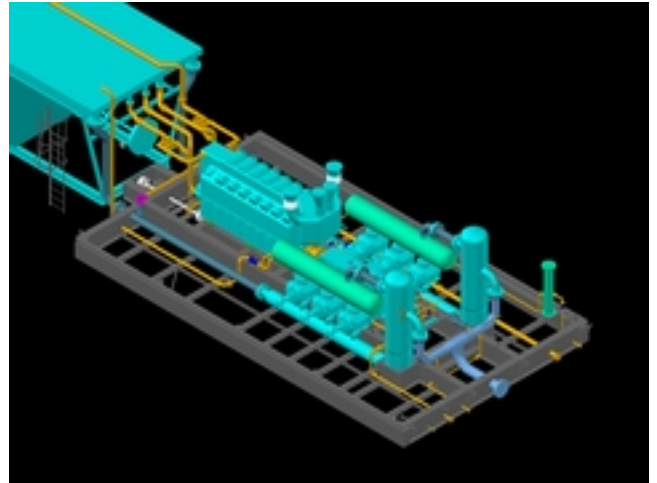
# Dynamic Pressure Drop and Reciprocating Compressors

*Based on a paper presented at the 2008 GMC, Albuquerque, NM*

Pressure drop is the pressure loss due to resistance to the flow. The resistance can come from a number of sources such as friction loss in the piping, change of pipe cross section, a tee, a cooler tube, an orifice plate or a choke tube. Pressure drop can be defined locally or on a system basis.

A “system” consists of a collection of piping, vessels and pulsation control devices. Static and dynamic pressure drop occur through all parts of a reciprocating compressor installation and not just the pulsation control devices.

Static and dynamic pressure drop are important factors in calculating reciprocating compressor system performance. Calculation of static pressure drop has been well understood for many years. Calculation of dynamic pressure drop resulting from flow fluctuations requires specialized pressure pulsation analysis. Dynamic pressure drop can be as large, or larger, than static pressure drop in some cases, so accurate calculation of the dynamic pressure drop is critical.



Understanding the pressure drop through each component is key to accurately calculating the compressor capacity and power requirements.

**Technical gaps** in some pressure pulsation simulation programs do not allow for calculation of dynamic pressure drop. Also, industry practice for compressor performance modeling is to make generic assumptions about pressure drop through the piping system. These factors can lead to large errors in the calculated compressor performance.

**New simulation tools** have been developed to address this technical gap in calculating dynamic pressure drop as well as including the true total pressure drop in compressor performance calculations. Accurate calculation of dynamic pressure drop means the compressor performance can be verified in the design stage, thus **avoiding costly redesign, or retrofit**, after installation. Also, these new simulation tools result in accurate compressor pulsation studies that allow for optimization of the compressor package design and **ensure safe, long term operation**.

The full article is on our web site, [www.BetaMachinery.com](http://www.BetaMachinery.com) > Articles, and describes the analytical tools used in accurately calculating the system static and dynamic pressure drop;

- case studies that demonstrate the effect of dynamic pressure drop on the compressor performance; and
- a recommended design approach to ensure the compressor is designed appropriately for the application.

*Authors: Kelly Eberle and Gordon Q. Sun (Beta Machinery Analysis) and Dwayne A. Hickman (ACI Services, Inc.)*

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# Case Study – Transient Analysis

The purpose of transient analysis of equipment operation such as compressors, pumps and piping system is to ensure the system will not be adversely affected by a sudden event such as an emergency shut down (ESD), upset condition, or sudden events that are part of normal plant operation.

**Transient events include** actions such as sudden opening or closing of valves, equipment start-up or shutdown, or sudden changes in flow conditions. These transient events typically involve changes in the pressure, flow or boundary conditions (end points) in a system over very short periods of time. During the event, high dynamic pressures and forces can be created. These dynamic loads can lead to excessive vibration and stress which can result in a fatigue failure and or damage to the system. Owners want to avoid reliability problems associated with these transient events.

Transient analysis requires simulation of the flow conditions using a time domain tool. Beta pioneered the development of time domain (TD) capability in 1998 to support a variety of transient studies. Here are two examples:

## Case 1: What happens to a flare system during an ESD event?

The client was concerned about the design of the relief valve and flare system layout and support with respect to the dynamic forces generated when the relief valves open during an emergency shut down (ESD). Figure 1 is a model of the ESD piping system.

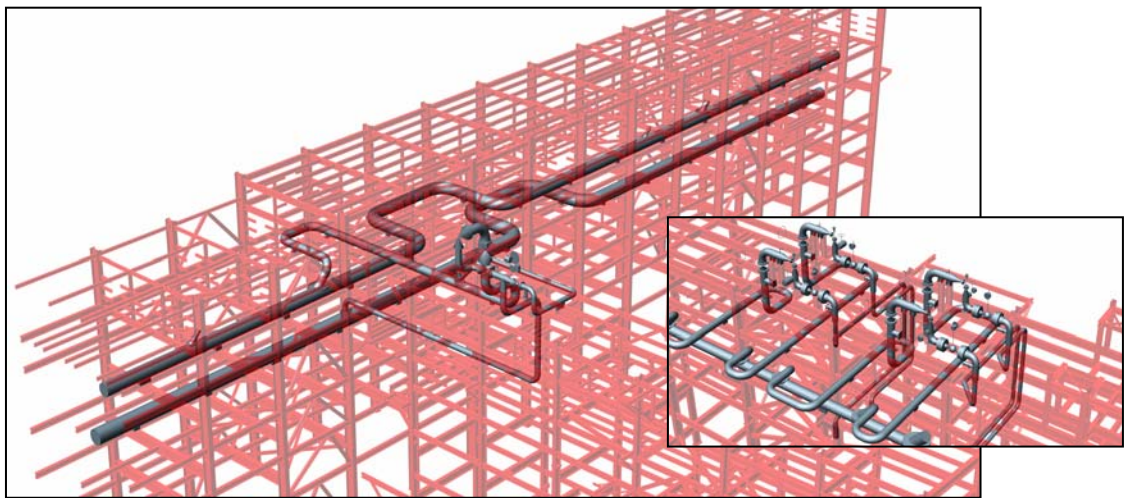


Figure 1: Plant ESD Piping System Included in Beta's Transient Study

There are two main concerns with the flare system. First there is high frequency acoustic excitation (noise) generated during the relief event that can cause failures. Second, there are lower frequency forces generated in the piping upstream and downstream of the relief valve due to the change in flow and pressure inside the piping when the relief valve opens.

The analysis of the low frequency forces in the flare system includes two parts. First, a transient acoustical simulation is conducted to calculate the time varying pressure and forces in the piping (see Figure 2). The flare system in this case is a closed system with the flare gas captured in a large vessel rather than being vented to atmosphere. There are several simplified approaches for the analysis of relief valves which vent to atmosphere, but the analysis of a closed flare system is more complex requiring a full system model.

The second part of the analysis includes applying the calculated dynamic loads to a finite element model of the piping and supports to calculate vibration and dynamic stress.

Based on the analysis, a number of recommendations were made to minimize the excitation forces, as well as changes to the pipe layout, adding reinforcing pads, and modifying support designs to minimize piping response. These improvements will avoid fatigue failures on the piping system.

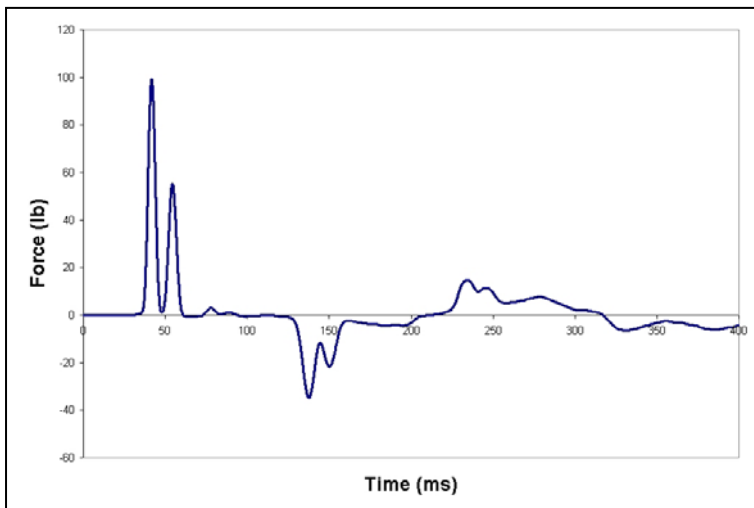


Figure 2: Transient Force in the Flare System Piping

## generators during a plant upset?

The scope of this study included a transient analysis to evaluate two reciprocating compressors supplying gas to two turbines used for power generation. Figure 3 shows an image of the model used in this analysis. The purpose of the study is to determine the size of a vessel (buffer tank) required in the discharge system to meet strict pressure guidelines at the turbine inlet for normal operation as well as for a plant upset or unit shut-down.

The pressure pulsation at the turbine inlet must be controlled to very low levels for normal steady state operation to minimize the effect on the turbine performance. Also, the mean pressure at the turbine inlet must be controlled in a very specific way during an upset condition to allow time for the control system and turbine to take appropriate action to ensure safe operation. Large volumes (buffer tanks) are required in the discharge system to ensure there is a sufficient volume of gas in the discharge system during this transient event.

The governing design criterion in this application was to ensure a maximum pressure change at the turbine inlet, 11 psi/sec or less. The pressure change at the turbine inlet was found to be well above the design specification for the original design, 54 psi/sec. Two buffer tanks of 58" ID x 178" s/s were required for this application to meet the design criterion. Figure 4 shows some typical results from the analysis. This case study illustrates how a transient analysis study can be used to ensure safe operation for turbines when supplied by reciprocating compressors.

### Summary

As illustrated by these two cases, transient analysis is an effective tool to improve reliability and safety of the piping system.

*Authors: Kelly Eberle and Gordon Q. Sun, Beta Machinery Analysis*

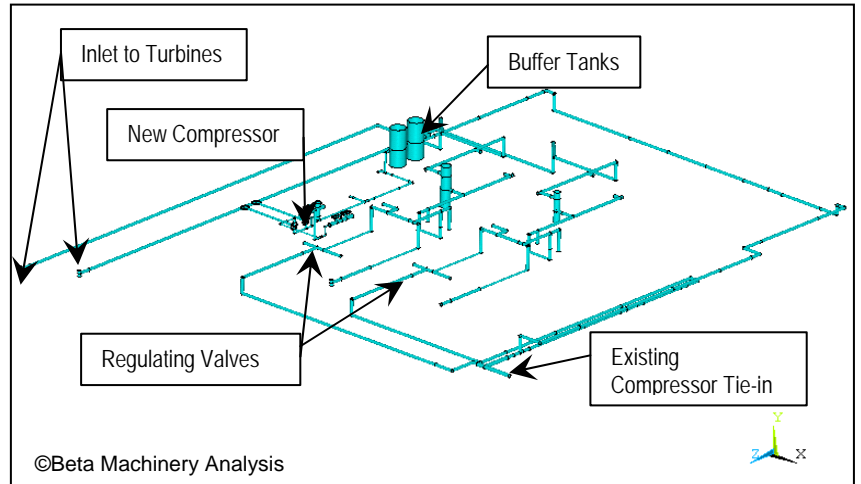


Figure 3: Model of Reciprocating Compressor Discharge to Turbine Inlet

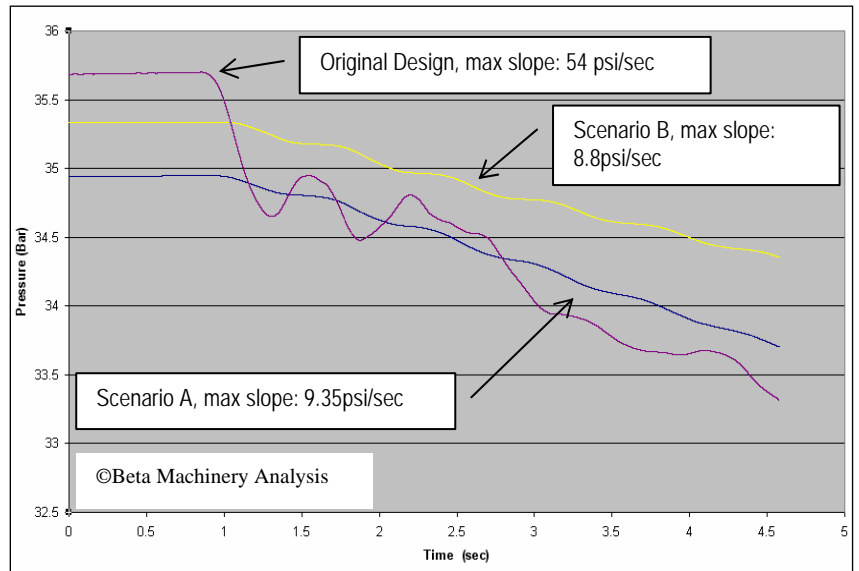


Figure 4: Pressure at the Turbine Inlet for Different Operating Scenarios

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## Humor

Four surgeons were taking a coffee break and were discussing their work. The first said, "I think accountants are the easiest to operate on. You open them up and everything inside is numbered."

The second said, "I think librarians are the easiest to operate on. You open them up and everything inside is in alphabetical order."

The third said, "I like to operate on electricians. You open them up and everything inside is color-coded."

The fourth surgeon said, "I like Engineers...they always understand when you have a few parts left over at the end..."



**Just wondering...**

If you could drive your car at the speed of light, ...  
...would your headlights work?

**You might be an engineer if...**

...Your favourite James Bond character is "Q".  
...You bring a technical journal as vacation reading.  
...You say, "It's 70 degrees Fahrenheit, 25 degrees Celsius, and 298 degrees Kelvin" and everyone else says, ... "Isn't it a nice day?"

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## Trade Shows and Conferences...

We met up with some of you in 2008 at the GCA in Galveston, the TurboMachinery Symposium in Houston, the GMC in Albuquerque, and the EFRC in Düsseldorf, and we look forward to seeing you at the events below in early 2009.

**Feb 3-4, ESD Compressor Optimisation Conference, Aberdeen, Scotland.**

**Feb 23-24, GCA, Galveston, TX USA**

**March 16-18, GSRMS, Baton Rouge, LA, USA.**

## ...and Training

It's been a busy year giving onsite training and presentations to customers and interest groups covering topics such as,

- Compressor design considerations,
- Remote online monitoring and analysis, and
- Vibration troubleshooting.

Let us know if you're interested in a Lunch and Learn or presentation for your group.

## Season's Greetings



**As 2008 comes to a close, it is, naturally, a time of reflection.**

At Beta, we look back over the year with appreciation and a big thank you to our customers, our staff, and our families. The events of this year have given us all in increased awareness of how connected this world really is.

We also look forward with anticipation for what the New Year will bring. At this special time of year, we wish you the love of family and friends, many precious moments, and a happy, healthy, and prosperous New Year.

The photos below show a few precious moments enjoyed by Beta staff in 2008:



Brian's 60<sup>th</sup> Birthday



Gordon  
Calgary Stampede Breakfast



Jordan



Santa  
Family Christmas Party, Lake Louise, AB.



Sleigh Rides

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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, we invite you to send an email to: [jwalters@betamachinery.com](mailto:jwalters@betamachinery.com).

Sincerely,  
Jackie Walters  
Beta Machinery Analysis

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**Many helpful resources are available to you on our web site. Here is a partial list of Application Notes and Case Studies:**

## Application Notes

- 1a Overview of API 618 5th Edition Changes
- 1b Implications of API 618 5th Edition for Packagers, OEMs, and End Users
- 2 What API 618 Scope of Pulsation and Vibration Study is Required?
- 3 How to Avoid Scrubber Vibration
- 4 Confusion With Mechanical Analysis API 618 (M5, M6, M7 Studies)
- 5 Compressor Frame Model Increases Accuracy in Mechanical Studies (super element model)
- 6 Vibration Issues on Compressors with a Wide Speed Range
- 7 FPSO and Offshore Platforms

## Case Studies

### Design

- Transient Analysis
- Compressor Pulsation Bottle Sizing Optimization: Generates Over \$120,000 in Savings
- Optimized Compressor Design: Enables Over \$3 million/year of Incremental Cash Flow
- Offshore Platform Projects: Integrated Design Approach
- Optimal Design Consideration For Compressors with Multiple Operating Conditions
- Structural Analysis: FEA Techniques Used to Reduce Skid Costs
- Transient Analysis of Equipment Operation

### Monitoring and Troubleshooting

- How to Avoid a \$300,000 Repair Bill: Excessive Vibration in Engine Turbocharger
- Comparison of Engine Maintenance Program: \$300,000 Savings per Engine Due to Inspection Program
- Troubleshooting an Indonesia Facility: Not All Identical Units are Equal
- Diagnosing Compressor Valve Problems
- High Pressure CO<sub>2</sub> Compressor: Internal Bottle Failure
- Meter Error in Gas Packages: Significant Error Can Be Caused by Pulsation Problems
- Methanol Processing Plant Valve Failures
- Noise Survey: Equipment Testing to Assess Noise Impact
- Screw Compressor – Rotor Vibrations
- When to Overhaul an Engine? \$100,000 Savings by Deferring Overhaul