GE Energy

Introducing OptiComp-BN

Antisurge protection & detection using vibration measurements

Measurement & Control Systems

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Compressor SURGE.....

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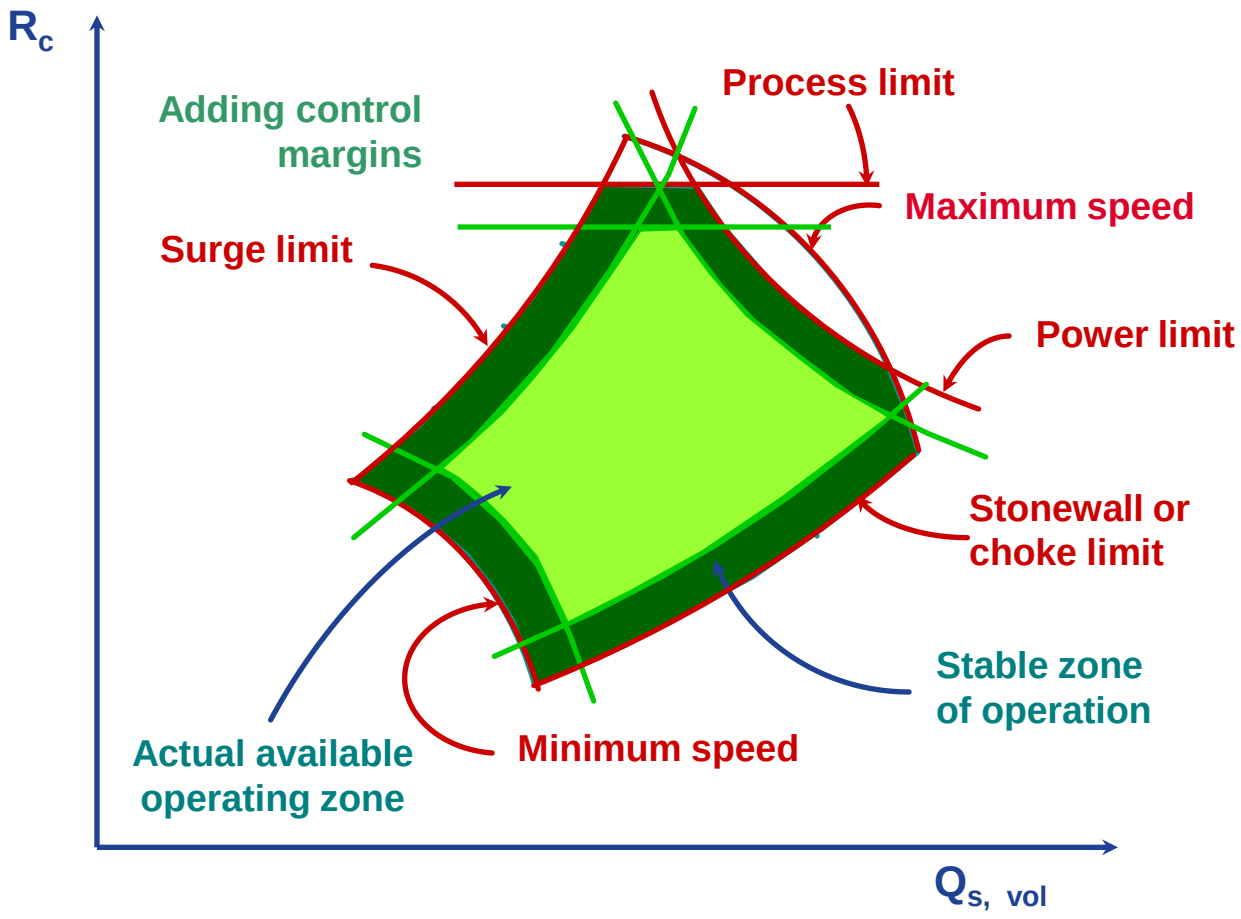
Typical Compressor map



Definition of Surge

Surge: large and self-sustaining pressure and flow oscillations in a compression system

- Rotating speed or motor current is affected
- Interactions between the compressor and the process system
- Fluid aerodynamic phenomena
- Flow reduction (light surge)
- Flow reversal (hard surge)

Major safety risk

Major equipment damage and downtime

Why Is Surge Avoidance Important?

- Causes Unit Trips - lost production
- Machine damage (seals, bearings, rotor etc.)
- Process disturbance
- More efficient operation by:
  - Avoiding recycle
  - Off design operation needs more reliable and accurate surge protection
  - Maximize operating envelope

Surge and Stall Detection

Current methods rely solely on process measurements

- Process measurements are only reliable for an actual surge detection as the compressor experiences a full surge event
- Cannot detect stall and surge in cases when compressor characteristics change due to degradation or malfunction
- Can give a false indication and response to a surge event
- Can not be analyzed for severity for internal damage
- Compressor must be surged for accurate field mapping of surge points

Issues in antisurge protection

Accurately defining the Surge Limit Line (SLL)

- SLL can be significantly different from values shown on compressor map:
  - Flow instability is a function of both the compressor design and the overall compressor network (piping, vessels, valves, etc.)
  - Accuracy of the flow measuring device
  - OEM cannot predict surge limit exactly
  - In retrofits, the performance curves and SLL are likely shifted, due to internal recycle, fouling, and changes in compressor mechanical components accumulating over maintenance cycles
- Leads to:
  - Unnecessary recycling
  - Surging

Mechanical Indications for surge

Radial vibration measurements

- Frequency used to detect the onset of rotating stall (incipient surge), which may precede full surge
  - in some machines stall and surge occur nearly simultaneously
  - other machines exhibit significant differences in the flow rates at the inception of stall and actual surge

Axial Displacement and Radial Vibration

- Combination used to detect surge
- Able to gauge severity of surge

Field testing to determine surge

- Most reliable method for determining the location of the SLL and “surge signature” of the compressor
- OEMs and end-users reluctance: concerns for mechanical damage or process safety
- Onset of instability is a function not just of the compressor design, but also of the overall compression system
- Identifying the onset of incipient surge or rotating stall, prior to “deep” surge with flow reversal (which can cause damage), would reduce damage potential of field testing

Observations

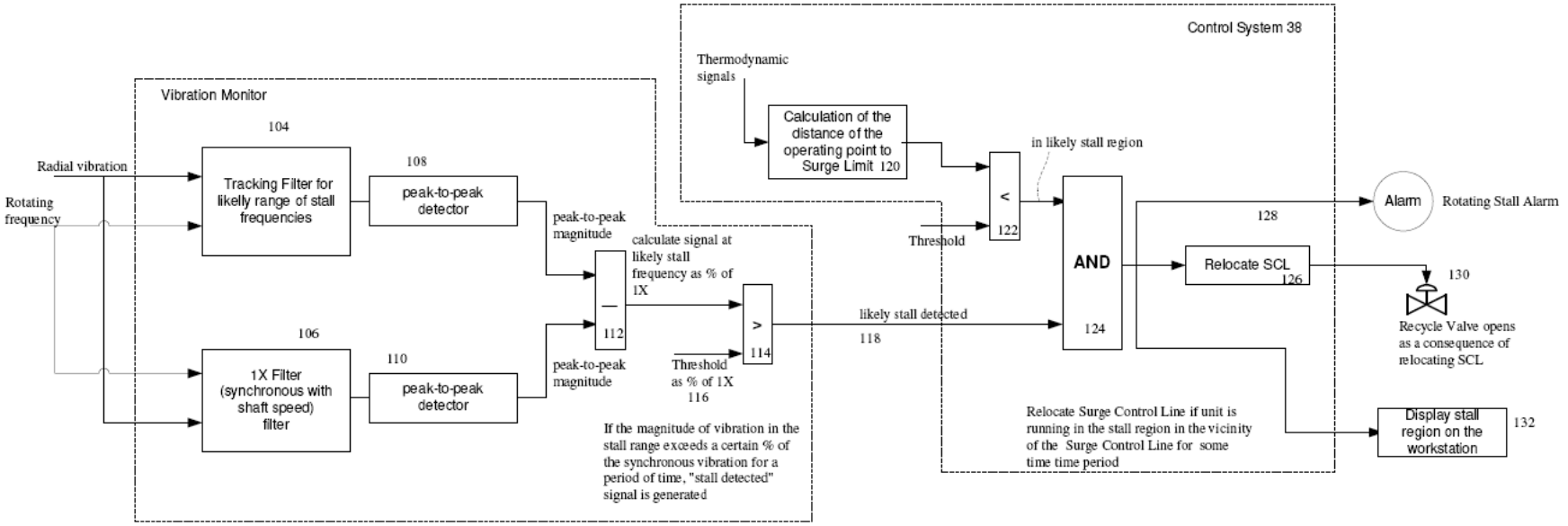
Correlation exists between rotating stall and an impending surge event, providing a means for incipient surge monitoring

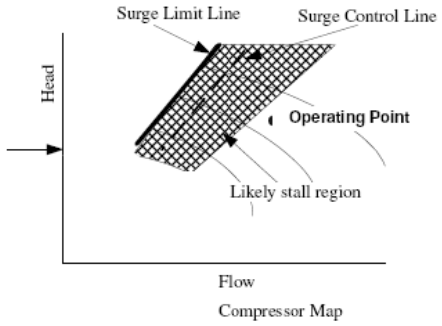
Correlation exists between axial position (thrust loading) and compressor surge, providing a means to detect surge cycles.

Reviewed approximately 10 confirmed cases of incipient surge on various machine trains:

- Approximately 75% of cases exhibited rotating stall prior to a surge event
- Correlation exists between incipient Surge signal strength and speed of machine (stronger at higher speeds?)
- Fluid instabilities in the impeller appear at 0.6X – 0.8X
- Fluid instabilities in the diffuser appear at 0.1X – 0.4X

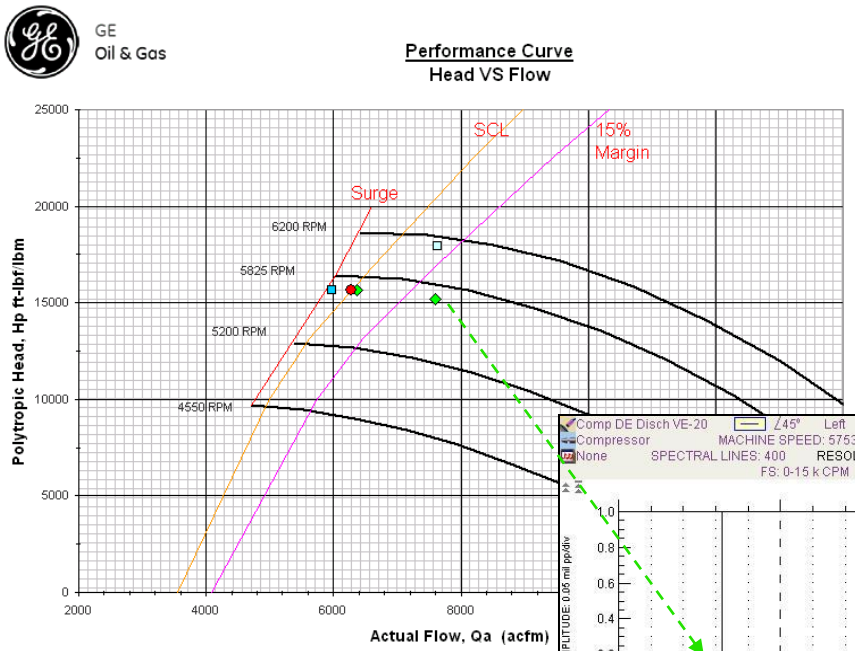
Rotating stall detection





Compressor Map vs. Vibration– *Spectrum Analysis*

(Apr Testing)



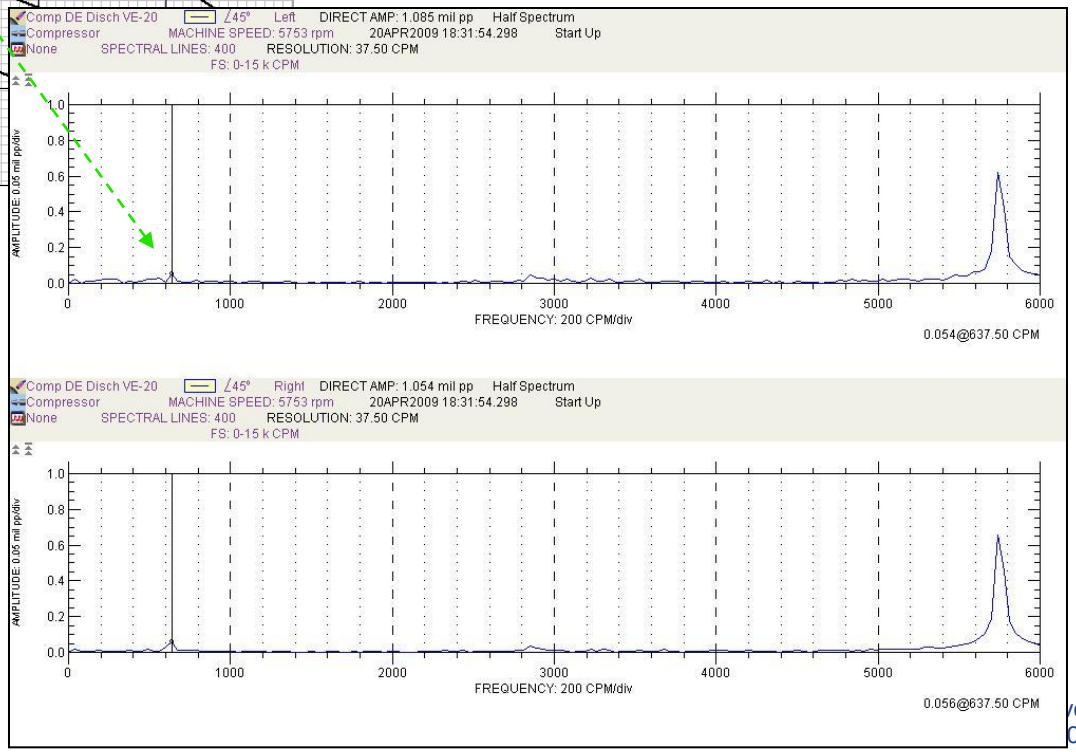
First signs of incipient surge

Machine Speed: 5753 rpm

Compressor Flow: 7500 acfm

Polytrophic Head: 15100

Freq. = .110X Amplitude=.054 mil



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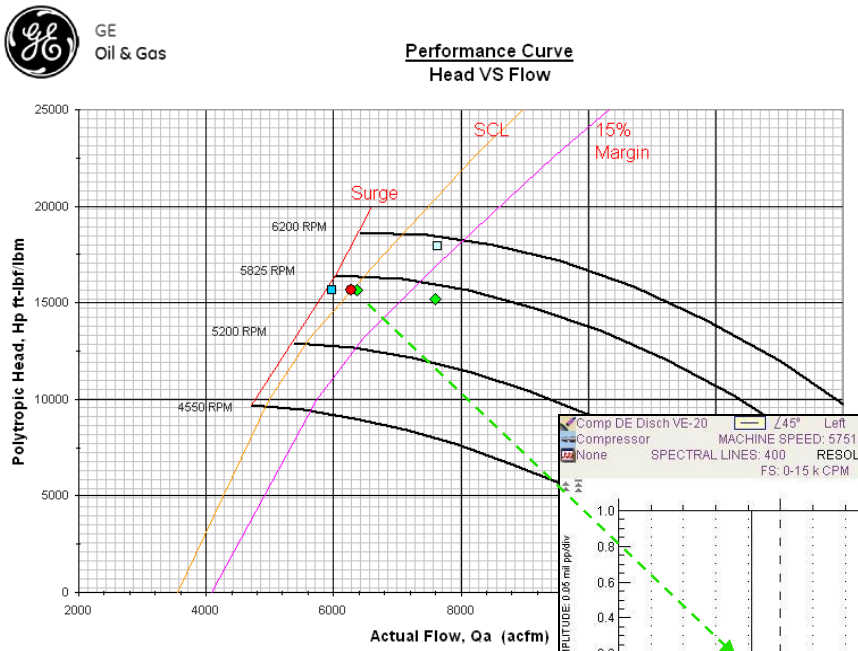
Comp. Map & Vibration Correlation – *Spectrum Plots*

(Apr Testing)



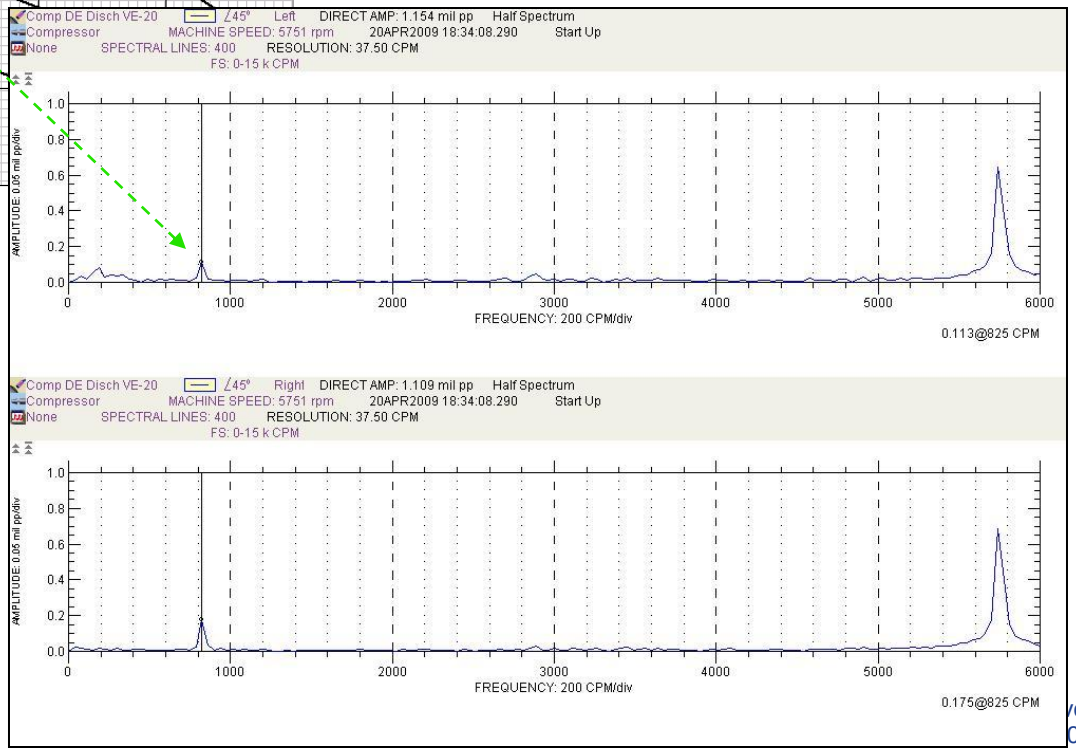
Increasing Amplitude

Machine Speed: 5751 rpm

Compressor Flow: 6350

Polytrophic Head: 15500

Frequency= .143X Amplitude=.113 mil



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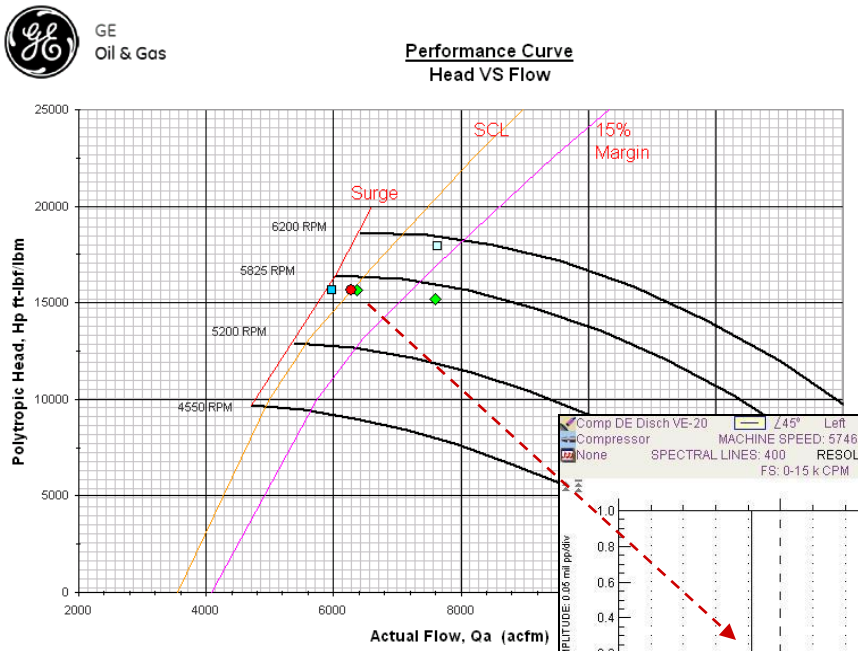
Comp. Map & Vibration Correlation – *Spectrum Plots*

(Apr Testing)



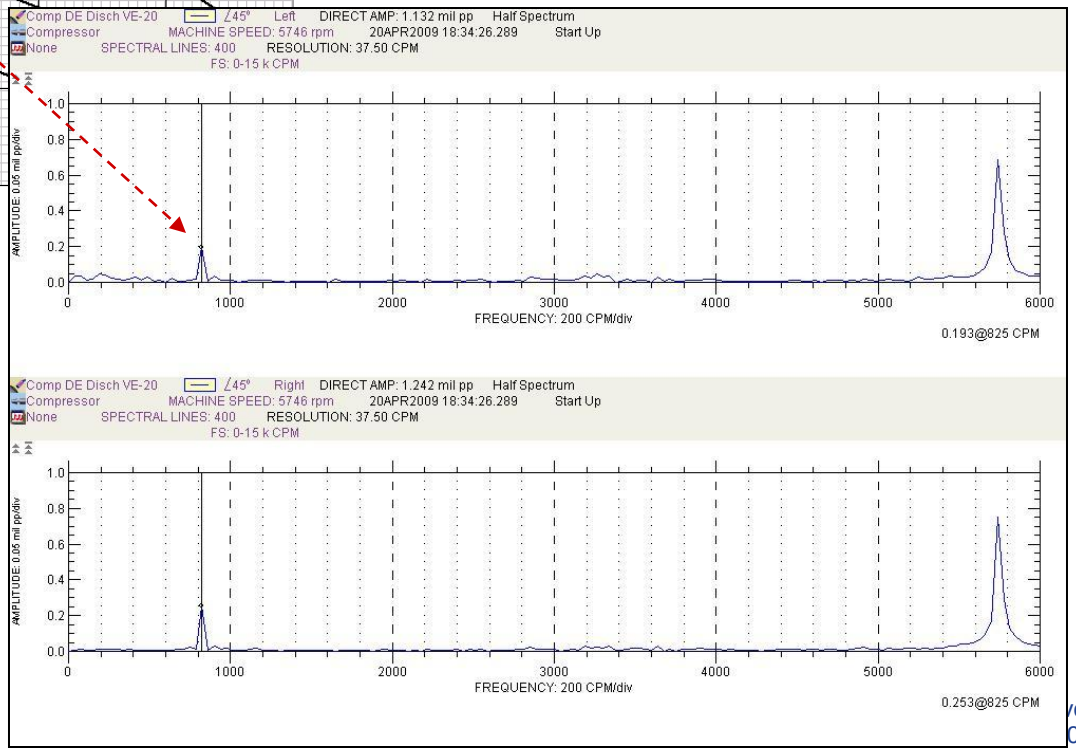
Robust Amplitude

Machine Speed: 5746 rpm

Compressor Flow: 6200

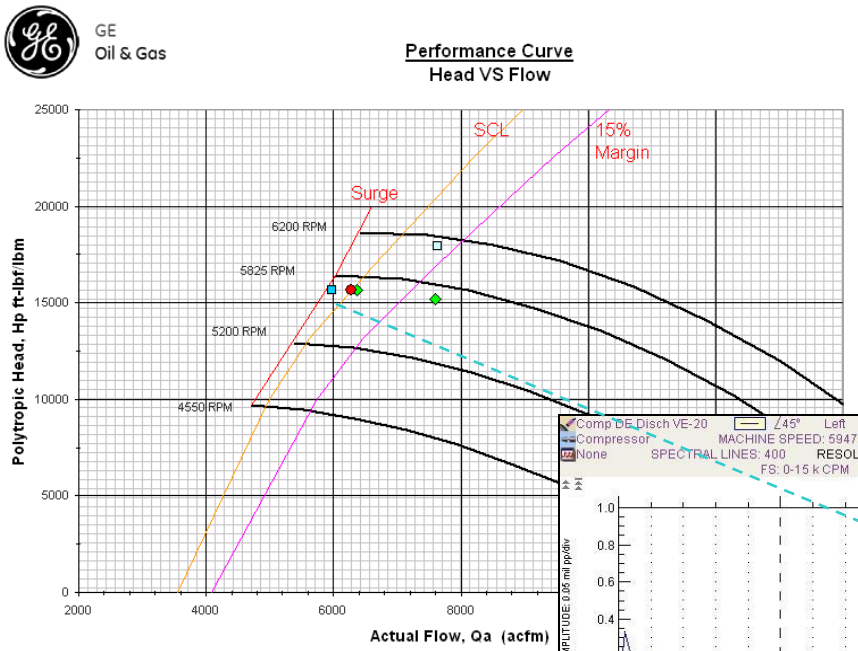
Polytrophic Head: 15500

Frequency=.143X Amplitude=.193 mil



Comp. Map & Vibration Correlation – *Spectrum Plots*

(Apr Testing)

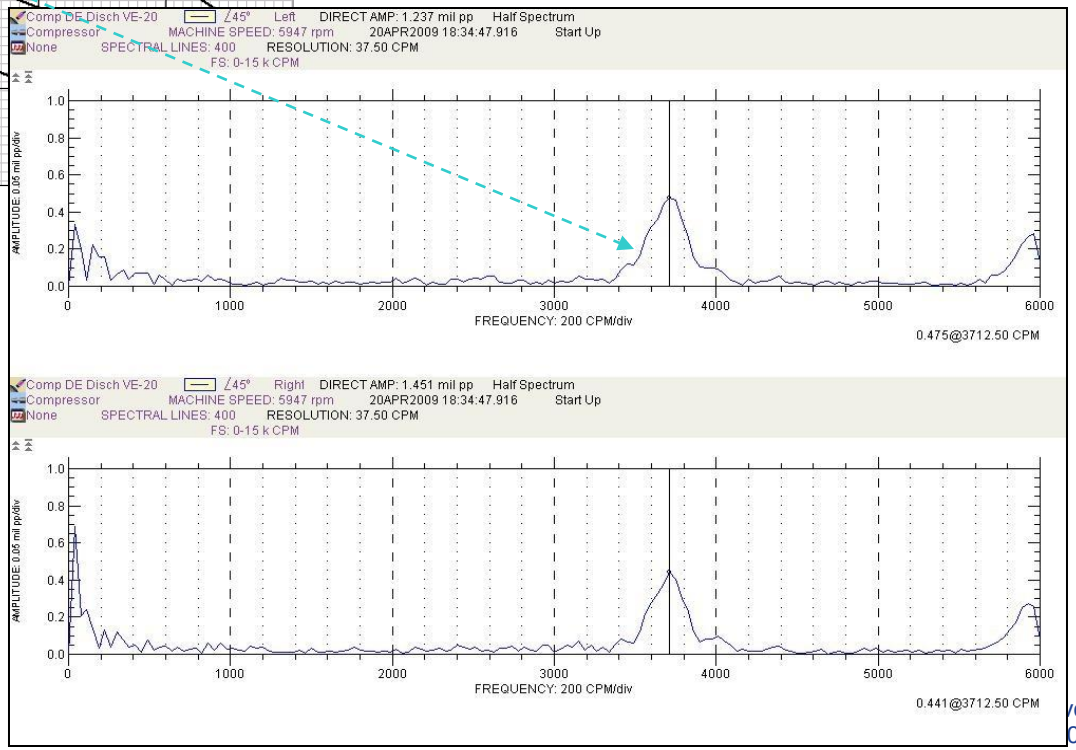


SURGE!

Machine Speed: 5947 rpm

Compressor Flow: 6000

Polytrophic Head: 15500



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Waterfall Plot Analysis -

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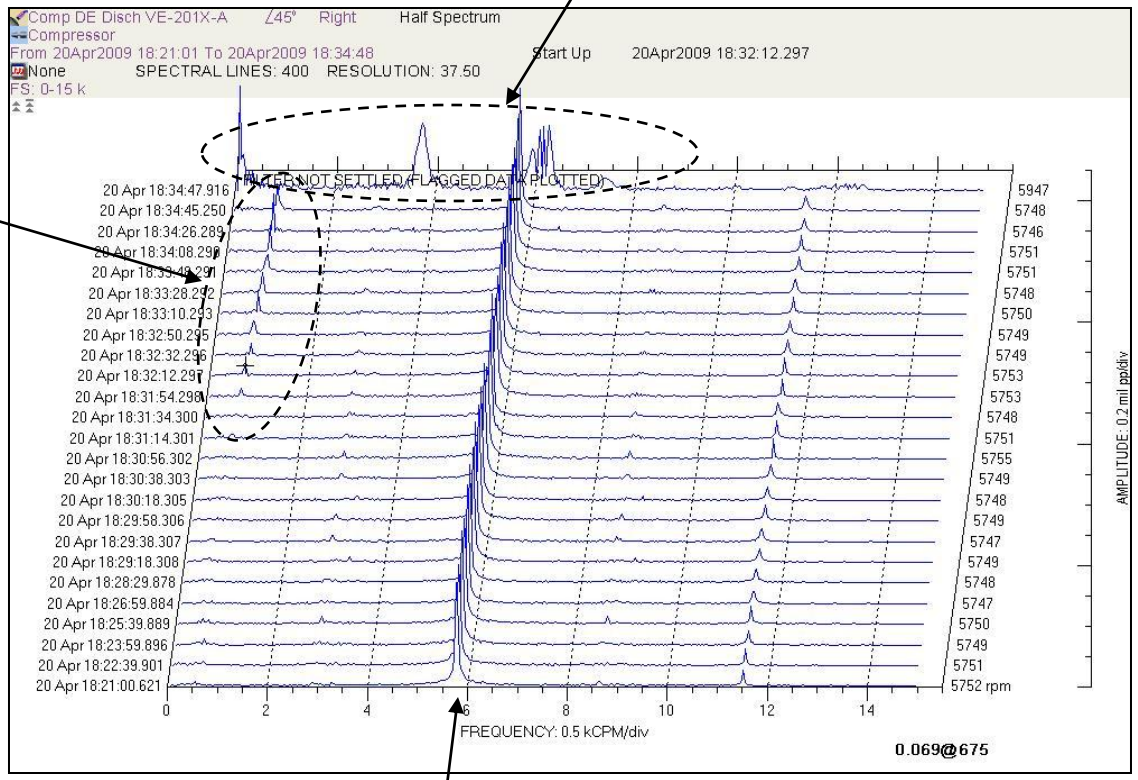
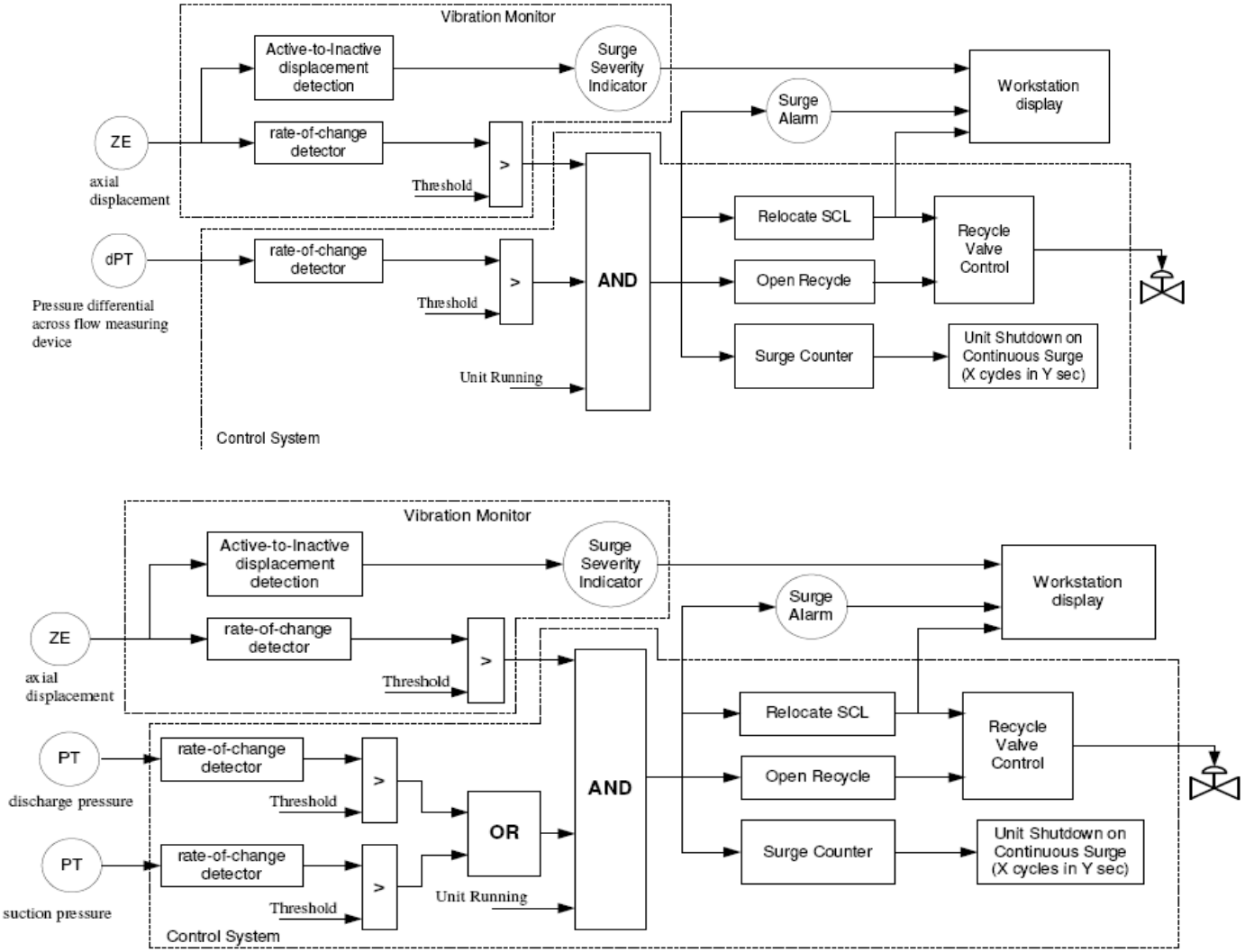
Confirmed Surge Event

Sub-synchronous peak anomaly



1x Vibration (running speed of machine)

Surge detection schemes using axial displacement and process measurements 1



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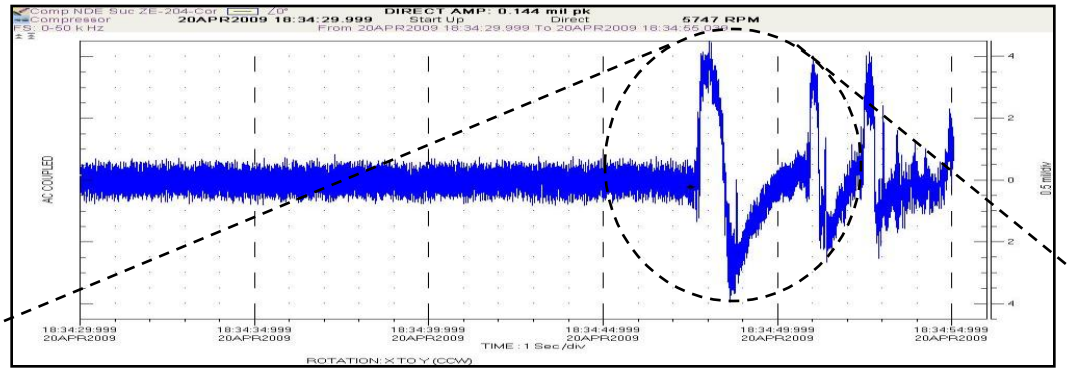
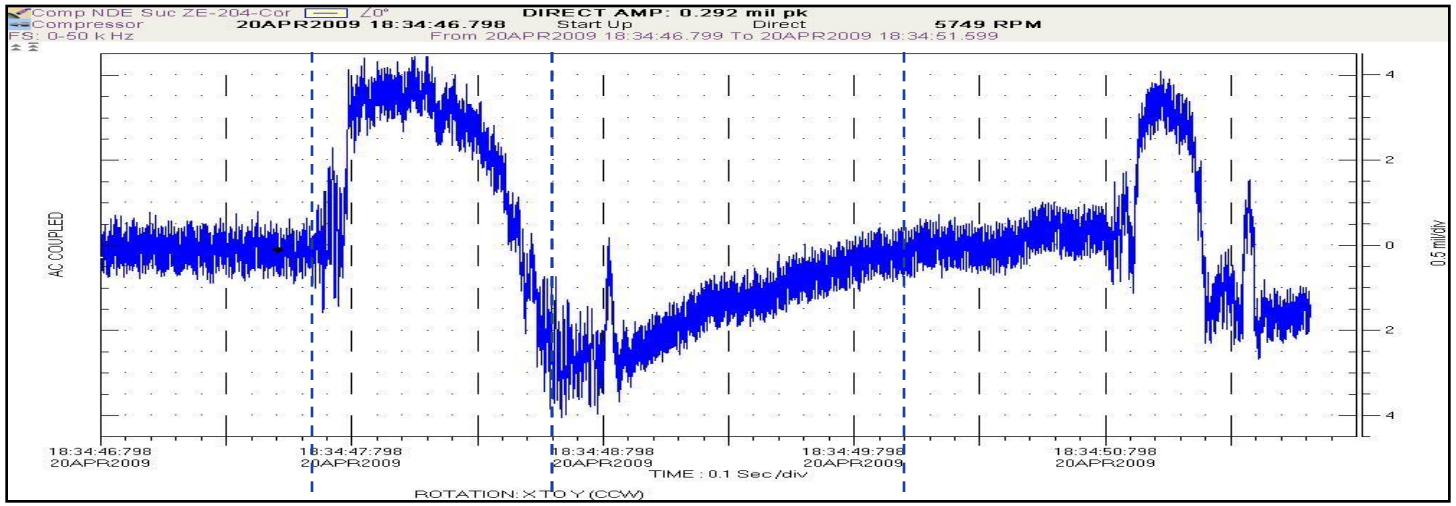
Thrust Vibration Data – *Surge Cycle Counting*

(Apr Testing)

Waveform Signal





Compressor Stall and Surge Axial Movement	Flow Re-attachment and Compressor Recovery

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Thrust Vibration Data – *Vibration vs. Process Comparison*

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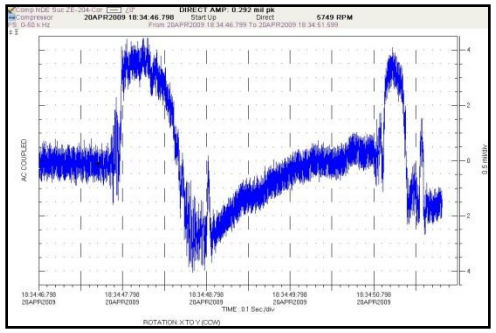
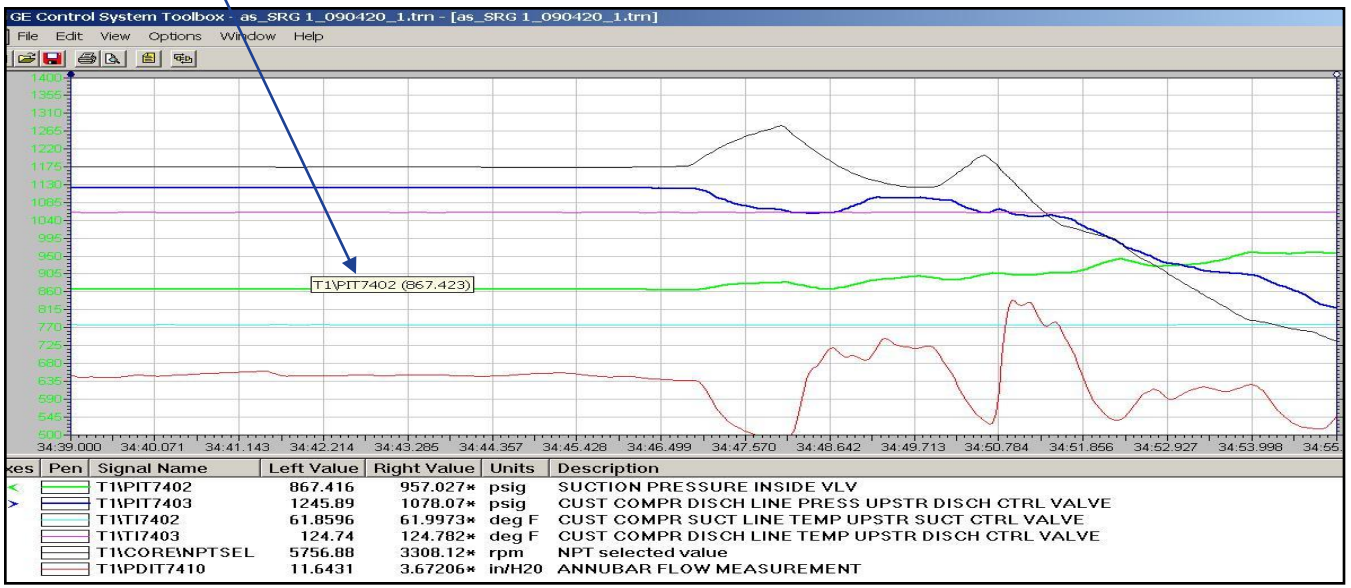
Waveform Signal



Label Lines below like so

Fluid Process Measurements



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Customer Benefits

- Lower risk when field testing to establish accurate surge limit (detect “stall” pre-cursor to surge vs. full surge of compressor)
- More precise location of the actual surge limit used in controller
- Detect stall and surge in cases when compressor characteristics change due to gas composition, degradation or malfunction
- Ability to alarm should the compressor be operating in an unstable area of the compressor map
- Identify and highlight unstable areas of performance map on HMI
- More reliable surge detection and appropriate response for recovery
- Assess potential mechanical damage resulting from compressor surge