



**Brüel & Kjær Vibro**



# **Machine Condition Monitoring in the Oil and Gas Industry**

## Monitoring strategies to address maintenance challenges ...

The fiercely competitive environment in the oil and gas industries results in constant pressure on production facilities to be more flexible, efficient and productive. This puts greater demands on the machines, with their operation being driven to the edge of the operating envelope. Flexible processes make production more efficient, but at the cost of machine maintainability. Additionally, tight delivery schedules and competitive operating margins mean less tolerance for unplanned downtime, with associated production losses reaching into the millions.

Finally, the consequences associated with a catastrophic machine failure are more pronounced than ever before. Such failures not only pose a safety and environmental risk, but can result in enormous financial impacts through additional maintenance costs and lost production.



## ... and bring benefits!

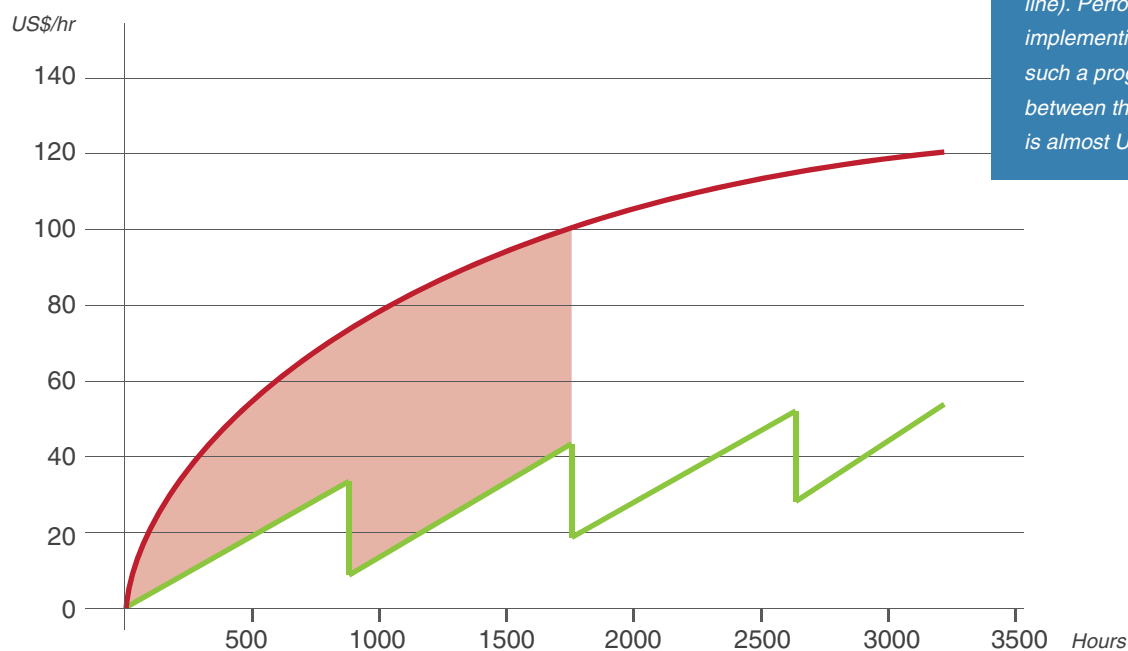
Brüel & Kjær Vibro is keenly aware of the challenges in the oil and gas industry and has a long history in successfully providing safety, condition and performance monitoring solutions for the critical and balance-of-plant machines. Our diagnostic solutions maximise lead-time to maintenance, with early fault detection giving reliable, accurate information for the diagnostics support teams and the operations and maintenance crews.

The result is maximized production, improved machine efficiency, reduced downtime and maintenance costs that together deliver **increased plant reliability and availability**.



*This blade crack was detected on a four-stage, 25 MW centrifugal compressor. If this fault was not detected and monitored by our system, a costly catastrophic failure would have resulted. By avoiding consequential damages, downtime was limited to six weeks instead of six months.*

## Life-cycle cost savings with a Brüel & Kjær Vibro monitoring system



*Extra fuel required per hour of operation due to fouling for a 30 MW simple-cycle gas turbine with optimized online/offline washing schedule based on performance monitoring (green line) and without any washing (red line). Performance monitoring is vital for implementing and confirming the results of such a program. Total savings (red area between the curves) for the first two years is almost US\$ 770,000!*

*Data based on empirical power loss measured over time due to fouling. (Assumptions: Natural gas price US\$/MMBTU, heat rate 10000 KJ/kWh, continuous baseload operation)*

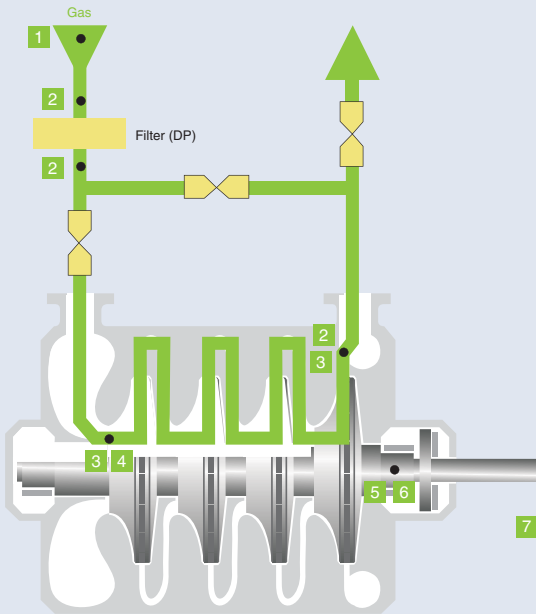
## Example: How we monitor a compressor drive train

Brüel & Kjær Vibro presently monitors thousands of machines in various areas of the oil and gas sector. One such machine is the centrifugal compressor. Based on the potential failure modes of a critical compressor (see below), a dedicated monitoring strategy is defined to detect machine problems at an early stage of development. This ensures corrective actions are planned in advance to minimise machine downtime.

Of course we can thoroughly investigate the underlying cause of a machine trip, however our aim at Brüel & Kjær Vibro is to prevent the trip in the first place.

Failure Modes	Safety and Condition Monitoring		Performance Monitoring
	Vibration Measurements	Process Measurements	Performance Measurements
Unbalance	●		
Misalignment	●		
Rotor rub	●		
Foundation problems	●		
Worn, loose journal bearings	●	●	
Mechanical looseness of impeller	●		
Thrust bearing film thickness loss	●		
Oil and lubricant faults	●	●	
Cracked impeller	●		
Thermal expansion	●		
Fouled, eroded, corroded impeller diffuser and blades	●	●	●
Flow disturbance (surge, recirculation, stonewalling)	●	●	●
Leaky seals		●	●
Poor efficiency			●

# Performance Monitoring

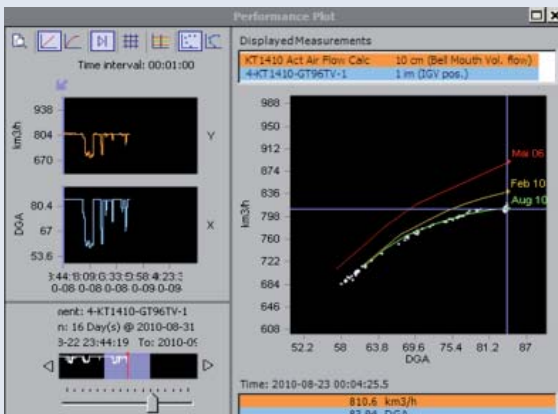


## Process Measurements

- 1 Gas properties
- 2 Pressure
- 3 Temperature
- 4 Flow
- 5 Shaft speed
- 6 Power
- 7 Control signals (IGV, machine state, ....)

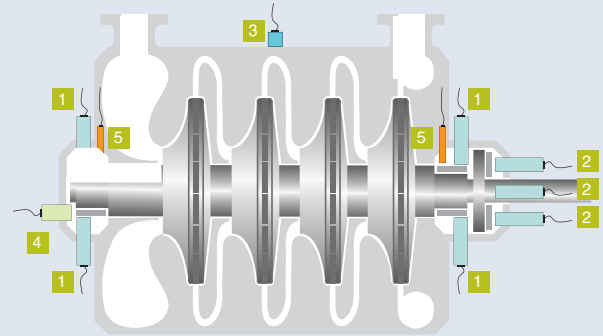
## Performance Calculations

- Power consumption
- Pressure ratio
- Polytropic head
- Polytropic efficiency
- Speed (corrected)
- Volumetric flow (corrected)
- Pressure ratio deviation
- Polytropic head deviation
- Polytropic efficiency deviation



This efficiency vs. flow plot shows a drop in efficiency, for an offshore gas reinjection compressor, indicating deposit build-up on the impeller.

# Condition Monitoring



## Vibration and Process Measurements

- 1 Relative vibration / radial
- 2 Relative vibration / axial
- 3 Absolute vibration / radial
- 4 Tacho
- 5 Bearing temperature

## Steady state

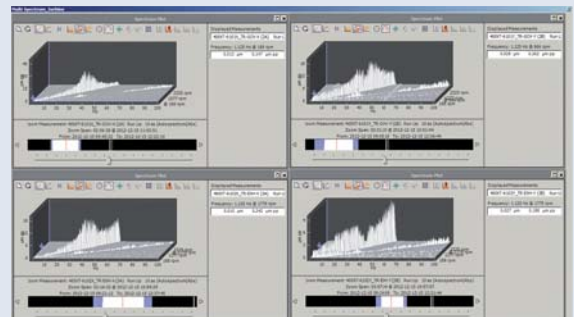
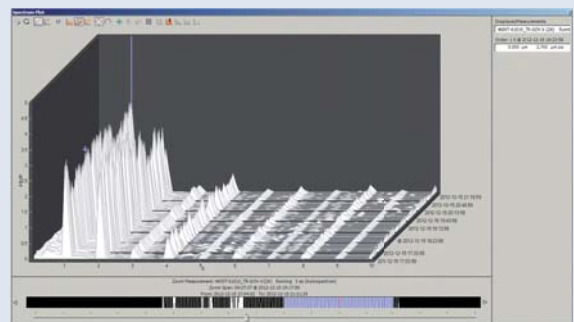
- Bandpass
- FFT (zoom)
- Vector (1x, 2x, nx)
- CPB
- Orbit

## Diagnostic

- Trending
- FFT (zoom)
- Vector (1x, 2x, nx)
- CPB
- Orbit

## Transient monitoring

- Bandpass
- Vectors
- Bode (delta rpm based)
- Waterfall spectra
- Shaft centerline



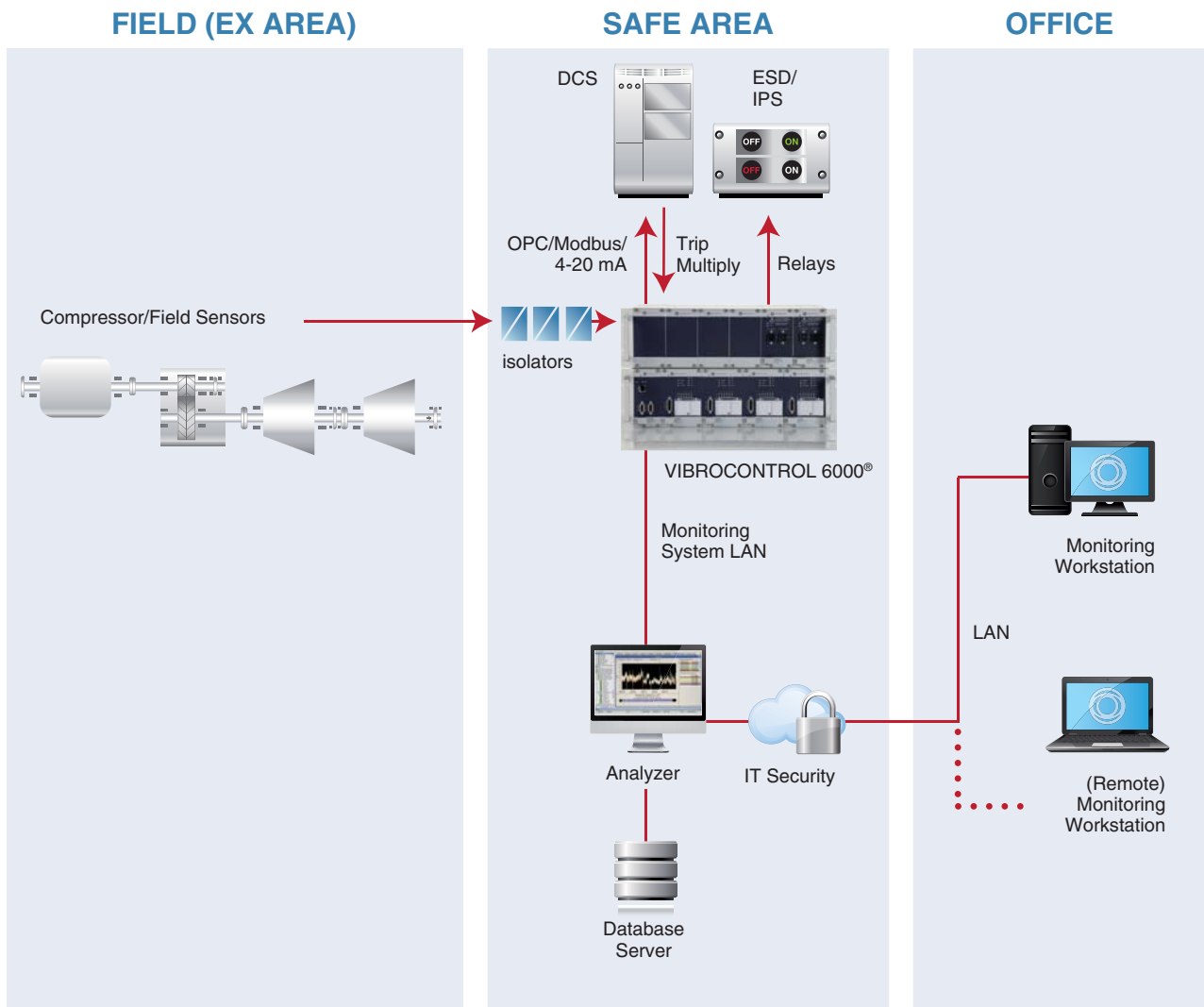
The order based waterfall plot above is useful in identifying unbalance, misalignment and other speed-related faults. Order plots vs. speed below

# Monitoring concept

Brüel & Kjær Vibro has been providing condition monitoring solutions to our global customer base with the sole aim of maximizing production by increasing uptime, reliability and performance of the customer's machines. Much of this success is achieved by working in close cooperation with selected machine manufacturers and end-users to better understand their monitoring requirements. Our products and services have been designed to reflect these requirements, thus adding real value to our customers' operation and maintenance management process.

Some of the important functionalities include:

- **Cost-effective installation**  
Condition monitoring functionality can be added to an existing machine protection system with ease.
- **Trending**  
Enables you to detect potential failure modes at an early stage of development
- **Performance monitoring**  
Optimizes efficiency and production
- **Automated monitoring**  
Ensures the best possible monitoring at the lowest operational costs by reducing the required manpower to run the system
- **Adaptive monitoring**  
Ensures versatile monitoring capability, both in running and transient conditions
- **Profile monitoring**  
State-of-the-art condition monitoring technique ensuring machine faults are detected in an early stage of development. Method to detect faults which are not seen in safety monitoring parameters (Hidden Fault Detection).
- **Information import/export**  
Enables interfacing to/from a wide range of plant-wide systems
- **Project service**  
Delivery, training, system maintenance, long-term service agreements
- **Diagnostic services**  
Machine diagnostic assistance and root cause analysis, remotely or on-site
- **Eventmaster**  
Data is saved at high resolution before and after an event (e.g. trip) for post-processing analysis.



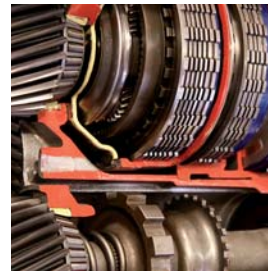
Brüel & Kjær Vibro provides safety, condition and performance monitoring solutions to a number of different industries and machines within the global oil & gas sector. Contact us to get more information, case studies and machine monitoring strategies of the machines and applications.



Offshore platforms, gas distribution, refineries, upstream olefin plants, downstream polyolefin plants, LNG plants, aromatics plants, petrochemical and chemical plants.

Driver machines: Gas turbines (aero-derivatives, frame, power turbines), steam turbines, motors.

Driven machines: Compressors (axial, centrifugal, roots, reciprocating, hyper), liquid expanders, pumps, fans, coolers, mixers, extruders, generators, transmission components (couplings, gearboxes).



*Brüel & Kjær Vibro has a global network of sales and service offices. Contact your local sales representative today to find out how our monitoring solutions can reduce the life cycle costs of your machines.*



## Contact

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