

# Condition monitoring solutions for reciprocating compressors





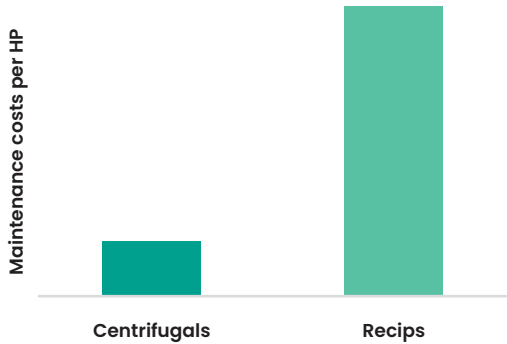
# Why monitor?

As one of the oldest compressor designs, reciprocating compressors (recips) enjoy unique capabilities and are quite flexible with features such as broad capacity control ranges and the ability to compress gas regardless of mole weight or k value. Add multiple stages and they can compress a gas to extremely high pressure ratios. Consequently, they are an ideal fit for selected applications—such as hydrogen compression in the de-sulfurization process of many refineries—and as part of the low-density polyethylene production process in chemical plants.

However, reciprocating compressors suffer from one very serious drawback: high maintenance costs. In fact, compared to similarly sized centrifugals, recips can consume as much as five times the amount in maintenance costs.

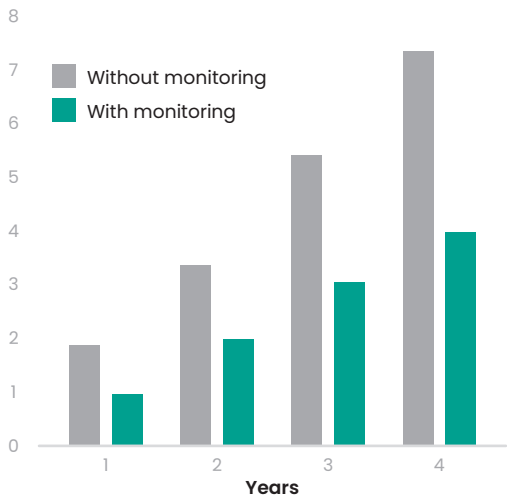
That’s why a continuous monitoring system is so important. Specifically designed to meet the unique machinery protection and condition monitoring needs of recips, our solutions, which include safety integrity level (SIL) certified products can help close the gap, bringing your recip maintenance costs closer to the levels associated with centrifugals while simultaneously improving reliability, availability, and safety. And, with patented technology, comprehensive services, and over 55 years of experience monitoring reciprocating compressors, no one is better equipped to help you than Bently Nevada, a Baker Hughes business.

A monitoring system can save millions in maintenance costs over the life of the compressor



Recips can consume five times as much maintenance costs as an equivalently sized centrifugal compressor.

Reciprocating compressor Cumulative unplanned repair costs



A monitoring system from Bently Nevada, a Baker Hughes business, will often more than pay for itself in the first year and can save millions in maintenance costs over the life of the compressor.

# Malfunction/ measurement— in detail

# Malfunction/ measurement— in detail

		Measurements																	
		Frame vibration	Main bearing temperature	Crosshead acceleration	Multi-event-per-revolution Keyphasor	Single event Keyphasor <sup>5</sup>	Cylinder chamber pressure	Combined rod load <sup>3</sup>	Cylinder acceleration	Piston rod monitoring	Hyper plunger position	Discharge gas temperature	Discharge valve temperature	Suction gas temperature	Suction valve temperature	Pressure packing case/Vent temperature	Crosshead shoe (slipper) temperature	Online gas analyzer data input	Trending and analysis software
See note 2	API 618 5 <sup>TH</sup> Edition <sup>4</sup>	●	●			●						●							
	API 670 5 <sup>TH</sup> Edition <sup>4</sup>	●		●		●													
	Protection solution	●	●	●	●	○ <sup>5</sup>	●	●		●	●	●							
	Management solution	●	●	●	●	○ <sup>5</sup>	●	●	●	●	●	●	●	●	●	●	●	●	●
Malfunction <sup>1</sup>	Excessive crankcase/frame and cylinder vibration	●		●	●	●													●
	Excessive main bearing temperature (loss of lubrication)		●																●
	Rod load faults (includes reversal, excessive loading, joint faults, etc.)			●	●	●	●	●	●										●
	Mechanical looseness (piston, cylinder liner, piston rod, etc.)	●		●	●	●	●	●	●	●	●								●
	Liquid ingestion/carryover			●	●	●			●										●
	Cylinder suction/discharge valve failures	●		●	●	●	●	●	●			●	●	●	●			●	●
	Excessive clearance in crosshead bushing/pin			●	●	●	●	●											●
	Worn rider bands				●	●				●									●
	Cracked piston rod				●	●				●									●
	Piston rings leakage				●	●	●					●						●	●
	Excessive crosshead slipper clearance			●	●	●	●	●		●							●		●
	Pressure packing case leaks and seizures			●	●	●	●			●	●					●		●	●
	Capacity control problems			●	●	●	●	●	●										●
	Performance items (flow balance, power losses, efficiency, etc.)				●	●	●	●				●		●				●	●

1. All the measurements marked in each column are highly recommended to detect the malfunction  
2. The dark green dots marked measurements are recommended for auto-shutdown machinery protection  
3. Combined rod load is derived from the pressure chamber sensors but is used for specific malfunction and protection functions  
4. Newer versions of the API documents may have different recommendations for shutdowns and measurements  
5. Single event Keyphasor in measurements is equivalent to phase-reference transducer mentioned in API 670 and API 618 for once per crank revolution signal. Bently Nevada recommends a Multi-Event Wheel pattern for best accuracy in performance calculations and analysis but can accept a Single Event signal.




# Recip monitoring—in detail

1. **Crosshead vibration**  
Crosshead-mounted accelerometers can detect machinery problems due to impact-type events such as excessive crosshead clearance, liquid ingestion into the cylinder, excessive clearance in the crosshead pin bushing, and loose or cracked nuts, bolts, liners, or pistons.

3500 Monitor: 3500/70M Four-Channel Impulse/Velocity Monitor  
Transducer: 330425 Accelerometer

Crosshead shoe temperature  
Continuous monitoring of crosshead shoe (slipper) temperature provides useful information on developing slipper problems such as overload, fatigue, and insufficient lubrication.

3500 Monitor: 3500/60 or 3500/61 Six-Channel or 3500/65 16-Channel Temperature Monitor  
Transducer: RTD or Thermocouple



2. **Frame vibration**  
Increases in frame vibration can indicate problems such as imbalance due to unusual pressure differential or inertial unbalance, looseness in the foundation attachment (such as deteriorating grout or shims), and high moments caused by excessive rod load.

3500 Monitor: 3500/70M Four-Channel Impulse/Velocity Monitor  
Transducer: 190501 Velomitor CT Piezo-Velocity Transducer

3. **Main bearing temperature**  
This measurement indicates problems related to fluid-film bearings, including overload, bearing fatigue, or insufficient lubrication.

3500 Monitor: 3500/60 or 3500/61 Six-Channel or 3500/65 16-Channel Temperature Monitor  
Transducer: RTD or Thermocouple


4. **Cylinder chamber pressure profiles**  
The single most effective way of determining the overall health of a reciprocating compressor is by examining the cylinder pressure profile. Online access to the internal pressure for each cylinder chamber enables continuous monitoring of cylinder pressures, compression ratios, peak rod loads, and rod reversal. This provides valuable information on the condition of suction valves, discharge valves, piston rings, packing glands, and crosshead pins. And, interfacing the 3500 system
- with System 1 software provides valuable diagnostic plots such as Pressure versus Volume (P-V), Log P versus Log V, Pressure versus Crank Angle (Theta-θ) (P-T), and rod load curves. Performance monitoring is a standard feature of System 1 software for chamber pressure measurements and delivers important information such as indicated horsepower, flow balance, and power losses.

Continuous rod load  
Combined (inertia and gas) rod load calculated at the crosshead pin provides information about the lubrication condition of the crosshead pin. Insufficient reversal or excessive rod load can be identified and corrected before costly running gear damage occurs.

3500 Monitor: 3500/77M Four-Channel Cylinder Pressure Monitor  
Transducer: 165855 Cylinder Pressure Transducer

5. **Piston rod/plunger position**  
Horizontal and vertical proximity probes observing the piston rod provide information on rod bow, rod flex (vibration), and rider band wear. Continuous monitoring gives maximum magnitude and direction of rod movement along with the crank angle at which the maximum occurs. The source of movement can be identified, enabling the proactive scheduling of maintenance for rider band replacement or crosshead repair. Monitoring the piston rod vibration provides early warning for rod break. Monitoring the plunger position in hyper compressors provides protection against deteriorating plungers.

3500 Monitor: 3500/72M Four-Channel Rod Position Monitor  
Transducer: 3300XL Series Proximity Transducer



6. **Multi-event Keyphasor signal**  
A proximity probe observing a multi-toothed wheel on the crankshaft provides a precise reference timing signal every 30 degrees of rotation in comparison to a once-per-turn reference point. The torsional vibration of the crankshaft changes from revolution to revolution for each load step on the machine. Having multiple events per revolution improves the ability of the system to capture data with respect to crank position, regardless of the shape or change in shape of the torsional vibration. This allows measurements such as rod position and cylinder pressure to be correlated with a highly accurate crank angle measurement. Rod position can be captured at the same point in the piston rod stroke, and cylinder volume can be computed precisely at each point in the stroke for highly accurate P-V curves.

3500 Monitor: 3500/25 Keyphasor Module  
Transducer: 3300XL Series Proximity Transducer
- Prime mover
- Suction gas temperature  
Continuous monitoring of suction gas temperature provides a useful baseline against which to compare suction valve temperature. Relative changes in temperature between suction valves and suction gas can give an indication of worn suction valves. In addition, suction gas temperature, combined with the integrated equation of state engine in System 1 software, provides the information necessary to calculate capacity at suction conditions and cylinder flow balance numbers.

Discharge gas temperature  
Continuous monitoring of discharge gas temperature can give an indication of worn valves, unloaders, excessive compression ratio, or insufficient cooling water.

3500 Monitor: 3500/60 or 3500/61 Six-Channel or 3500/65 16-Channel Temperature Monitor  
Transducer: RTD or Thermocouple

8. **Cylinder acceleration**  
Placing accelerometers on the cylinder monitors the opening and closing events of the valves. The impact-type waveform information can be combined with cylinder pressure data to assess the health of the cylinder valves. Valve related malfunctions such as loose valve cover bolts, valve fluttering, or capacity control malfunctions can be detected. For hyper compressors, the cylinder acceleration changes significantly when valve springs break or valve seats wear out.

3500 Monitor: 3500/70M Four-Channel Impulse/Velocity Monitor  
Transducer: 330425 Accelerometer

9. **Pressure packing case temperature**  
Continuous monitoring of pressure packing temperature provides useful information on developing problems related to the packing including excessive wear, insufficient cooling, and inadequate lubrication.

Packing vent line temperature  
Continuous monitoring of the vent line provides an indication of leaking pressure packing. With an increase in process flow, the vent line becomes hotter. For years, operators have used the subjective method of touching the line to see if gas is leaking.

3500 Monitor: 3500/60 or 3500/61 Six-Channel or 3500/65 16-Channel Temperature Monitor  
Transducer: RTD or Thermocouple
- 4
- 5



# At the heart of our recip monitoring solution is the Bently Nevada 3500 Series machinery protection system



## Integrated machinery protection and machinery management

Our powerful 3500/22M TDI rack interface module eliminates the need for bulky external data acquisition on the hardware or special interface modules between the monitor rack and software. Simply plug an ethernet cable into the 3500/22M rack and you're ready to communicate with our powerful System 1 software for advanced diagnostics, condition monitoring, and other plant asset management functionality, without interrupting or interfering with machine protection. The result is a zero-footprint solution that simplifies System 1 connectivity for existing machinery protection systems.

And, the enhanced data collection technology of our 3500/22M TDI rack allows earlier and improved diagnosis of previously difficult-to-recognize intermittent events (such as cylinder liquid ingestion).

- Fully compliant with the requirements of American Petroleum Institute (API) Standard 670 for machinery protection systems and Standard 618 for reciprocating compressors
- Available in 19 in. 14-slot EIA rack or space-saving 12 in. 7-slot mini-rack
- Available with a variety of high-quality display options ranging from self-configuring VGA touch screens to remote workstations to LCD panels that mount directly on the rack face
- Digital (Modbus) and analog (4-20 mA) interfaces available for connection to control systems and historians
- Safety integrity level (SIL) certified monitor modules are available for use in functional safety applications

- Six- or 16-channel temperature monitors accept a variety of RTDs or thermocouples. Absolute and differential alarming capabilities allow the monitors to be used for valve temperatures, gas, or other process temperatures, bearing temperatures, crosshead shoe (slipper) temperatures, pressure packing case temperatures, and a variety of other machinery or process temperature measurements
- Capabilities for assessing piston rod vibration and position at precisely defined crank angles for repeatable, useful information on rider band wear, rod bow/flex, and other conditions. Also applicable to hyper compressors using plungers instead of conventional pistons
- All monitor modules are totally software configurable via the 3500's rack interface module—key lockable to prevent unauthorized tampering
- Keyphasor module accepts multi-event-per-turn signals for greater accuracy—required for reciprocating compressor applications where crank angle must be precisely determined
- Single-cable ethernet connectivity to our System 1 software for advanced diagnostics and condition monitoring functionality



- Highly reliable power supplies accept worldwide AC/DC voltages/frequencies and can be ordered as fully redundant to ensure uninterrupted performance
- Powerful cylinder chamber pressure measurements now available for the most complete picture of reciprocating compressor health. Dynamic P-V curves, rod reversal measurements, and much more
- Special-purpose four-channel vibration modules are designed to address the casing vibration, crosshead acceleration, and cylinder acceleration measurement requirements unique to reciprocating compressors by providing reliable machinery protection without false or missed alarms. Filtering, alarm delay, full-scale range, transducer input type, and a host of other options are fully software configurable on a per-channel basis
- Generic four-channel vibration modules accept velocity, acceleration, and proximity transducers. Filtering, alarm delay, full-scale range, transducer input type, and a host of other options are fully software-configurable on a per-channel basis. Used for a variety of measurements on the recip's prime mover
- Relay modules allow voting of user-configurable alarms and health statuses across multiple channels. Relays are highly reliable and intended for connecting the monitoring system to external annunciators and machinery control systems for auto-shutdown
- Fully digital communications of all monitored parameters and statuses using a variety of industry-standard protocols—ideal for connection to process and machine control systems rather than using analog (4-20 mA) outputs. Supports time-stamping of alarms and clock synchronization



# Cylinder pressure—where the action is

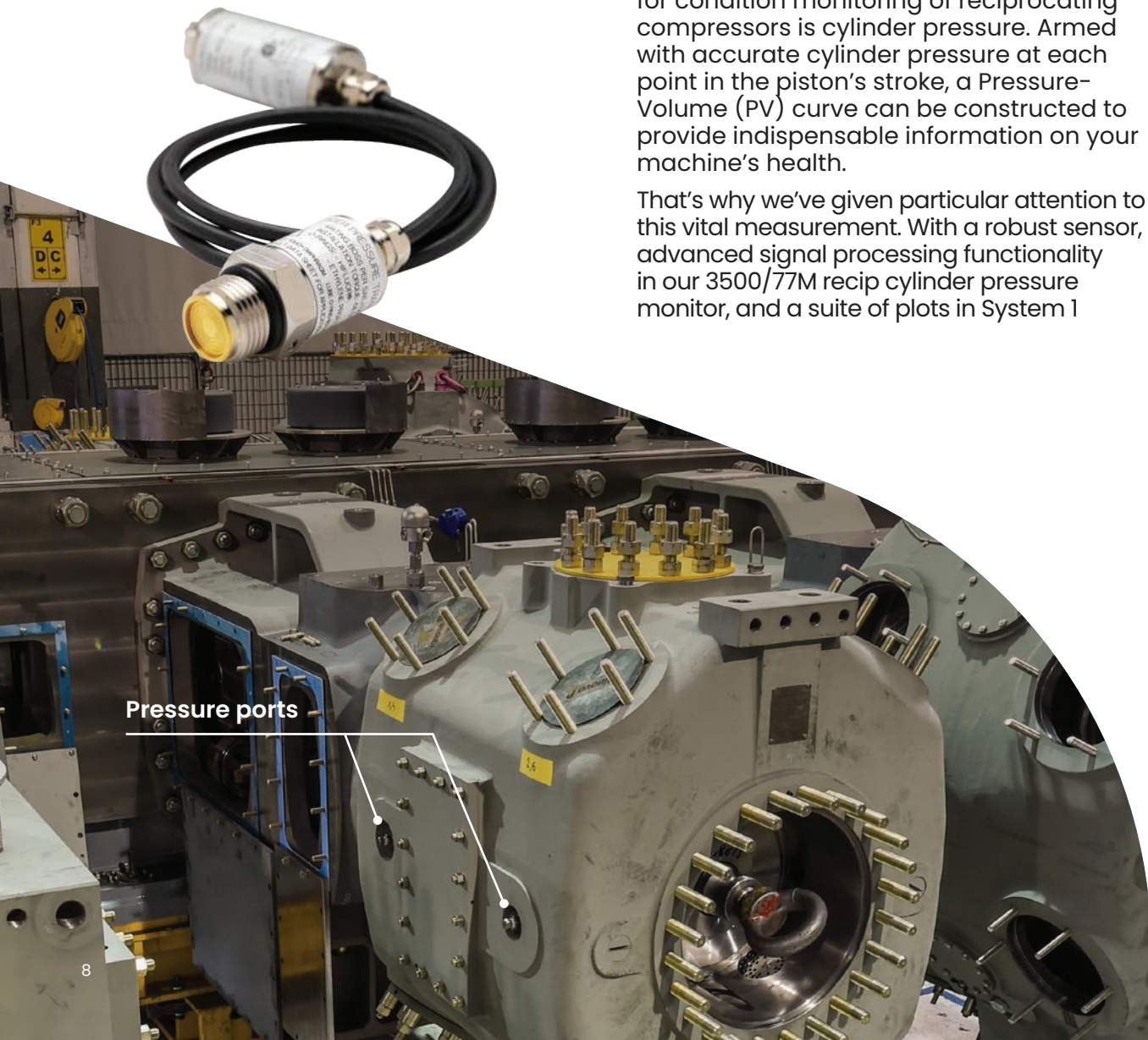
The single most important measurement for condition monitoring of reciprocating compressors is cylinder pressure. Armed with accurate cylinder pressure at each point in the piston's stroke, a Pressure-Volume (PV) curve can be constructed to provide indispensable information on your machine's health.

That's why we've given particular attention to this vital measurement. With a robust sensor, advanced signal processing functionality in our 3500/77M recip cylinder pressure monitor, and a suite of plots in System 1

software, specifically for analyzing cylinder conditions, there's simply no better way to get inside your cylinders—where the action is. Historically, measuring these conditions meant temporarily attaching transducers to isolation valves on each cylinder. Although cumbersome, this practice was necessary because pressure transducers simply couldn't survive under long-term exposure to the harsh environment of cylinder chambers. We knew that the key to reliable and effective assessment of machinery health—not to mention convenience—was to design a sensor that could endure 24/7 exposure to such an environment, eliminating the burden of constantly connecting and disconnecting every time you wanted data.

With our proven Bently Nevada 165855 cylinder pressure transducer, we've done just that. It provides continuous static and dynamic pressure data and is specifically designed for use with our 3500/77M recip cylinder pressure monitor. Innovative materials and construction techniques allow it to deliver reliable measurements in the extreme temperatures, pressure cycling, and harsh chemical environments (such as H<sub>2</sub>S) inherent in reciprocating compressor cylinder applications.

Available in a variety of pressure ranges from 100 psia to 10,000 psia (68947 kPa/689 bar), the 165855 has undergone extensive testing. In fact, we're so confident of its performance that we offer something unique to the industry: a three-year warranty.



## System 1 software Bently Nevada machinery management

Do more than just protect your recips, proactively manage them with the enhanced condition monitoring and Decision Support capabilities of System 1, our most advanced software ever.

System 1 streamlines decision-making processes by bringing machine data into a single platform, providing clarity and context to your operations and enterprise. Its connectivity, analytics, and visualization capabilities combine to specifically address the unique needs of reciprocating compressors.

The result is a total reciprocating compressor solution, capable of providing:

- Discharge pressure
- Suction pressure
- Minimum/maximum pressure for each crankshaft revolution
- Compression ratio
- Peak rod load for both compression and tension
- Number of degrees of rod reversal
- Suction volumetric efficiency
- Discharge volumetric efficiency
- Indicated horsepower
- Capacity at suction conditions
- Capacity at discharge conditions
- Suction power losses
- Discharge power losses
- Indicated clearance volume
- Flow balance of suction capacity to discharge capacity
- Adiabatic median capacity between suction and discharge capacity
- Adiabatic flow balance of theoretical suction to theoretical discharge capacity
- Power to median capacity ratio
- Adiabatic discharge temperature
- Crosshead impact knock analysis
- Cylinder impact knock analysis
- Piston rod vibration analysis including rider band wear
- Cylinder trim analysis:
  - Leaking discharge valve
  - Leaking suction valve
  - Leaking piston rings
  - Leaking pressure packing
  - Frame loading
  - Crosshead pin loading
- Vertical force plot and more plot formats as seen on the following pages



## Decision Support: enhanced insights

Decision Support contains a collection of proven Bently Nevada machine condition monitoring analytics engineered to provide a variety of insights. Configured property rules can be adapted to suit the unique operational characteristics specific to a machine or asset. Extractions provide a set of rules that combine different measurements, statuses, reference values and machine properties which can be further used to evaluate the behavior of the reciprocating compressor and can be used in developing custom rules.

In addition to packaged algorithms, Decision Support allows users to create and deploy custom rules that help you capture, disseminate, and leverage knowledge of your equipment, processes, and business solutions. Custom rules preserve operational knowledge in a useable format that can be broadly applied in an easily repeatable and manageable way. You want to trend the total horsepower delivered by your compressor? No problem; a simple custom rule can be written to sum all the chambers' Indicated Horsepowers and can provide you with a trendable value. Further, this trended variable can be used for comparison with frame rating to identify overload conditions.

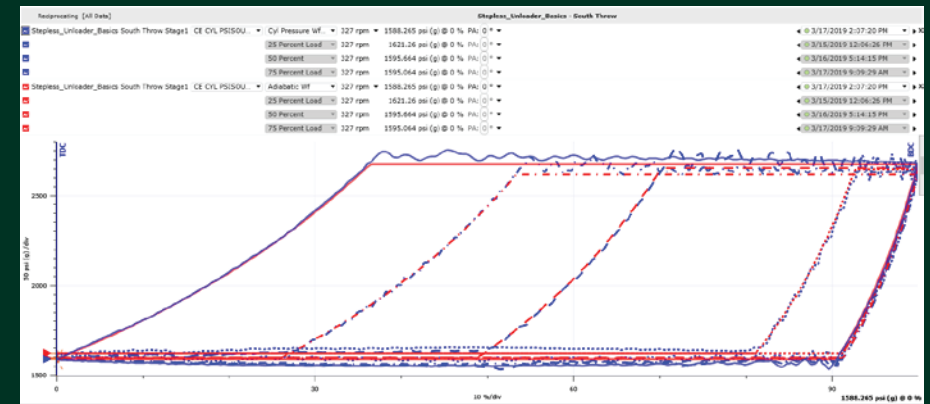
Decision Support InsightPak™ Analytics provide early detection of failure modes associated with machine, process and auxiliaries. The application acquires logic rules and feeds the results back to System 1 for notification, visualization and root-cause diagnostics. For example; Decision Support can detect gas leak through packing rings and can provide notifications on System 1 and via emails once the pressure packing temperature case/vent ratio extractions exceed beyond pre-defined threshold levels within configured property of pressure packing limit constants.





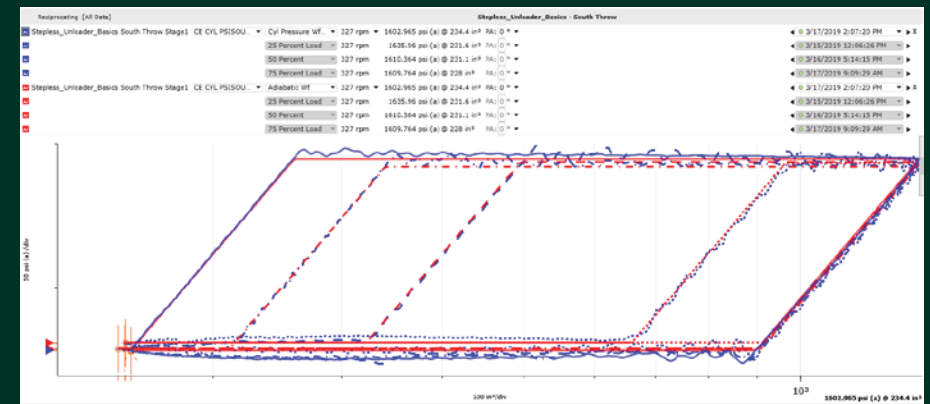
Pressure versus displaced volume—PV plot

Plotting indicated and theoretical cylinder chamber pressure versus displaced volume enables detection of malfunctioning seals (rings, valves, and unloaders). A patented algorithm also smartly draws the theoretical compression curve when stepless unloaders are used as the software detects the valve closure point and adjusts the theoretical curves in real time. Multiple reference samples can be stored and configured for display with your current values too.



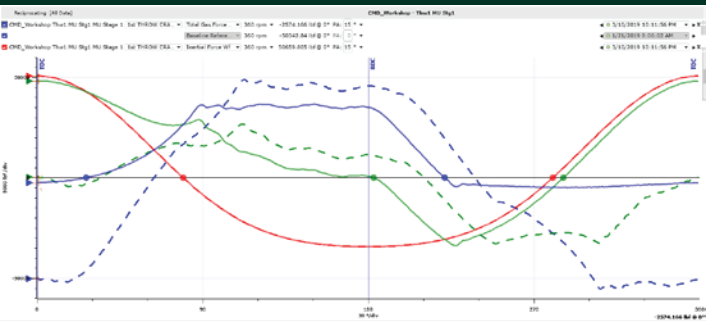
Log PV

Plotting PV curves on a logarithmic scale makes valve and piston ring leaks more apparent to the diagnostic user.



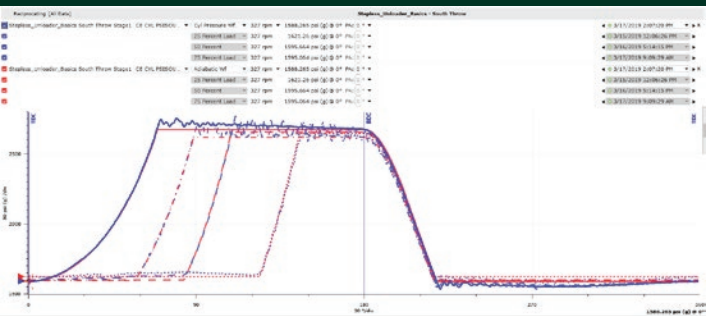
Rod load plot

Cylinder pressure is used to calculate total gas force. This is added to the inertia force of the reciprocating components to calculate combined rod load, and all three are plotted against the crank angle. Peak rod load compression and peak rod load tension are used to ensure overload conditions are not present for the throw. Additionally, the crossing points of the combined rod load curve across the 0 force axis determines the degrees of rod reversal, which is an indicator of adequate lubrication in the crosshead pin area. This plot shows a partially loaded condition (solid lines) overlaid with a baseline fully-loaded condition (dashed lines).



Pressure versus crank angle (θ-Theta)—PT plots

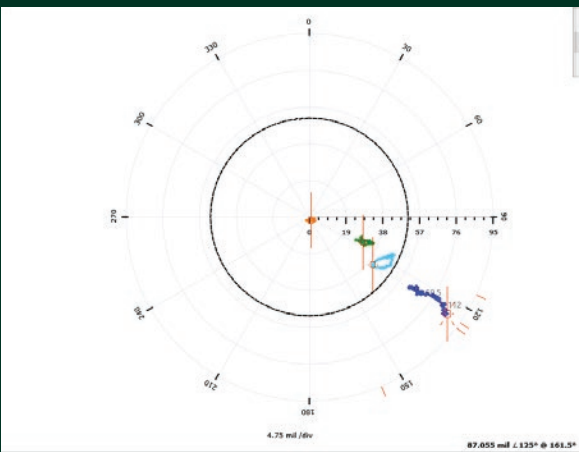
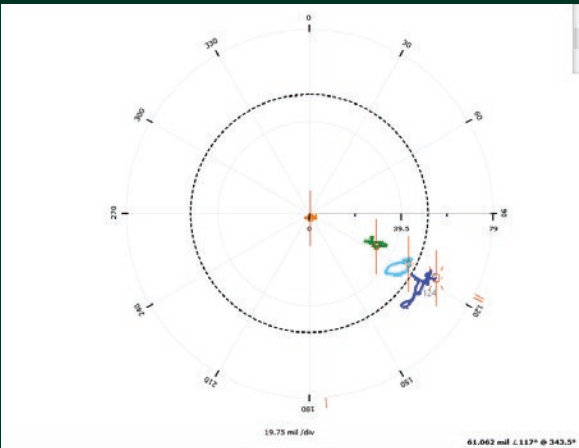
The crank angle domain is another useful format. Any timing issues, as well as cylinder trim conditions, can be readily identified using this view. Simply double-clicking on the units of the horizontal scale of the PT plot shown here conveniently toggles between it and the PV plot shown in the upper left and vice versa.



Rod position plots

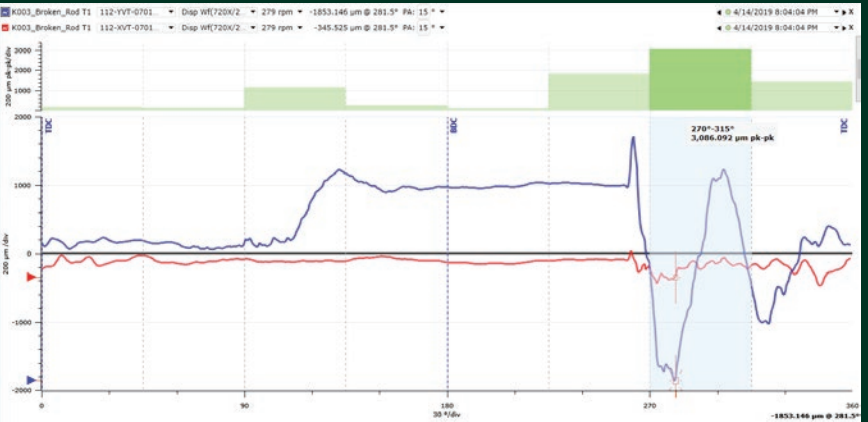
Rod position plots display the total movement of the plunger or piston rod at the pressure packing case. Typically, effects of changes in mechanical clearances, such as plunger to guide bearing, crosshead-to-crosshead guide, etc., and changes in average position, such as the thermal growth of a piston from cold to operating conditions can be seen in this format. In this example, the reference curves reflect a progression away from the bore center over a seven week period.

For any plot the headers can be collapsed for maximum plot viewing area.

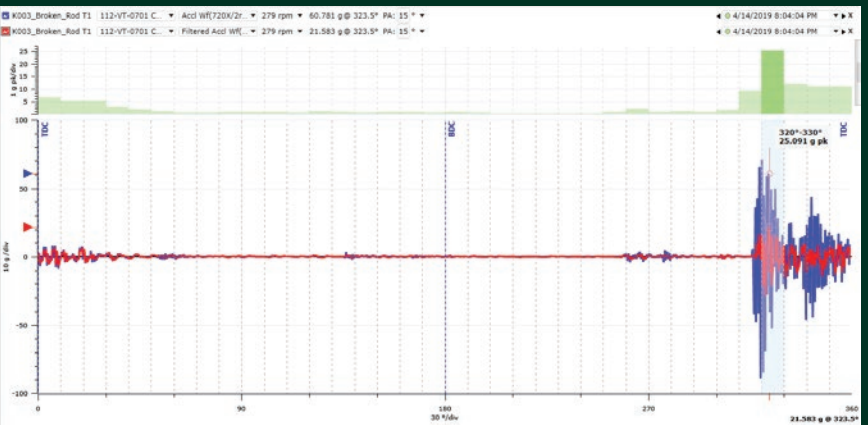


Variables in crank angle domain

Leveraging the 3500 Series architecture, which simultaneously captures data across multiple channels, this plot format enables users to correlate events across different measurements and to correlate events with piston position inside the cylinder. Piston rod monitoring can be represented in eight crank angle bands of 45 degrees width for each revolution with the maximum amplitude shown for each 45-degree band.



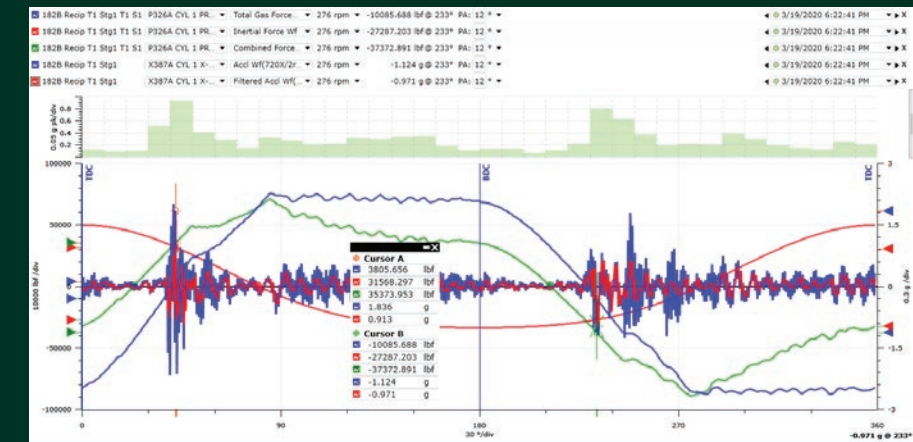
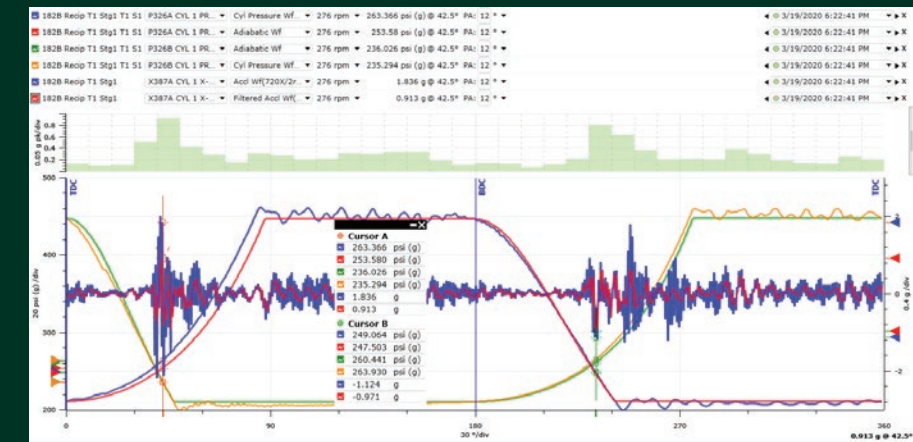
Crosshead and cylinder vibration can be represented in 36 crank angle bands of ten degrees width for each revolution for both the filtered and unfiltered waveforms with the maximum amplitude shown for each 10-degree band.



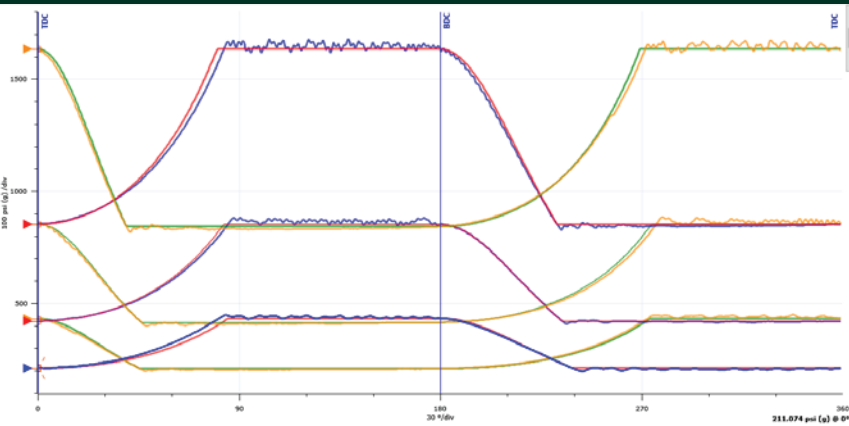


## Variables in crank angle domain—other views

The software allows plotting the waveforms from different transducers in the same view. The plots below have the PT plot (top view) with the crosshead acceleration and combine rod load plot (bottom view) with the same crosshead vibration. Both views show an example of a loose piston-to-piston rod connection. The PT reveals the acceleration impacts at the points where the pressures cross in the expansion and compression curves and the combined rod load reveals the acceleration impact events occurring when the total gas force (blue curve here) crosses the 0 force line.

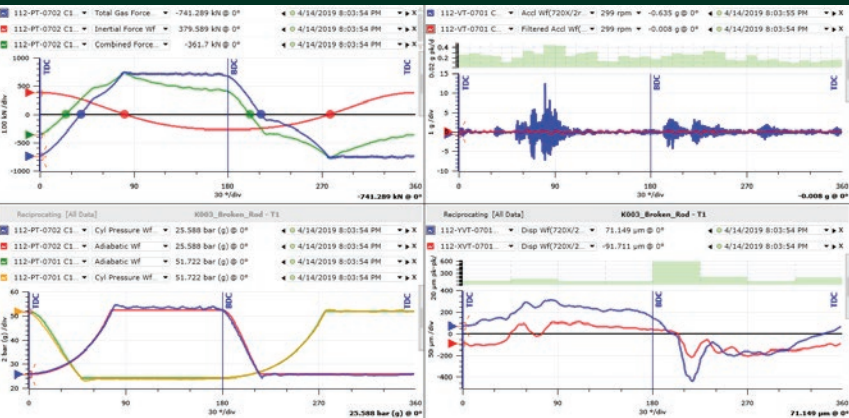


The software allows the diagnostic engineer to review the data on a per throw basis or even looking at all the stages in one view as shown below.



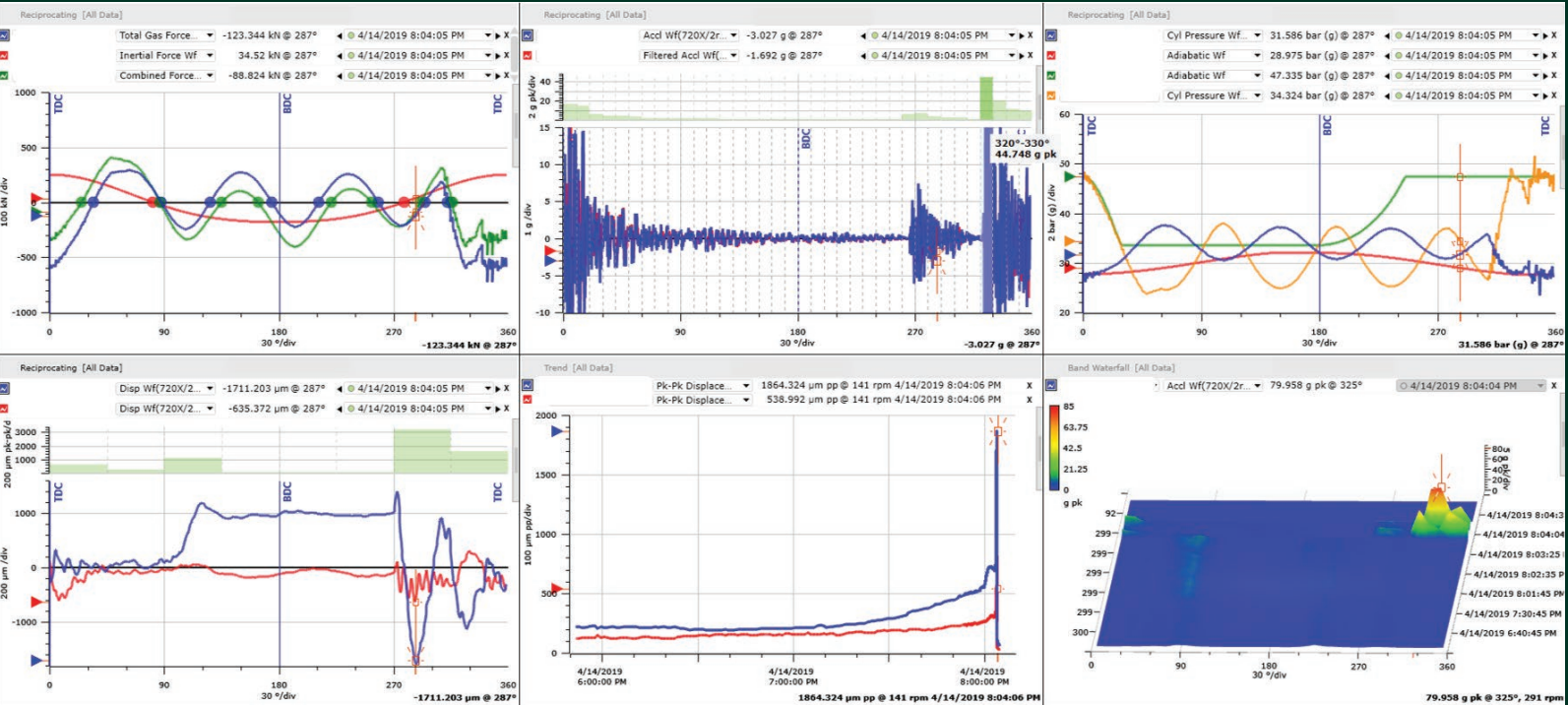
## Mechanical integrity

System 1 provides an intuitive user interface that enables plotting of multiple measurements across events within a single pane, facilitates efficient arrangement of multiple panes, and synchronizes cursors and/or samples across panes. The plot format incorporates graphics optimization algorithms to enhance data presentation quality. This helps the user to more quickly and accurately correlate events across multiple measurements.



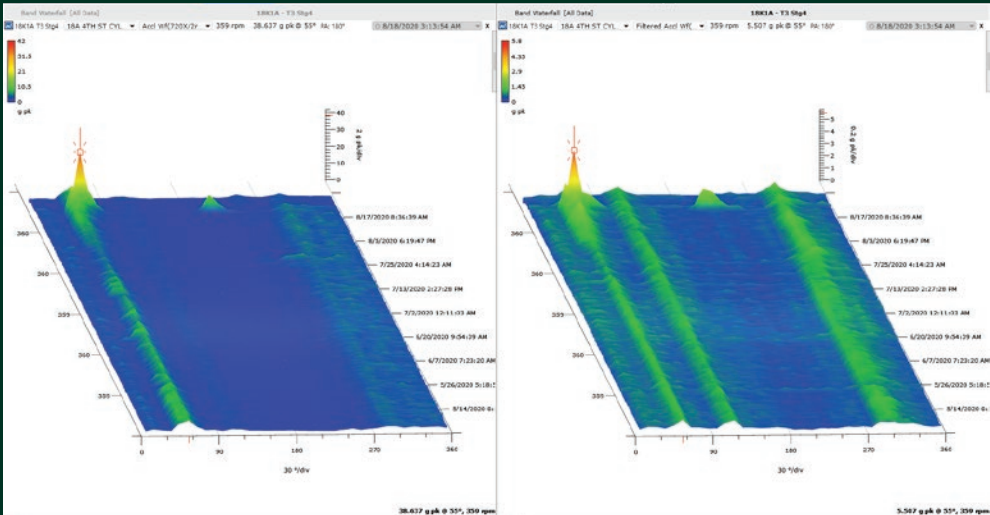
## Multiple measurements

Adding additional plot types provides even more flexibility to your diagnostic requirements. And, with active curve synchronization enabled, you can quickly see the waveform for a point on your trend plots.



## Band waterfall plots

Trendable variables are configured for the impulse acceleration channel to have 36 bands (10 degrees wide) for both the filtered and unfiltered waveforms. These are then graphically displayed in a band waterfall plot with a color-contoured amplitude scale for easy viewing of amplitude changes. This format allows the user to see how individual events in the compression cycle behave over time and during operational or process changes. The plot on the left shows an unfiltered crosshead Accel signal (3-20 kHz) that had a peak of 43 g's towards the end. The filtered crosshead signal on the right (3-2000 Hz) reveals the maximum value of 6 g pk following an upward trend that began six days prior. The obvious diagnosis was mechanical looseness, and a loose suction valve cage with broken tie rods was discovered upon inspection after the shutdown.





# Comprehensive condition monitoring services

## Proactive care for your reciprocating compressors

Our Bently Nevada condition monitoring solutions for reciprocating compressors continue a legacy of many years across more than 4,000 installed compressors. Our machinery diagnostic engineers help you reach your safety and efficiency goals—increasing uptime, while reducing operation and maintenance costs.

A worldwide team of machinery diagnostic experts is available 24/7 to assist you, providing proactive asset health information, analyzing compressor data, and performing root cause analysis on malfunctions.

## Machinery diagnostics—supporting services

The mechanical and thermodynamic behavior of your reciprocating compressors is analyzed by our machinery diagnostics experts; malfunctions on valves, piston rings, rider bands are analyzed as well as vibration on running gear components. Machinery diagnostic services (MDS) can be provided either remotely or onsite, on call, periodically, or continuously. This includes:

- Startup, commissioning, and operational assistance. Data analysis, system optimization (hardware and software), fine tuning of settings, and customization of data visualization and management (based on actual operations and users' needs)
- Alarm and event management (daily, weekly, 24/7): the “real time” disposition of alarms to indicate machine problems, process problems, or instrumentation problems
- Baseline audits (onsite/remote), asset “baseline” and report for diagnostic and alarming purposes so that data is available for ongoing diagnostics, minimizing nuisance alarms, or missed warnings
- Periodic audits (onsite/remote), asset audit, and diagnostic report. Assessing and reporting machine condition, providing recommended actions and, where applicable, performing root cause analysis

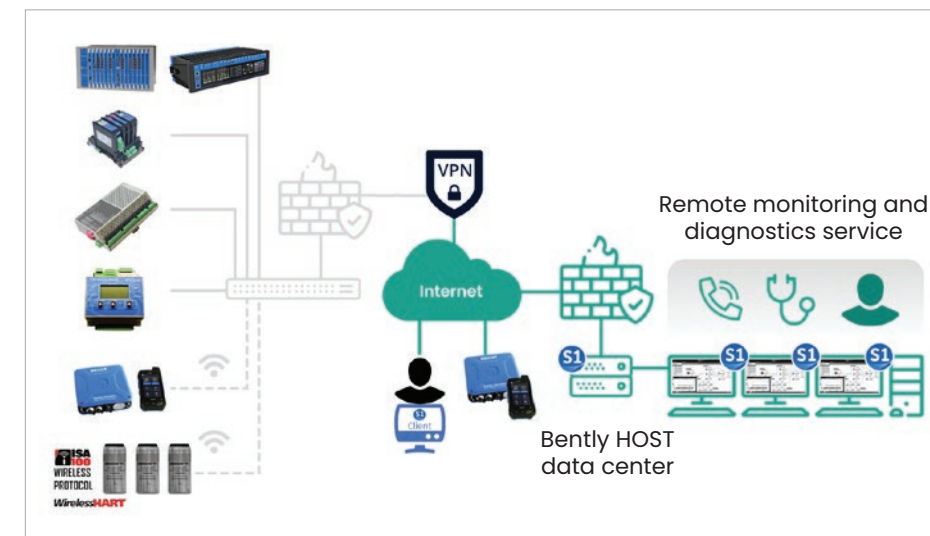
## Retrofits

Bently Nevada will make retrofits of our instrumentation systems simple by managing the entire project. Bently Nevada will handle everything, from drilling and tapping holes in the machine to accommodate our transducers, to packaging and configuring our monitoring systems into enclosures suitable for your plant's environment, to pulling field wiring, to integrating our software into your plant's IT infrastructure, while documenting every detail.

## Bently HOST

Bently HOST™ is an all-in-one monthly subscription for hosted infrastructure, software, and asset health management services as the outcome. This allows asset owners to benefit from our decades of domain expertise embedded in System 1 and delivered through our remote monitoring and diagnostics (RM&D) service centers to realize the full value of asset condition monitoring programs without CAPEX investment. This enables three key capabilities:

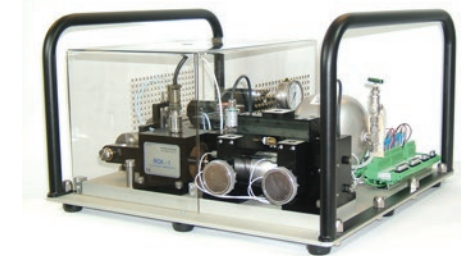
- Asset management strategy at an affordable monthly price
- Flexible, scalable, and secure condition monitoring by domain experts
- Peace-of-mind through outcome-focused solutions



## Training

Understanding the vibration and performance behavior of your machinery is the key to asset optimization. To achieve this, we offer tailored training:

- Instrumentation and monitoring systems operation and maintenance: training for instrumentation engineers that provides basic knowledge of the Bently Nevada 3500 Series system and components, operation, and troubleshooting procedures
- System 1 for reciprocating compressor “getting started” course: hands-on training on system usage, data management, and interpretation to enable trainees to analyze malfunctions and use of supporting data for root cause analysis
- Reciprocating compressor monitoring and diagnostics: in this course attendees learn reciprocating compressor components, mechanics, performance theory, and recip-specific diagnostic techniques. The course illustrates several failure patterns through hands-on workshops with actual case histories. Workshops may optionally use the recip kit pictured here. Designed for system users to understand the compression process and interpret vibration readings of reciprocating compressors



## Services and total solution packages (supporting service agreements)

To help you get the most from our installed condition monitoring solution, we back it up with a full array of support services. Our total solution packages can boost the reliability and efficiency of your reciprocating machinery—and help you make informed maintenance decisions.

We offer training to plant personnel on all aspects of system use and maintenance, from instrumentation basics to in-depth mechanical and thermodynamic data analysis. These services can be tailored in a supporting service agreement, ensuring our availability anytime you need us.



1631 Bently Parkway South  
Minden, Nevada USA 89423  
+1 775 782 3611  
[bentlysupport@bakerhughes.com](mailto:bentlysupport@bakerhughes.com)

Copyright 2024 Baker Hughes Company. This material contains one or more registered trademarks of Baker Hughes Company and its subsidiaries in one or more countries. All third-party product and company names are trademarks of their respective holders.

The information contained in this document is the property of Baker Hughes and its affiliates; and is subject to change without prior notice. It is being supplied as a service to our customers and may not be altered or its content repackaged without the express written consent of Baker Hughes. This product or associated products may be covered by one or more patents. See [Bently.com/legal](https://www.bently.com/legal).

BakerHughes\_BN\_ReciprocatingCompressorsMonitoring\_Brochure-Print-NA-022324



[bently.com](https://www.bently.com)