

Plantwide condition monitoring

Implementation and migration guide

Abridged version: doc BHDW00001



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Before you read any further...



NOTE 1: this guide is intended to augment—not replace—the guidance that your local Bently Nevada team of professional sales and service personnel can offer, given their familiarity with your specific operations, assets, objectives, and the entirety of the Bently Nevada portfolio. It is not intended that this guide be read cover-to-cover. Much of the content is reference material for those that need assistance identifying their installed Bently Nevada products and ascertaining its connectivity to System 1 software.



NOTE 2: System 1 software in this guide is divided into two major version categories. Versions released in 2017 and thereafter (v17.1 and above) are referred to simply as “System 1”. Versions released prior to 2017 (v6.X and below) are referred to as “*System 1 Classic*”. The version numbering changed in 2017 to reflect the year of release and the major increment (two major releases are now planned each calendar year). Prior releases did not maintain a semi-annual rhythm and did not reference the year. Unless otherwise stated, the term “System 1” in this guide refers only to versions 17.1 and above. When earlier versions are being discussed, they will explicitly say “*System 1 Classic*”. Earlier Bently Nevada literature may sometimes refer to versions 17.1 and higher as “System 1 Evolution” but that nomenclature is no longer used and thus does not appear in this guide.

1 How to use this guide

The intent of this guide is to assist customers in creating a plantwide ecosystem of Bently Nevada machinery protection and condition monitoring products, unified by System 1 software. It also briefly covers connection of 3rd party products to the System 1 ecosystem. It does this by helping customers understand the connectivity of their existing Bently Nevada and third-party products, upgrade options where necessary, and by providing a systematic framework for moving to a plantwide ecosystem regardless of where you are starting.

Two versions of this guide exist:

Version	Doc #	Description
Abridged	BHDW00001	This version omits Appendices B-E appearing in the comprehensive version. These appendices contain numerous older, fully obsolete products that are not compatible with System 1. It is intended for customers that have Bently Nevada protection systems produced during the last 30 years (3300 and later) and condition monitoring hardware produced during the last 20 years. Software older than 20 years (prior to System 1) is not included because these platforms ran on older operating systems that are no longer supported by Microsoft or other manufacturers. It is thus very unlikely they are still in use.
Comprehensive	BHDW00002	This version covers virtually all Bently hardware and software products manufactured since 1985, and protection systems manufactured since 1965. It contains four additional Appendices (B-E) that do not appear in the abridged version, providing supplementary information on older products that are now fully obsolete and incompatible with System 1. This version is intended primarily for Bently Nevada personnel, but is available for download from http://bntechsupport.com for customers with a Technical Support Agreement (TSA). It is also available upon request for customers without a TSA.

To use this guide most effectively, follow these three steps:

- 1** Read sections 1-6.
Read also section 11.
- 2** In conjunction with the companion document *Online Periodic Condition Monitoring (BHCS38948)*, consult your local Bently Nevada sales and application solutions professionals for guidance in selecting appropriate Bently Nevada solutions that correspond to your specific assets.
- 3** Where existing Bently Nevada (and selected third-party) products are already installed, identify them using the reference material in sections 7-10 and the appendices. Determine the level of connectivity supported using this guide, and in conjunction with your local Bently Nevada sales and applications professionals, build an upgrade plan where required.

2 Plantwide condition monitoring background

Condition monitoring is, at its core, a planning tool. The goal for systems to be successful is to identify developing problems on machines at the earliest possible opportunity and then intervene at a point in time before machine functional failure occurs while minimizing impacts to plant output and getting maximum useful life out the affected component (such as a bearing or seal) before replacing. This enables machinery asset management decisions to be made such that problems are addressed/corrected on a planned and scheduled basis sufficiently in advance of the possibility of failure in service.

Portable data collection systems are the most basic approach to condition monitoring and are discussed later in this section. They form a part of almost any plantwide condition monitoring implementation, but are rarely adequate for every asset. Because it is not generally cost-effective to manually gather data from machinery more than once per month, and because many machines have failure mechanisms that can progress in seconds or minutes (much faster than monthly data collection intervals), there is a need for online condition monitoring. The three primary considerations for augmenting an offline system with online condition monitoring are:

1. The data needs to be collected and evaluated more frequently than it is cost effective for a person to accomplish this with a portable instrument, or
2. The machine is located in an inaccessible or hazardous area where it is unsafe to send a person to collect the data, and/or
3. The cost consequences of a machine's unexpected failure in service justifies the investment.

Many evaluations have been done over the years to justify the investment required to install online condition monitoring for machines where shorter data collection and evaluation intervals are required. These evaluations typically result in the determination that if the data is required more frequently than every two weeks for the program to be effective, then an online system is justified when compared to sending a person out to collect data with a portable device.

Machine criticality is also rightfully used as a consideration for online versus purely offline condition monitoring. The more critical the machine, in terms of the cost consequences of unexpected failure in service, the greater the value of permanently installed condition monitoring technologies. Figure 1 shows the generalized relationship between cost consequences, the time from malfunction detection to asset failure, and the recommended corresponding type of condition monitoring.

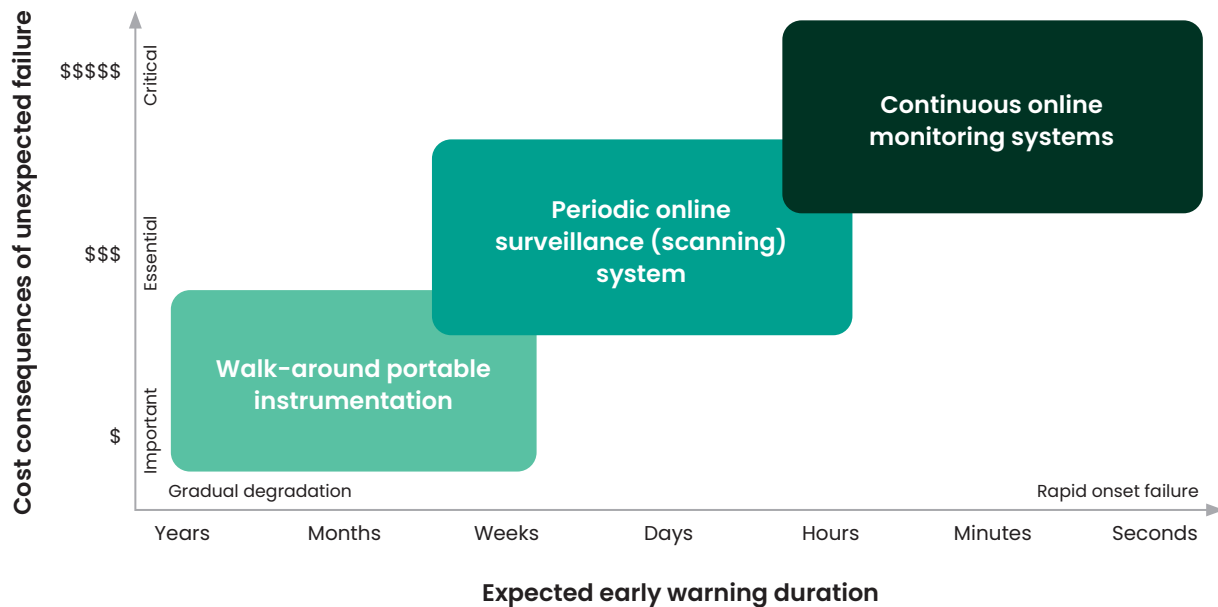


Figure 1: Recommended condition monitoring approaches as a function of cost consequences and early warning duration

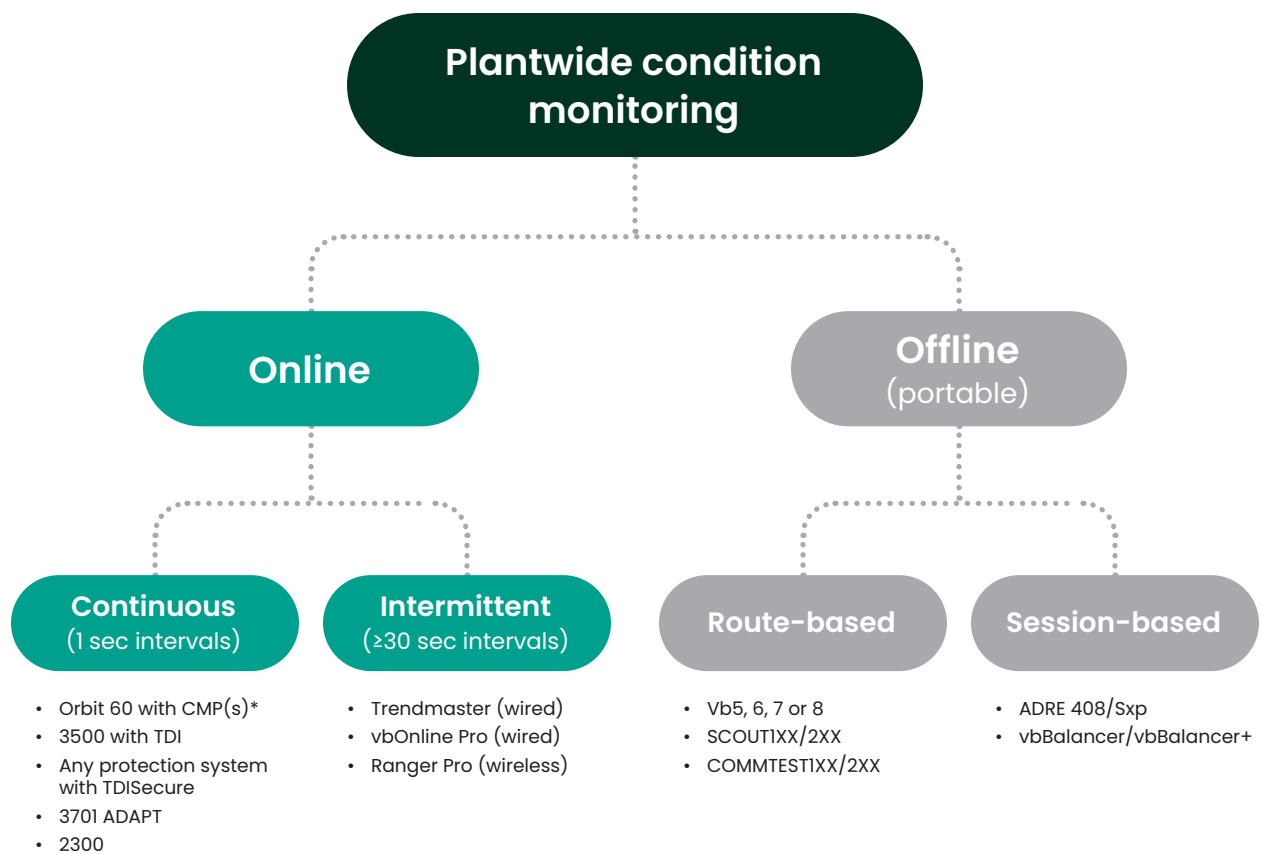
While the adoption of vibration-based protection systems for critical machinery became widespread during the 1960s and 1970s, condition monitoring during that same period was adopted more slowly because it was both cumbersome and labor-intensive. For critical machinery, condition monitoring was little more than strip chart recorders that could automatically trend the readings from the protection systems using recorder (i.e., 4–20mA) outputs. When a trend indicated a developing problem, benchtop instruments such as oscilloscopes, spectrum analyzers, and pen plotters were used to capture data from the protection system and generate plots in an attempt to determine severity and root cause. For assets without machinery protection systems, condition monitoring involved the use of portable vibration meters that could display but not store data. The readings were tediously captured manually and then logged on a clipboard using pen and paper. Trending was an entirely manual exercise and involved transcribing numerical logs—essentially handwritten tabular data—into graphs.

It was not until the mid-1980s that the route-based portable data collector and trending/analysis software running on a desktop computer would be introduced. This technology was rapidly adopted by industry as the first truly practical way to implement condition monitoring and move an organization from reactive, breakdown or inspection-based maintenance to Predictive Maintenance (PdM). The most common use case was for an engineer or technician to load routes into the data collector and visit every machine to collect vibration data for evaluation at monthly or quarterly intervals. The goal was to identify machinery with internal (i.e., otherwise invisible) damage or degradation so that it could be corrected in advance of surprise operational failure. While this worked well in many cases, some machinery still experienced failures that could develop and progress more rapidly than the scheduled route intervals could catch.

Online condition monitoring (OCM) systems collect data at more frequent intervals than is practical with a portable system. The original OCM systems were developed from portable data collectors with a controllable multiplexer that was permanently connected to the data collection and evaluation software. The term “online scanning” describes the periodic nature of a multiplexed system, where sensor channels are “scanned” or cycled through individually or in small groups. The Bently Nevada Trendmaster System, introduced in the late 1980s, is one example of a scanning architecture. The Ranger Pro, a more modern wireless sensing system, is another example as each sensor can be programmed to return data to the condition monitoring server in intervals ranging from as little as every 10 minutes to as much as every 28 days. These systems are “online” in the sense that they eliminate manual data collection, but the individual channels or sensors are measuring and returning data to the server only intermittently. As such, many customers refer to these systems as “online surveillance.” In this document, the terms “surveillance” “intermittent” “periodic” and “scanning” will be used interchangeably when referring to systems that measure and collect data at intervals measured in minutes

or longer. In contrast, condition monitoring systems that are capable of returning their data in intervals of seconds or milliseconds will be referred to as continuous systems. The dividing line between “continuous” and “intermittent” is somewhat subjective, but still useful in understanding the various offerings and where they are designed to be used.

It is important to note that no system is truly continuous in that it perpetually measures and returns every waveform from every shaft revolution where it is stored in a condition monitoring server—this would quickly overwhelm even the largest server storage capacity. However, continuous systems can measure large amounts of data in a short period of time, such as during a startup/shutdown or surrounding an alarm, and the data captured and returned during such events can essentially be a continuous record. We thus refer to continuous OCM systems as those that can return their static (i.e., non-waveform) data at intervals of one second or better and waveform data at variable rates based on the machine operating and alarm states. Figure 2 shows the taxonomy and nomenclature associated with Bently Nevada’s condition monitoring hardware. The products interconnected as part of a plantwide condition monitoring ecosystem are shown in the 2-page spread on the following pages and are discussed in more detail in sections 7 and 8 of this guide.



* Condition monitoring processor

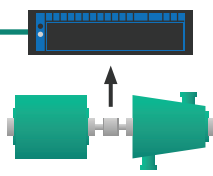
Figure 2: Condition monitoring product taxonomy and nomenclature



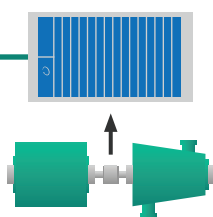
Machinery protection systems

Continuous machinery protection systems such as Orbit 60, 3500, and 3701 ADAPT can be connected to System 1 software using their integrated condition monitoring capabilities. Third-party protection systems can be connected to System 1 using a Bently Nevada hardware interface such as TDISecure or Orbit 60.

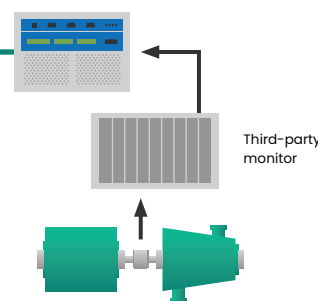
Orbit 60



3500

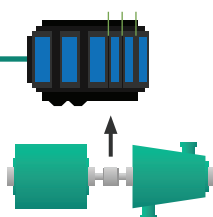


TDISecure



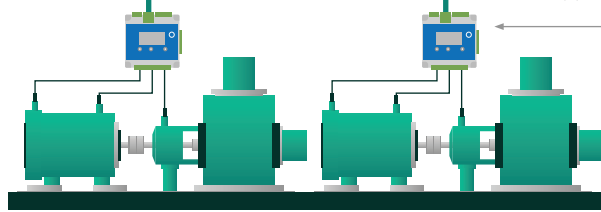
Third-party monitor

3701 ADAPT



2300 Series monitors

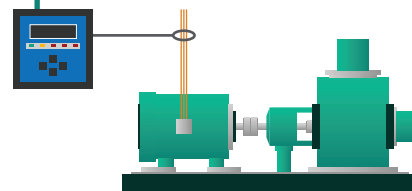
These 2-channel (+ speed) monitors can connect directly to System 1 via Ethernet or can optionally interface to a Trendmaster bus.



Up to 254 points

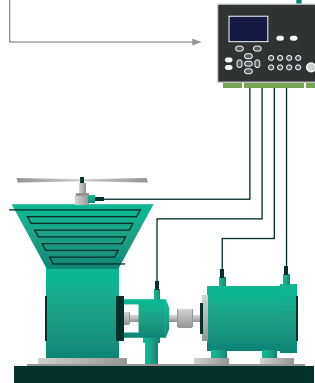
AnomAlert

This device monitors 3-phase motors and can detect problems in both the motor and its driven machinery through analysis of the voltage and current using embedded AI. It communicates with System 1 using OPC-DA protocol.



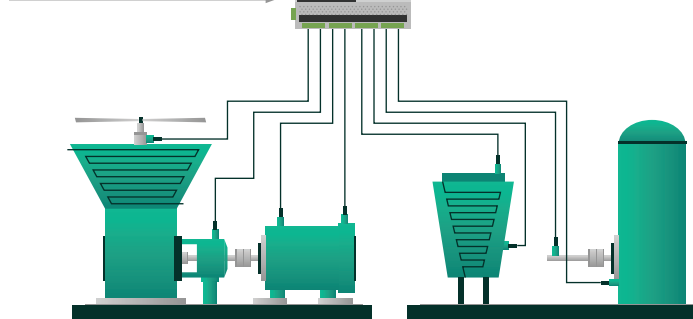
1900/65A monitors

These 8-channel monitors (4 vibration channels and 4 temperature channels) provide machinery protective functions and can communicate with System 1 via Modbus.



vbOnline Pro

These 12-channel monitors (+ 2 speed channels) accept accelerometer inputs and communicate directly with System 1.



Trendmaster®

254 points can be connected to a single bus cable and up to six bus cables connected to a single Trendmaster chassis. Points are scanned sequentially at intervals of approximately 15 seconds. Collecting data from a total of 960 connected points would thus require about 4 hours.



Up to 254 points

Up to 254 points

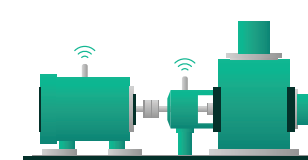
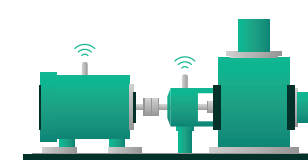
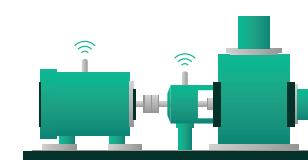
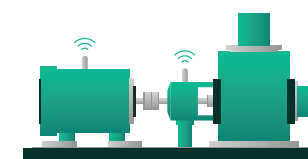
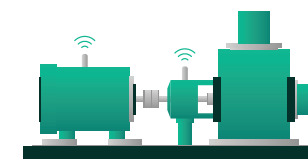
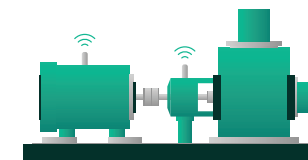
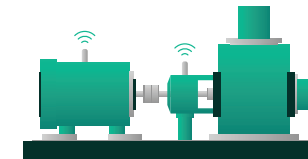
Up to 254 points

Up to 254 points



Ranger Pro

Our Ranger Pro wireless vibration and temperature sensors support both ISA100 and WirelessHART protocols.



Portable data collection

Our SCOUT and COMMTEST portable data collectors are fully compatible with System 1 software. They can be used to collect data from assets that don't have online systems, or to simply augment your online data from a particular asset with additional offline measurements.

Legend

- I.S. isolation device
- T-connection
- Ranger Pro wireless sensor
- Transducer
- Trendmaster® Transducer Interface Module (TIM)
- Trendmaster® sensor bus cable
- Transducer cable
- Ethernet
- 3-phase power cable

3 Implementation steps and asset classifications

STEP 1: inventory and categorize your assets.

For purposes of implementing a plantwide condition monitoring program, the first step is always the same: audit your assets and classify them according to criticality. The categories below may be used, or similar categories you may have already adopted in your organization. The key is that the distinction between categories should clearly identify whether protection is required, and the type of condition monitoring (online versus offline) that is required for all except those assets where a “no monitoring” (run-to-failure) approach is justifiable. This step can be performed using your own in-house or contracted resources, or you can enlist Bently Nevada to assist you. We have performed hundreds of such audits with and for our customers to inventory, categorize, and prioritize their assets.

		Monitoring requirements					
		Protection		Condition monitoring ³			
		Online continuous (API 670) ¹	Online continuous (non-API 670) ²	Online continuous CM	Online intermittent CM	Offline (portable) CM	None
Asset criticality	Category A—Critical	●		●			
	Category B—Essential		●	●	●		
	Category C—Mid-criticality				●	●	
	Category D—Low criticality					●	
	Category E—Run to failure						●

Notes:

1. These protection systems should conform to the requirements of American Petroleum Institute (API) Standard 670.
2. These protection systems do not necessarily need to conform to the requirements of API 670 and may reflect lower-cost offerings with a reduced feature set consistent with the needs of the asset.
3. The criteria for selecting online versus offline condition monitoring were discussed in section 2. The criteria for selecting an online condition monitoring system with intermittent versus continuous collection intervals are discussed briefly in section 8 of this Guide and in considerably more detail in the companion document *Online Periodic Condition Monitoring* (BHCS38948).

STEP 2: prioritize the order in which these categories will be pursued and install protection systems where necessary.

The primary reason for the inclusion of a machinery protection system on an asset is often safety-related, and these assets (A and B) should thus be addressed first by applying protection systems. However, even if condition monitoring will not be added at that time, the protection systems should be selected based on the type of condition monitoring they support (continuous or intermittent) in order to minimize the need for hardware changes later on. Many Bently Nevada platforms simply allow the CM functionality to be turned on by means of firmware or other means, such as software licensing, which minimizes or eliminates any hardware-level or field wiring changes. For example, Bently Nevada protection systems such as 3500, ADAPT,

and Orbit 60 record and store data around startup/shutdown and alarm events that can be accessed and downloaded for analysis and diagnosis. These capabilities are integral to the hardware and merely need to be activated in most cases. Your local Bently Nevada sales and application solution professionals can assist in selecting the proper machinery protection system for your needs based on the type of asset and other factors, including the installed base of protection systems that may already exist in your plant.

STEP 3: install System 1 to establish a foundation for your plantwide ecosystem and begin adding condition monitoring data streams from your compatible Bently Nevada protection systems and third-party protection systems.

This again will usually start with the most critical assets (Category A). You can then immediately proceed to Category B assets, and save Category C and D assets until Step 4, or you can proceed to Step 4 and conduct an Economic Impact Analysis for all assets in Categories B-D.

STEP 4: do an Economic Impact Analysis for each remaining asset and selectively add online condition monitoring based on the ROI. Alternatively, you can proceed directly to portable data collection plantwide as an intermediate step and then go back and selectively supplement with online condition monitoring later in steps 5 and 6.

Once the most critical assets (Category A) have been addressed with online condition monitoring, the ideal next step is to conduct an economic impact analysis on the remaining assets to see which ones will provide the best return on investment when addressed with online condition monitoring. Many plants cannot afford to address all assets simultaneously from a budget or personnel perspective, and a phased approach must be used instead, beginning with the assets that represent the best ROI and proceeding to those with more modest ROI. These will usually (but not always) be Category B assets followed by Category C assets, but in some cases the priorities will reflect a mix of the two as assets are prioritized based on ROI. The ROI does not change an asset's classification—merely the relative priority in which it is addressed. It is also important to note that the criticality of an asset does not necessarily dictate the type of condition monitoring that will be used. They are frequently related, but not always. The choice of condition monitoring will always reflect the types of failures that must be detected, the speed at which those failures can progress, the technology that must be employed to reliably detect the failure in time to avoid or mitigate it, and the relative impact on the organization the asset will reflect if it fails. For some assets, the impact will be process downtime. For others, repair costs. For still others, fines and penalties for environmental/emissions incidents.

An alternative approach is to use a portable data collection system at this stage before progressing with additional online connections to Category B and C assets. The reason for this alternative approach is quite simple: it allows a plant to address all of their assets with basic condition monitoring rather than excluding some assets by going purely with online systems first and then later offline (portable) systems. While starting a portable data collection regimen from scratch may be feasible for plants with only dozens or hundreds of assets, it may not be practical for plants with thousands of assets as the necessary team size to address that many assets purely with portable data collection can be quite large. Indeed, as the example on the next page shows, a team of a dozen people is required to run the portable data collection program at one large North American refinery. Fortunately, very few industrial plants today are without a portable data collection program.

Although the use of a portable data collection strategy at this stage admittedly entails purely manual data collection, it is an intermediate step born of pragmatism and is not intended to be permanent. The desired online condition monitoring warranted for category B and C assets will be implemented in Steps 5 and 6 and can be implemented simultaneously with Step 4 or sequentially thereafter.

In the interim between Steps 4 and 5, higher criticality assets (Categories B and C) can be addressed by simply using shorter intervals between walk-around routes (perhaps twice monthly) while lower criticality assets (Category D) can be addressed with more customary manual data collection intervals—typically monthly or quarterly.

Example

A study of one 250,000 bpd¹ refinery in North America showed that it had approximately 7,000 pieces of rotating machinery falling into asset categories A–D as shown at right (category E assets were not included in this total).

Asset category	# of Assets
A	150
B	750
C & D	6,100
TOTAL	7,000

All category A and category B assets had protection systems installed (Bently Nevada 3500 for category A, and Bently Nevada 2300 for Category B) but there was no online system such as System 1 installed. The customer instead relied upon their existing portable data collection program as an interim step for all assets while they launched sequential projects to begin adding online condition monitoring, beginning first with their Category A assets and then proceeding to Category B. A decision to address category C assets with online technologies was still pending. In contrast, other plant locations within the same company had already addressed all Category A assets with online System 1 capabilities from their 3500 racks, and all Category B assets with online System 1 capabilities from their 2300 monitors. Their Category C assets had not yet been uniformly addressed and relied on the same approach as their Category D assets: portable data collection. Wireless (Ranger Pro) and Wired (Trendmaster) solutions were being investigated longer term for application to their Category C assets.

For the plant without any online condition monitoring, the team to collect portable data across their 7000 assets consisted of a dozen people divided into four teams of three individuals each. There were a total of four data collection instruments—one for each team. The majority of assets were addressed with a monthly interval between data collection rounds, but machines showing problems were addressed with more frequent data collection—sometimes weekly in an attempt to more closely predict remaining time until failure.

STEP 5: add online condition monitoring hardware for assets that are impractical or impossible to address with a portable data collector.

These may be Category B or C assets. The common denominator is that data collection via manual means is not practical, desirable, or safe and an online means is necessary instead. If it is not possible to do “impractical/impossible” Category B and C assets simultaneously, start with B and then proceed to C as budget and resources allow.

The type of online condition monitoring hardware selected will vary based on a number of factors that are best addressed with the help of your local Bently Nevada sales and application solution professionals. The solutions will generally consist of one or more of the following:

- Wireless sensing with our Ranger Pro offerings
- An economical sensor bus with our Trendmaster offerings that may be implemented in purely wired or hybrid wired/wireless topologies. This solution is suitable for assets where intermittent collection intervals ranging from minutes to days are suitable

¹ Barrels per day

- Continuously collected (i.e., non-intermittent) condition monitoring data from our vbOnline Pro hardware. This solution is suitable for assets that need collection intervals in seconds rather than minutes, hours, or days
- Selected electric motor assets with our AnomAlert™ offerings that cannot be adequately addressed by vibration-based condition monitoring alone

STEP 6: add online condition monitoring hardware for Category B and C assets that were not addressed in Step 5.

This will fully build out the online portion of your plantwide system by finishing the mix of assets that will be addressed with online systems.

STEP 7: add offline condition monitoring hardware for Category C and D assets not already addressed. If using a third-party system that is not compatible with System 1, migrate to System 1 by moving to portable data collection instruments from within the Bently Nevada portfolio.

This will fully build out the offline portion of your plantwide system while integrating everything—both online and offline—into System 1. Bently Nevada’s portable data collections offerings enable world-class predictive maintenance programs and users no longer need to entertain the use (or continued use) of third-party data collectors in order to obtain best-in-class functionality. Refer to section 9 for details on incorporating Bently Nevada data collection instruments into your System 1 ecosystem as well as migration options to System 1 when using several of the most popular third-party data collectors such as Emerson/CSI and SKF. For those using older COMMTEST Ascent™ software, engineered migration tools and services exist to seamlessly move from Ascent to System 1.

STEP 8: add process data to your System 1 implementation, enabling better correlation of cause-effect relationships for assets where process conditions impact mechanical conditions.

Many assets will benefit from the inclusion of relevant process data that supplements condition data to help determine cause-effect. Examples might include differential pressure across machinery inlet filters, suction and discharge pressures on pumps and compressors, as well as ambient, bearing, and process fluid temperature on most asset types. Even fixed (non-rotating) assets can often be addressed with a basic level of condition monitoring by trending and alarming on relevant variables such as differential or absolute pressures, temperatures, flows, and other measurements typically available from the process control system, but which may not be trended or alarmed in ways that are specifically tailored for condition monitoring purposes rather than process control purposes. The System 1 environment enables such capabilities and can thus allow extension of your condition monitoring beyond just rotating and reciprocating assets to include fixed assets.

STEP 9: consider the addition of optional System 1 analytic components such as thermodynamic performance, decision support, and Predictive Emissions Monitoring (PEM), applying to relevant asset types.

Thermodynamic performance monitoring allows maintenance intervals on some assets, such as gas turbines, to be optimized based on the economics of increased fuel costs as efficiency degrades. PEM is another closely related use of process data within System 1 to ensure that operators remain compliant with regulatory

requirements for emissions on assets such as gas turbines. Exhaust gas temperature profiles are yet another example of supplemental System 1 capabilities that allows decisions regarding maintenance on the hot gas path components of gas turbines to be made based on actual measured conditions rather than strictly on running hours.

Decision Support is a particularly important supplemental capability that can considerably improve the productivity of condition monitoring teams by automatically and continuously auditing data to identify incipient or more fully developed machinery malfunctions. This relieves practitioners from the burden of manually reviewing data, allowing them instead to focus on assets where anomalies or malfunctions have been flagged. Decision support can be applied to all categories of data, whether process only, vibration only, or a mix of the two. It can also be applied to all categories of assets A to D whether the data originates from an online system or offline system.



NOTE: the above order for steps is advocated because it provides a systematic way to first address the assets that are most likely to provide the strongest Return-On-Investment. There is no wrong place to start. If you are doing nothing at all, you may elect to pursue a portable data collection program first, followed by other online technologies. The key to success is to select the right technology for the asset and then maintain good records that demonstrate the financial benefits so that the value of condition monitoring can be documented at each step of your plantwide journey.

4 Typical as-found scenarios/ recommendations

Most customers can be defined by one of the as-found conditions described below. Recommended next steps are covered that will assist you in using the remainder of this Guide to proceed with your plantwide strategy and efforts.

4.1 Only machinery protection systems are installed—no online or offline condition monitoring...

If your plant has an installed base of Bently Nevada machinery protection systems, use this guide to identify them and then consult section 7 for guidance on connectivity to System 1 software. If you are using non-Bently Nevada protection systems, connectivity options may also exist. Consult section 8.4.

4.2 Bently Nevada machinery protection systems are installed but no online condition monitoring—only offline condition monitoring from a third-party...

Many plants will find themselves in this scenario. We recommend that the the protection systems first be fitted with appropriate online condition monitoring systems as outlined in step 3 of Section 3, and then proceeding to steps 4-9 sequentially.

4.3 Bently Nevada protection systems are installed, but a mix of third-party online and offline condition monitoring systems exist in your plant, from various suppliers...

This approach is identical to that of 4.2; proceed to step 3 and then sequentially to steps 4-9.

4.4 Nothing is installed; you are essentially starting from scratch...

Perform the nine steps of Section 3, sequentially.

5 Product lifecycle phases

Bently Nevada’s product lifecycle consists of the following five phases (P1–P5) plus an additional pre-release phase referred to as P0:

Bently Nevada product lifecycle phases	
Phase	Description
P0	<p>Pre-release</p> <p>Product is in design/development with the following four sequential pre-release statuses:</p> <ul style="list-style-type: none"> • ATD (Available to Disclose/Discuss) • ATQ (Available to Quote) • ATO (Available to Order) • ATS (Available to Ship)
P1	<p>Product release</p> <p>Product is released for sale with full support including ongoing enhancements, custom modifications, new spare parts, and full repair capabilities.</p>
P2	<p>Mature</p> <p>Same as Phase 1 except that no new enhancements are planned. Custom modifications are still available but discouraged. A notification of last time to buy new systems is typically issued several months before transitioning to Phase 3.</p> <p>NOTE: This phase is used primarily by hardware and only occasionally for software. Instead, software typically goes directly from Phase 1 to Phase 3.</p>
P3	<p>Spares only</p> <p>Product is no longer available for new installations and no new custom modifications are available. New spare parts (including those for existing custom modifications) are still available, and repair and support are provided as in Phases 1 and 2. A notification of last time to buy spare parts is typically issued several months before transitioning to Phase 4.</p>
P4	<p>No spares, limited support</p> <p>New spare parts are no longer available, and support is limited to repair, exchange, or remanufacture (subject to component availability). Notice of last date to repair is typically issued several months before transitioning to Phase 5.</p> <p>NOTE: This phase is used only for hardware—not software.</p>
P5	<p>Obsolete</p> <p>The product has no or limited support and is not recommended for continued use in a machinery protection application. Customers are advised to migrate to an appropriate replacement product with the assistance of a Bently Nevada technical specialist.</p>

Bently Nevada sales and service professionals may from time-to-time discuss products with you that are in Phase 0, and if so, will use the nomenclature described above. However, most of the time the products under discussion will fall into phases P1–P5.

Each of the products discussed in this guide fall into phases P1 through P5, and for convenience, the lifecycle phases for the products² discussed in this guide are summarized in the tables in sections 5.1 through 5.4 on the following pages. Current products are shown in green. Obsolete products and those that are still active but for which a newer replacement exists are shown in black.

² Transducers/sensors comprise a much larger list and are covered in a table found in section 10 of this guide.

5.1 Software

(see also section 6 and Appendix B³)

Product	Phase	OS	Recommended replacement
System 1 (v17.1 & above)	P1	Win8/10 ¹	Current
System 1 Classic (v6.X & below)	P3	Win7/8/10 ²	System 1
Decision Support for SI	P1	Win8/10 ¹	Current
Decision Support for SI Classic	P3	Win7/8/10 ²	System 1 w/Decision Support
Bently Performance for SI	P1	Win8/10 ¹	Current
Bently Performance for SI Classic	P1	Win7/8/10 ²	System 1 w/Bently Performance
Bently Balance ³	P1	Win7/8/10 ²	Current
COMMTTEST Ascent 2015	P3	Win7/8/10 ²	System 1
Bently Performance for DM2000	P5	WinNT	System 1 w/Bently Performance
Performance Manager 2000	P5	WinNT	System 1 w/Bently Performance
Bently Performance SE	P5	Win7/8/10 ²	System 1 w/Bently Performance
Data Manager 2000	P5	WinNT	System 1
Machine Condition Mgr 2000	P5	WinNT	System 1 w/Decision Support
Engineer Assist	P5	DOS	System 1 w/Decision Support
Engineer Assist Online	P5	QNX	System 1 w/Decision Support
ADRE SXP	P1	Win 7/8/10	Current
ADRE for Windows	P5	Win 9X/XP	ADRE Sxp (and ADRE 408 DAQ instrument)
ADRE 3	P5	DOS	ADRE Sxp (and ADRE 408 DAQ instrument)
ADRE I & II	P5	HP-UNIX	ADRE Sxp (and ADRE 408 DAQ instrument)
Trendmaster 2000	P5	DOS	System 1
Trendmaster 2000 for Windows	P5	WinNT/2K	System 1
Bently Lube	P5	Win2K	No replacement
Bently DocuView SE	P5	WinNT	System 1
3500 Operator Display	P3	See Note ⁴	System 1
Data Manager	P5	HP-UNIX	System 1
Dynamic Data Manager	P5	DOS	System 1
Dynamic Data Manager 2	P5	QNX	System 1
Transient Data Manager	P5	DOS	System 1
Transient Data Manager 2	P5	QNX	System 1
System 64	P5	VAX/VMS	System 1
Snapshot Software	P5	DOS	All COMMTTEST/SCOUT data collectors
Snapshot Balance Software	P5	Win CE	COMMTTEST vbX and SCOUT100-series devices
Snapshot Clipboard Software	P5	Win PktPC	All COMMTTEST/SCOUT data collectors
Multiplane Balancing Software	P5	DOS	Bently Balance ⁴ or vb7, vb8, SCOUT100/140 ⁵

Notes:

1. Also Windows Server 2019, 2016, 2012R2; all supported operating systems are 64-bit (not 32-bit).
2. Also Windows Server 2008 and 2012.
3. Bently Balance software is designed for use directly with ADRE SXP databases, System 1 Classic databases, or any product that can import/export balancing data into generic spreadsheet format (.csv).
4. Windows 95/98/XP/NT, Windows Server 2000/2003, Windows 2000 Professional.
5. The vb7, vb8, and SCOUT100-series data collectors feature integrated 1- and 2-plane balancing from within the handheld unit.

³ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

5.2 Machinery protection systems

(see also section 7 and Appendix C⁴)

Product	Phase	Recommended replacement for System 1 compatibility
Orbit 60	P1	Current
9000	P5	Orbit 60 or 3500+TDI
7200	P5	Orbit 60 or 3500+TDI
7000	P5	Orbit 60 or 3500+TDI
5000	P5	Orbit 60 or 3500+TDI
3500 and 3500 w/ TDI	P1	Not applicable
3500 ENCORE™	P4	Orbit 60
ADAPT.MDM 3701/40	P1	Current
ADAPT.GT 3701/44	P1	Current
ADAPT.HYDRO 3701/46	P1	Current
ADAPT 3701/68*	P1	Current
ADAPT.WIND 3701/60 & /60A	P4	60M100 (adapt.wind) or 60M500 (System 1)
ADAPT.ESD 3701/55	P1	Current
3300 and 3300 w/ DDI/SDI	P5	Orbit 60 or 3500+TDI
3300 w/ TDe	P5	Orbit 60 or 3500+TDI
2300	P1	Current
2201	P5	Orbit 60
1900/65	P4	1900/65A is form/fit/function replacement
1900/65A	P2	Current
1900/15, /17, /25, /27	P5	2300
1900/55	P5	1900/65A (retrofit kit exists for reuse of /55 housing)
1701	P4	Orbit 60
1700	P5	2300, 3701/40, or 1900/65A

* Only replacement parts are available directly through Bently Nevada. Complete systems must be purchased through select gas turbine OEMs

4 The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

5.3 Online condition monitoring systems

(see also section 8 and Appendix D⁵)

Product	Phase	Recommended replacement for System 1 compatibility
TDXnet	P5	Orbit 60 or TDISecure (if retaining protection system)
TDIX/TDIXconnX	P5	Orbit 60 or TDISecure (if retaining protection system)
Ranger Pro	P1	Current
COMMTTEST Ranger	P5	Supported by Ascent only; replace with Ranger Pro
Essential Insight.mesh	P5	Supported by <i>S1 Classic</i> only; replace with Ranger Pro
Rackmate/Rackmate IX	P5	Orbit 60 or TDISecure
DDM-CP/TDM-CP/PDM-CP/GPIU	P5	Orbit 60 or TDISecure (if retaining protection system)
DDIX/SDIX	P5	Orbit 60 or TDISecure (if retaining protection system)
3300/03 DDI/SDI	P5	Orbit 60 or 3500+TDI
3300/02 TDe	P5	Orbit 60 or 3500+TDI
TDISecure™	P3	Current
vbOnline16/32 and TurningPoint	P4	Limited System 1 support
vbOnline Pro (aka 60M500)	P1	Current
Trendmaster 2000 SPA Cards	P5	Not supported by S1; replace with Trendmaster DSM
Trendmaster DSM and TIMs	P1	Current; supported in <i>System 1 Classic</i> and <i>System 1 v20.2</i> and above
AnomAlert™ Motor Current Monitor	P1	Current
60M100 (wind turbine monitor)	P1	Compatible only with adapt.wind; use vbOnline Pro (60M500) for System 1 compatibility

5 The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

5.4 Portable instruments

(see also section 9 and Appendix E⁶)

Product	Phase	Recommended replacement
SCOUT200 series	P1	Current; supported by System 1
COMMTEST200 series	P1	Current; supported by System 1
COMMTEST vb5, vb6, vb7, vb8	P2	Current; supported by System 1 and COMMTEST Ascent
SCOUT100 series	P2	Current; supported by System 1 and COMMTEST Ascent
ADRE® 408 DSPi	P1	Current; no System 1 connectivity (uses only ADRE Sxp Software)
ADRE® 208 DAIU	P5	Supported by ADRE for Windows only; replace with ADRE 408 DSPi
ADRE® 108 DAI	P5	Supported only by ADRE 3/ADRE for Windows; replace with ADRE 408 DSPi
TK8—Tunable Filter Vibration Meter	P5	Predecessor to TK80
TK80—Tunable Filter Vib'n Meter	P5	Predecessor to TK81
TK10—Dual Low-Pass Filter	P5	All current COMMTEST/SCOUT portable instruments
TK20—Vector Filter & Balancing Kit	P5	vb7, vb8, SCOUT100 series
TK15—Keyphasor® Signal Conditioner	P5	No replacement
TK16—Keyphasor® Multiplier/Divider	P5	No replacement
TK17—Torsional Vib'n Sig Conditioner	P5	No replacement
TK3—Proximity Sensor Test Kit	P1	Electric (TK3e) and pneumatic (TK3g) versions available ¹
TK77—REBAM Test Kit	P5	No replacement
TK88—VAM Test Kit	P5	Ranger Pro
TK81—Handheld Vibration Meter	P5	All current COMMTEST/SCOUT portable instruments
TK82—Handheld Tachometer	P5	All current COMMTEST/SCOUT portable instruments
TK83—Balance Master 2	P5	All current COMMTEST/SCOUT portable instruments
TK84—Transducer Interface	P5	All current COMMTEST/SCOUT portable instruments
TK85—Battery Powered Proximito [®]	P5	No replacement
DVF 2 & 3—Digital Vector Filter	P5	ADRE 408 or COMMTEST/SCOUT portable instruments
Snapshot, Snapshot Plus, Snapshot Pro	P5	All current COMMTEST/SCOUT portable instruments
Trendmaster/Trendmaster FFT ²	P5	All current COMMTEST/SCOUT portable instruments
Snapshot IS	P4	SCOUT200-series
Snapshot Balance	P5	Replace with vb7, vb8, SCOUT100- / COMMTEST100-series
Snapshot Clipboard	P5	All current COMMTEST/SCOUT portable instruments
Snapshot CE	P5	All current COMMTEST/SCOUT portable instruments

Notes:

1. A prior generation of these products used slightly different model numbers (TK3-2E and TK3-2G). These older models can be distinguished by a gray fiberglass case and metal latches rather than the black NEMA 4X case of current models. Current models also contain a spindle micrometer in the kit and numerous other usability, accuracy, and robustness improvements.
2. Not to be confused with Trendmaster online scanning system.

⁶ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

6 Software

6.1 System 1

(2000 – present)
OS: MS Windows



System 1 is the heart of Bently Nevada’s plantwide condition monitoring solution landscape. As such, the majority of this Guide focuses on connectivity options for various Bently Nevada and non-Bently Nevada hardware to System 1, along with importing and exporting data when dealing with complementary systems. A separate companion document (BHCS38948, *Online Periodic Condition Monitoring*) focuses on selection criteria for the appropriate condition monitoring hardware based on the particulars and criticality of the asset.

At its simplest level, System 1 collects both dynamic (waveform) and static (characterized by a single value and a timestamp) data from connected data sources as follows:



- Machinery protection hardware
- Online condition monitoring hardware, including wired and wireless systems
- Offline condition monitoring hardware, such as portable data collectors
- Process data sources, such as DCSs, PLCs, and process historians

In most cases, this hardware will be Bently Nevada, but it is also possible to connect third-party hardware using an appropriate Bently Nevada interface device such as Trendmaster or TDIsecure™.

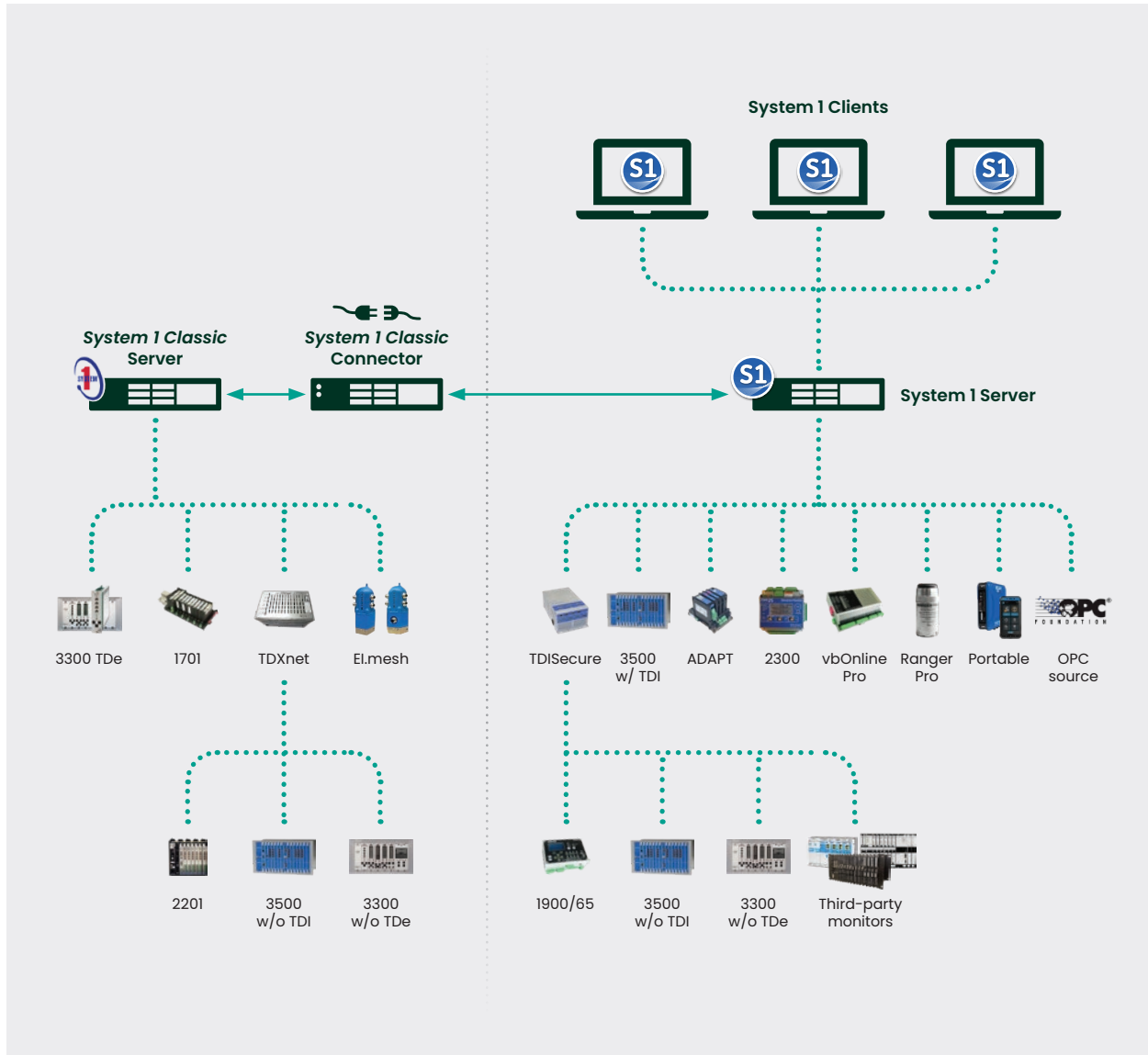
Process data will most often originate in the process control system and/or historian, and it is most often desirable to bring this into System 1 via Modbus or OPC. However, it is also possible to “hardware” process signals directly into compatible Bently Nevada hardware as 4-20mA, 1-5 Vdc, and other supported signal formats. In some instances, such as when a signal is not present in the DCS, this can be more economical than going through the process control system and using a digital communications protocol.

System 1 is a client-server application. The server applications are designed to run on compatible Microsoft Windows Server operating systems. The client applications are “thick” and do not require server versions of Microsoft operating systems. However, they can be run on server versions of the OS when the server and client will reside on the same machine as an engineering workstation.

There have been two primary versions of System 1 as follows:

Marketplace name	Release date	Version numbers	Lifecycle phase
System 1 Classic 	2000	1.X through 6.X	3
System 1 	2017	17.X and higher	1

Not all hardware natively supported under *System 1 Classic* is currently supported in System 1. As a migration path for customers with *System 1 Classic* that are using hardware not supported in System 1, an application called *System 1 Classic Connector* (Bently Nevada p/n 3071/60 and /61) is available. This allows customers to retain *System 1 Classic* for connectivity to older hardware while accessing the data through System 1 and its more modern and feature-rich display client as shown in the figure below.



Once the customer has upgraded their hardware to systems natively supported by System 1, their Classic Connector and *System 1 Classic* installations can be entirely replaced by a current version of System 1 and the infrastructure to the left of the dotted line in the figure above can be retired.

The hardware that will not be supported in System 1 is limited to systems that are near the end of their recommended service life and due for replacement anyway. The table on the following page provides a comprehensive summary of all systems supported under System 1, *System 1 Classic*, and via the Classic Connector. Legacy COMMTEST Ascent software is also included to show devices that can be migrated to System 1 complete with their historical data.

Hardware platform	Hardware lifecycle phase	Hardware lifecycle phase			
		Supported in System 1 (v21.1 or later)	Supported via 6.X Connector System 1 v20.2 or later	Supported in System 1 Classic (version 6.X)	Supported in Ascent 2015
3500 TDI	P1	●	●	●	
Trendmaster™ DSM	P1	●	●	●	
TDISecure	P3	●	●	●	
Orbit 60	P1	●		Note 1	
2300	P1	●		Note 1	
vbOnline Pro	P1	●		Note 1	
vbOnline 16 (and TurningPoint equivalent)	P4	●		Note 1	●
vbOnline 32 (and TurningPoint equivalent)	P4	●		Note 1	●
3701/40, /44, /46	P1	●		Note 1	
SCOUT100 series	P1	●		Note 1	●
SCOUT200 series	P1	●		Note 1	
vb5,6,7,8, vbBalancer, vbBalancer+	P1	●		Note 1	●
COMMTEST200 series	P1	●		Note 1	
Snapshot™ CE	P5	Note 2		●	
Snapshot™ IS	P5	Note 2		●	
Snapshot™ Clipboard	P5	Note 2		●	
TDXnet	P5	Note 3	●	●	
3300 TDe	P5	Note 4	●	●	
3500 ENCORE	P4	Note 4	●	●	
Essential Insight.mesh	P5	Note 5	●	●	
1701 FieldMonitor™	P3	Note 6	●	●	
Ranger	P5	Note 7			●
Ranger Pro	P1	●			

Notes:

1. These products are supported natively in System 1 and will not be supported in *System 1 Classic*. *System 1 Classic* is a P3 product and is sustained with bug fixes and security patches only—not functionality upgrades.
2. Recommended replacement is COMMTEST or SCOUT200 series.
3. Recommended replacement is TDISecure or replacement of underlying protection system with one that has integrated condition monitoring. *System 1 Classic Connector* can be used in the interim.
4. Recommended replacement is Orbit 60. *System 1 Classic Connector* can be used in the interim.
5. Recommended replacement is Ranger Pro. *System 1 Classic Connector* can be used in the interim.
6. Recommended replacement is Orbit 60. *System 1 Classic Connector* can be used in the interim.
7. Recommended replacement is Ranger Pro. Although Ranger hardware is not supported, its historical data can be imported to System 1 using the Ascent-to-System 1 platform upgrade utility, SW part number 3071/65 where AA=02 and FF=02.

6.2 Bently Performance for System 1

(2019 – Present)
OS: MS Windows

This is Bently Nevada's fourth-generation performance monitoring platform and is tightly integrated with System 1. It provides functionality similar to *Bently Performance SE* (see 6.3), but is being actively enhanced to keep pace with customer requirements. It was released in v19.1 of System 1.



6.3 Bently Performance SE

(2001 – present)
OS: MS Windows

This is Bently Nevada's third-generation performance monitoring platform and is tightly integrated with *System 1 Classic*. It was released in 2001, concurrent with v2.0 of *System 1 Classic*. The SE suffix designates "System Extender" and was one of several add-on packages available for *System 1 Classic*. It is a mature product and is no longer being enhanced.

Enhancement efforts are instead directed to the version of the product compatible with System 1 v19.1 and later (see 6.2).



6.4 Decision Support for System 1

(2020 – present)
OS: MS Windows

This software provides functionality similar to the classic version (see 6.5) but it is being actively enhanced to deliver additional functionality that improves upon that in *Decision Support for System 1 Classic*. It was released with v20.1 of System 1.



6.5 Decision Support for System 1 Classic

(2003 – present)
OS: MS Windows

This software is similar in concept to MCM2000 (see B.12⁷) but works with (and is tightly integrated to) *System 1 Classic* instead. It was released with v3.0 of *System 1 Classic* in 2003. It is today a mature product and is no longer being enhanced. Development effort is now focused on *Decision Support for System 1* instead (see 6.4).

7 The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

6.6 Bently DocuView SE software

(2003 – present)
OS: MS Windows

This is a System Extender for *System 1 Classic* that allows the user to create links to images, documents, and any other type of file associated with an asset. For example, the user might click on a machine train in their System 1 hierarchy and wish to see cross-sectional diagrams, photos, or OEM specifications in PDF format, and all that is needed to view the files is a PDF reader program. Similar functionality is planned for System 1, but is not yet available.



6.7 3500 data acquisition/display software

(1999 – present)
OS: MS Windows

This software provides communications between a computer and the Rack Interface Modules (RIMs) on one or more 3500 racks, allowing display of current values, statuses, and trends. It does not allow display of any dynamic (waveform) data and is intended primarily for operators that would normally look at the front panel display of a monitor. It is more common for the same information to be brought into a plant control system (such as a DCS) via Modbus and the same information displayed and trended directly on the process control HMI. Most installations of 3500 in the last decade have used the Modbus-to-DCS approach or use a basic instance of System 1 that is accessible by control room operators.



6.8 COMMTEST Ascent software

(2003–Present)
OS: MS Windows



This software came to Bently Nevada as part of its acquisition of COMMTEST in 2011. The current version is Ascent 2015 (v15.1). It supports the following COMMTEST hardware:

- vb5, vb6, vb7, vb8, vbBalancer, vbBalancer+, SCOUT100, and SCOUT140 data collectors
- vbOnline 16 and vbOnline 32 data acquisition instruments (not vbOnline Pro)
- Ranger wireless systems⁸ (not Ranger Pro)

Users are advised to upgrade to System 1 using part number 3071/65 where options BB=02 and FF=02. This includes a special software utility that automates the importation of an Ascent database into System 1, providing an engineered migration path for vbOnline 16/32⁹, vbX portable instruments, and SCOUT portable instruments.

⁸ Users of legacy Ranger wireless systems must replace their hardware with Ranger Pro. Legacy Ranger components are not supported under System 1.

⁹ Although vbOnline 16 and vbOnline 32 can stream data to System 1, they cannot be configured from within System 1. Ascent software must be used for configuration changes.

6.9 ADRE® Sxp

(2005 – present)
OS: MS Windows



ADRE (Automated Diagnostics for Rotating Equipment) is a stand-alone system and is not integrated with System 1. It is used when more than 4 channels of simultaneous data acquisition are required and either the machine has no installed condition monitoring system, or the installed system is not able to acquire adequate data for the necessary diagnostics (such as a third-party system that cannot collect data in parallel, cannot collect transient data, etc.). The current-generation ADRE system was introduced in 2005 and consists of ADRE SXP Software and a companion portable data acquisition unit called the 408 DSPi (Dynamic Signal Processing instrument). Users of older ADRE systems (described below) are encouraged to upgrade to ADRE Sxp software and 408 DSPi hardware.

The original ADRE system was introduced in 1980 and consisted of numerous benchtop instruments such as oscilloscopes, tape recorders, amplifiers, spectrum analyzers, pen plotters, vector filters, and others. It ran on an HP personal computer with a proprietary HP operating system. Its purpose was to assist machinery diagnostic engineers with the playback and reduction of data (recorded on magnetic reel-to-reel tape) into suitable plot types such as spectra, orbits, shaft centerline, overall and filtered trends, polar, bode, and others. This process was very tedious and ADRE simplified things by automating many of those tasks. By the time ADRE 3 appeared in 1988, it was running on a DOS-based personal computer and the various benchtop equipment had consolidated to a single piece of hardware: the 108 Data Acquisition Instrument (DAI). The next generation of the product was called ADRE for Windows and was released in 1993 concurrent with a new data acquisition unit, the ADRE 208 DAIU (Data Acquisition Interface Unit). ADRE for Windows software was also backwards compatible with the 108 DAI.

6.10 Bently Balance software

(2003 – present)
OS: MS Windows



This is a stand-alone machinery balancing application running under most Microsoft Windows operating systems. It accepts ADRE Sxp and *System 1 Classic* databases, as well as data from any other system that can be exported in spreadsheet (.csv) format using a provided template for Microsoft Excel. It performs balancing calculations for up to 16 correction planes and 32 measurement planes under multiple speed and load conditions and is able to calculate optimized solutions even when the number of measurement planes differs from the number of correction planes. The software provides an additional level of functionality when balancing particularly complex machines, complementing the integrated balancing features in our route-based portable data collection instruments intended for machines where 1- and 2-plane balancing is sufficient.

7 Machinery protection systems

Bently Nevada machinery protection systems are distinguished from purely condition monitoring systems in that a protection system contains hardware alarming capabilities intended for auto-shutdown (machinery protection) purposes. Such systems use either hardware relays or equivalent “soft relay” functionality via high-speed digital communication with a control system that provides the auto-shutdown functionality. Only a handful of Bently Nevada protection systems use digital communications rather than conventional relays; namely, the 2201, 1701, and 3701 ADAPT platforms. All others use relays. Some customers prefer to use so-called “recorder outputs” from the protection system (i.e, 4-20mA or 1-5 Vdc proportional signals) into a PLC, DCS, or other controller where the alarm setpoints and alarming comparators are maintained. However, best practice is generally considered to be use of hardwired relay connections to the control system rather than use of the recorder outputs.

Digital communication interfaces such as Modbus and OPC are not considered suitable for use in a machinery protection loop and are thus discouraged. However, the digital interfaces of the 2201, 1701, and 3701 ADAPT platforms were specially engineered for highly reliable, high-speed communication with the host control system and stand as notable exceptions to this rule. Although Orbit 60 has conventional relay modules, it has also been engineered such that its digital communications interface can be used as part of a machinery protection loop if desired.

In contrast, pure condition monitoring systems do not contain relays or digital communications intended for machinery auto-shutdown (protection) purposes. The alarms and data from such systems are intended for ultimate use by personnel—not machinery control systems or ESDs—to provide more informed decisions in manually intervening to shut down the asset, plan maintenance on the asset, conduct an inspection of the asset, correct root cause issues, collect supplementary data from the asset manually via a portable data collector, etc. The key is that human beings are involved in actions taken from condition monitoring systems, while the actions of a machinery protection system can occur automatically to trip the unit and protect it from impending (or further) damage.

All current Bently Nevada machinery protection systems that are not in P5 have the ability for integrated condition monitoring¹⁰ without external hardware. Thus, there are no machinery protection offerings that do not offer some level of connectivity to our System 1 plantwide software.

Cybersecurity concerns for some customers require very strict segregation of the machinery protection and condition monitoring functions. Thus, separate condition monitoring hardware that connects to the protection system only via analog connections is sometimes required, precluding the possibility of malicious access to or disabling of the protection system via the condition monitoring system even though such a topology introduces more hardware, wiring, and associated complexity. Such systems are discussed in section 8.4 of this Guide. The Orbit 60 protection system, however, uses an innovative, cybersecure architecture that is able to combine the protection and condition monitoring functionality into the same device while providing the requisite segregation for full security. This platform is discussed in more detail in section 7.1.

¹⁰ The only exception is the 1900/65A which does not have integrated condition monitoring capabilities. It does have the ability to supply static (not waveform) data to System 1 and/or a control system such as a DCS via Modbus communications for its measured vibration and temperature variables. Refer to section 7.7 for additional information.

7.1 Orbit 60

(2020 – Present)

Connectivity: System I only (not System I Classic)



Orbit 60 is Bently Nevada’s flagship machinery protection system and was released to the market in 2020. Like most flagship monitoring systems Bently Nevada has released previously, it currently contains approximately 85% of the channel types available in the predecessor system (3500). Over the next several years, specialty channel types (hydro, reciprocating compressor, overspeed, etc.) will be released as well to eventually meet and then surpass the applications covered by the prior platform. Orbit 60 is intended for critical machinery applications previously addressed by 3500, 3300, 7200, and others. In time, it will also provide rolling element bearing and gearbox monitoring functionality currently only available in the 3701 ADAPT platform. For a list of specific channel types supported in Orbit 60 at this time, consult the table below. You are also advised to contact your local Bently Nevada sales professional who will be able to assist you in determining whether Orbit 60 or another Bently Nevada platform is the best option for your needs, particularly if you already have an installed base of other Bently Nevada monitoring systems and/or special channel types that are not yet supported in Orbit 60.

3500 Module	Measurement(s)	Equivalent Orbit 60 functionality
/15	Power Input	●
/22	Integrated Condition Monitoring	●
/25	Keyphasor® phase reference	●
/32 & /33	Relay outputs	●
/40 & /42	Standard Vibration and Position	●
/44	Aeroderivative Gas Turbines	●
/45	Extended Turbine Supervisory Information (TSI)	Planned for late 2021
/46	Hydroturbines/Generators	Planned for 2023
/50	Speed	●
/53	Overspeed	To be determined
/60 & /61	Temperature (RTD and TC)	●
/62	Process Variable	●
/63	Hazardous Gas Detection	To be determined
/64	Dynamic Pressure	●
/65	16-ch temperature (primarily recip valve temp)	Planned future release (2022) with full suite of reciprocating compressor measurements
/70	Reciprocating Compressor Impact/Impulse	
/72	Reciprocating Compressor Rod Drop/Position	
/77	Reciprocating Compressor Cylinder Pressure	
/XX	Custom user-defined channel type	Planned future release (late 2021)

The Orbit 60 is our first machinery protection platform to provide integrated condition monitoring capabilities while fully isolating those capabilities from the protection system to address stringent cybersecurity requirements. Prior architectures, such as those in 3300 and 3500, integrated the functions of condition monitoring and protection in ways that could not fully segregate the two in a cybersecure fashion. The only option was to use separate condition monitoring hardware connected to the underlying machinery protection system using only analog connections, precluding the possibility for any cybersecurity vulnerabilities via digital communications between the two systems. This resulted in redundant hardware, additional wiring, and additional cabinet space. The Orbit 60 platforms delivers cybersecure segregation without necessitating additional wiring or cabinet space, allowing machinery protection and condition monitoring to co-exist in the same hardware without enlarging its footprint.

Refer to section 8 for additional information about Orbit 60’s condition monitoring functionality relative to other Bently Nevada systems.

7.2 3500

(1995 – Present)

Connectivity: System 1 and System 1 Classic



The 3500 Series was introduced to the market in 1995 and [will continue to be fully supported by Bently Nevada for many years](#). Early versions of 3500 series required external condition monitoring hardware—called communications processors—that gave connectivity to various generations of Bently Nevada condition monitoring software including Data Manager 2000 (DM2000) and System 1. However, some were only compatible with DM2000 and not System 1. The table below summarizes the connectivity to System 1.

3500-compatible communications processor type	Internal/external to 3500 rack	Supported by	
		System 1 Classic	System 1
DDIX/SDIX	External		
TDIX	External		
TDXnet	External	●	
TDISecure™	External	●	●
TDI	Internal	●	●

Early versions of 3500 racks (1995 through July 1999) had a different backplane that was not compatible with the TDI module. Later versions of 3500 racks (July 1999 to present) incorporate an advanced backplane that supports the TDI module, eliminating the need for an external communications processor. These newer racks with backplanes supporting TDI can be identified by the presence of an embossed Bently Nevada orbit logo on the left-hand side of the rack's plastic bezel. These racks also require newer versions of monitor modules denoted by "M" (such as 3500/42M) in order to make their full dataset accessible to the TDI module. If you have an older 3500 rack, it will not be compatible with System 1 unless the TDISecure™ or TDXnet external communication processors are used. If you have a newer 3500 rack, the TDI module (or TDISecure™) can be used to communicate with System 1.

There are other factors¹¹ that influence the connectivity of 3500 racks to System 1 such as the firmware versions used in monitoring modules. If your 3500 rack is not currently connected to System 1 or *System 1 Classic*, you are encouraged to consult your Bently Nevada sales or application solutions professional on a case-by-case basis for detailed guidance on any necessary upgrades and whether replacement with a newer platform (such as Orbit 60) is recommended. In some cases, the costs to replace a 3500 rack with Orbit 60 versus upgrading it for System 1 connectivity will make replacement a more attractive option. Refer to section 8 for additional information about the 3500 system's condition monitoring functionality relative to other Bently Nevada systems.

¹¹ Refer to Appendix A for additional information.

7.3 3500 ENCORE

(2010 – 2021)

Connectivity: System 1 and System 1 Classic



The 3500 ENCORE was a retrofit solution that allowed installed 3300 series monitoring systems to be upgraded to use newer 3500-based modules without installing a completely new chassis and I/O modules. The ENCORE modules are in a different physical form factor than the modules in a standard 3500 rack, and they required the 3300 rack to be retrofit with a new backplane that was physically and electrically compatible with the ENCORE modules. ENCORE and legacy 3300 monitoring modules could not be mixed within the same rack, thus the appearance of ENCORE racks retained almost no 3300 identity when viewed from the front with exception of the rack bezel. Rather than upgrade 3300 racks, many customers elected to simply replace their 3300 racks entirely with 3500 racks than the hybrid approach of a legacy 3300 rack with newer ENCORE modules. As a result, a relatively small number of 3500 ENCORE systems are in use globally. As the ENCORE system is now in phase 4 (repair only) and is slated to reach phase 5 in late 2021, customers are encouraged to begin planning a migration to Orbit 60. The 3500 ENCORE offers condition monitoring functionality identical to 3500 series systems equipped with TDI or TDIsecure. Refer to section 8 for additional information about this functionality relative to other Bently Nevada systems.

7.4 2300

(2015 – present)

Connectivity: System 1 only (not System 1 Classic)



The 2300 is a 2-channel (plus speed) monitor designed to be mounted locally at the machine. It is intended for pumps and other general-purpose machines that can be addressed by a monitor with a reduced feature set compared to Orbit 60, 3500, and ADAPT 3701. The product supports proximity probe, accelerometer, velocity sensor, magnetic speed pickup, proximity switch, and generic voltage process inputs. Some process sensors, such as 4-20mA sensors, may require external signal conditioning before being connected directly to a 2300 monitor's inputs, as described in the instrument's operation and maintenance manual. The 2300/20 provides 4-20 mA outputs in addition to alarm relay outputs. It is designed to replace older 1900/17 and 1900/27 monitors, which were one-channel devices, as well as for new installations where a compact 2-channel monitor is suitable. The 2300/25 is identical to the 2300/20 but features an interface to our Trendmaster SPA bus cabling instead of 4-20mA outputs. It is designed to replace older 1900/15 and 1900/25 monitors in applications where connectivity between the local monitor and a Trendmaster bus is required. Refer to section 8 for additional information about the 2300's condition monitoring functionality relative to other Bently Nevada systems.

7.5 3701 ADAPT

(2010 – present)

Connectivity: System 1 only (not System 1 Classic)

The 3701 ADAPT series is provided in configurations intended for specific machine types or applications. It can coexist in a System 1 plantwide ecosystem with other hardware such as 3500, Orbit 60, 2300, and Ranger Pro. The table below summarizes the six different models available.



Model	System 1 support	Description and notes
3701/40 Machinery Dynamics Monitor	System 1 (not <i>SI Classic</i>)	This model provides advanced capabilities for machines using rolling element bearings and/or complex gearing that can benefit from its advanced signal processing and alarming compared to 3500, 2300, or 1900/65A monitors. In time, the Orbit 60 platform will provide channel types with equivalent or better capabilities, but for now, the 3701/40 Machinery Dynamics Monitor is recommended for such machine types.
3701/44 Aero Gas Turbine Monitor	System 1 (not <i>SI Classic</i>)	This model is designed for aeroderivative gas turbines and their driven equipment and is used by OEMs and packagers desiring a form factor that allows skid mounting in a junction box rather than a 19" rack such as 3500 ¹ . OEM aeroderivative gas turbines supported by 3701/44: <ul style="list-style-type: none"> • GE: LM500, LM1600, LM2500, LM5000, LM6000 • Rolls-Royce: RB211, Avon • Pratt & Whitney: GG3, GG4, FT4, FT8 • Others: consult your local Bently Nevada sales professional
3701/46 Hydro Monitor	System 1 (not <i>SI Classic</i>)	This model is designed primarily for smaller hydropower applications where a limited feature set is adequate. In contrast, the 3500 series platform targets larger hydro machine sizes with a more extensive feature set such as support for air gap measurements, state-based measurements, and temperature inputs. Your Bently Nevada sales and application solutions professionals can assist you in the proper selection of 3701 ADAPT versus our other platforms.
3701/55 ESD	Static data only ²	This model is designed to act as a safety PLC for Emergency Shutdown (ESD) applications on turbomachinery and incorporates a triple modular redundant (TMR) architecture. It can provide both overspeed protection capabilities using redundant speed sensors and logic solving capabilities using discrete (logic state) inputs and process variable (4–20 mA) inputs.
3701/60 3701/60A Wind Turbine Monitor	See remarks at right	These models were designed specifically for monitoring wind turbines. They are now in lifecycle phase 5 and were replaced in 2014 by a different hardware form factor (60M100) that uses the same firmware to provide equivalent functionality but in a different physical package that is more convenient for use by wind turbine OEMs and operators. Both products are designed for connection to adapt.wind software rather than System 1. For connectivity to System 1, 60M100 hardware can receive a firmware upgrade to become 60M500. No additional wiring or hardware changes are required.
3701/68 ³ Blade Condition Monitor	See remarks at right	This model is designed for use by selected OEMs as part of a blade crack monitoring service on gas turbine compressor stages. The output goes to a remote monitoring center and is not connected to a plantwide condition monitoring system as it requires additional special knowledge for interpretation.

Notes:

1. 3500 offers similar gas turbine monitoring capabilities but in a conventional rack-based form factor.
2. Can communicate static data only to *System 1 Classic* and System 1 via Modbus TCP protocol.
3. This product is only available for sale through select gas turbine OEMs and is not sold by Bently Nevada directly to end-users.

Refer to section 8 for additional information about the 3701's condition monitoring functionality relative to other Bently Nevada systems.

7.6 1900/1X and 2X

(1992 – 2017)

Connectivity: System 1 and System 1 Classic via Trendmaster® SPA bus

This family of products consisted of single-channel monitors designed primarily for local mounting at the machine. Versions with native connectivity to a Trendmaster sensor bus (SPA) and versions without such connectivity were available.



Model	Input types	Measurements	Connectivity		Support	
			Trendmaster	4–20mA	SI Classic	SI
1900/15	Proximity probes	Radial vibration	● ¹		●	
1900/17	Proximity probes	Radial vibration		●		● ²
1900/25	200150 accelerometer ³	Seismic vibration	● ¹		●	●
1900/27	200150 accelerometer ³	Seismic vibration		●		● ²

Notes:

1. Trendmaster SPA bus cabling connects directly to the 1900/15 and 1900/25.
2. System 1 connectivity to the 1900/17 and 1900/27 requires external condition monitoring adapters such as Trendmaster Rack Buffered Output TIMs. Upgrading to the 2300 is generally recommended instead as it contains direct connectivity to Trendmaster cabling or System 1 via Ethernet.
3. The 4-wire 200150 accelerometer used with 1900/25 and 1900/27 monitors provides a differential signal intended only for use by 1900/2X monitors and selected TIMs. It is not compatible with the 2300 or any other Bently Nevada machinery protection systems.

Although System 1 supports the 1900/1X and /2X monitors to some extent, customers are advised to upgrade to the 2300 instead since it provides integrated protection and condition monitoring, is a 2-channel (plus speed) device, and because the 1900/1X and /2X monitors are in lifecycle phase 5 and thus no longer supported for spares or repairs. The condition monitoring functionality of the 1900/1X and /2X series monitors rely on their connection to a Trendmaster SPA bus. Refer to section 8 for additional information about Trendmaster’s condition monitoring functionality relative to other Bently Nevada systems.

7.7 1900/65 and /65A

(2005 – present)

Connectivity: To System 1 and System 1 Classic via Modbus communications (static data only)



This 4-channel monitor was introduced in 2005 and is used where a low-cost, basic protection solution is required for general-purpose machinery such as fans, motors, pumps, crushers, pulverizers, and even smaller reciprocating compressors where a limited suite of measurements is required. It can be used with an optional detachable display (shown) when local HMI capabilities are required, or mounted in a junction box without the display when a “blind” system is preferred and the HMI will be solely by means of a DCS or other control system using data provided via the monitor’s Modbus port. The 1900/65A is a form/fit/function replacement for the earlier model (1900/65) which did not feature trip multiply and selected other functionality. It can also be used as a replacement for the 1900/55. It accepts 4 vibration inputs (proximity, acceleration, velocity) and 4 temperature inputs (RTDs and TCs) for vibration, thrust position, speed, and temperature measurements. The monitor provides features usually found in larger platforms such as bandpass filtering, acceleration enveloping, trip multiply, adjustable alarm delays, and configurable alarm logic to drive relays under user-defined combinations of alarm statuses. When additional condition monitoring functionality is required beyond the 1900/65A’s limited capabilities, it can be connected to a Trendmaster SPA bus using Rack Buffered Output TIMs, or to a TDIsecure device. Refer to section 8 for additional information about the 1900/65A’s condition monitoring functionality as well as the other devices listed here relative to other Bently Nevada systems.

7.8 1900/55

(1995–2012)

Connectivity: To System 1 and System 1 Classic via Trendmaster® SPA bus



This 4-channel machinery protection system was used for monitoring low-speed fans such as on cooling towers and heat exchangers. It could be ordered with an optional communications card. One version allowed connectivity to a Trendmaster SPA bus. The other provided conventional 4–20mA outputs for each channel.

Because this product is in phase 5 obsolescence, customers are encouraged to replace it with the 1900/65A using a special retrofit kit¹² for that purpose. It is rarely necessary to analyze vibration waveforms from such machines and trends are generally sufficient for condition monitoring purposes. The 1900/65A provides static data to System 1 using Modbus communications, allowing vibration data to be trended. When developing problems appear on trends or alarms, a portable data collector can be used to gather additional data for diagnostics and root cause determination. The condition monitoring functionality of the 1900/55 relies on its connection to a Trendmaster SPA bus. The 1900/65A can likewise be connected to a Trendmaster SPA bus, but uses external devices called Rack Buffered Output TIMs. Refer to section 8 for additional information about Trendmaster’s condition monitoring functionality relative to other Bently Nevada systems.

7.9 3300

(1988 – 2014)

Connectivity: System 1 Classic only



The 3300 series provided functionality similar to 3500, and used a rack-based form factor, but occupied more space (2 channels per 2-inch module rather than 4 channels per 1-inch module) and was not software configurable. It featured an integral bargraph display for each channel.

Connectivity to System 1 Classic was by means of a compatible external communications processor (TDXnet) or an internally mounted version called TDe contained on the 3300/03 System Monitor module. Neither of these are supported by System 1.

Although a 3300 rack can be connected to System 1 using a TDISecure™ communications processor, it is strongly recommended to upgrade to a newer platform such as Orbit 60, 3500, or 3701 ADAPT containing native connectivity to System 1. 3300 racks are frequently in machinery protection service—not strictly condition monitoring service—and it is not advisable to continue using platforms for which spares and repairs are unavailable and which have often already been in service for 20 years or more.

¹² Consult the 1900/65A datasheet when replacing a 1900/55, using ordering option CC=04. This provides a kit to reuse the 1900/55 weatherproof housing and place the 1900/65A along with its necessary accessories into the housing.

7.10 1701

(1998 - present)

Connectivity: *System 1 Classic* only



The 1701 platform was introduced in 1998 and was similar in concept to its predecessor, the 2201, which operated as a tightly integrated subsystem of a PLC used for machinery control. Like the 3701, the system uses a terminal base form factor and compact modules without any local user interface. It is designed to be bulkhead mounted in a junction box on the machinery skid. The 1701 series is linked with its host PLC by means of a suitable network connection and supports a variety of protocols:

- Allen Bradley® Remote I/O
- ControlNet™
- DeviceNet™
- MODBUS™
- PROFIBUS™ DP
- Ethernet/IP™

All communication occurs via the network connection and the system does not provide conventional monitoring system connectivity such as hardwired relays or 4-20mA outputs. It does provide buffered output connectors on the terminal base. The user interface for the system is via the PLC's display software, often configured specifically for turbine control applications.

The 1701 can be ordered with an optional FMIM (FieldMonitor Management Interface Module) that provides condition monitoring functionality and connectivity to *System 1 Classic*. Native communications with *System 1* is not supported, but users that already have a 1701 connection to *System 1 Classic* users can interface their *Classic* database (v6.X) to a *System 1* v17.1 or later database. In many instances, however, 1701 systems have been in service for 15 years or more and when condition monitoring rather than simply machinery protection is required, retrofitting with a platform such as 3701 ADAPT or Orbit 60 will be desirable¹³. Another option is to leave the 1701 in place and use TDISecure as an external condition monitoring interface to *System 1*. Your Bently Nevada sales professional can assist you in evaluating your options and helping you select an optimal solution.

7.11 2201 Series¹⁴

(1992 - 2015)

Connectivity: *System 1 Classic* only via TDXnet communications processor (see D.3¹⁵)



This system was almost identical in concept to the 1701 but used conventional rack-based cards and backplane communications rather than network communications as with 1701. The 4-channel cards were designed to fit in an Allen-Bradley® PLC-5 1771 chassis. A special backplane fit over the top of the 1771's backplane, allowing the 2201 cards to communicate with one another and with the PLC-5 controller. Most of these systems were shipped on Solar® gas turbines but a few were used in other installations by customers with PLC-5 control systems. There were also special low-speed cards available for monitoring hydro turbine generators. The same recommendations and considerations for upgrading 1701 systems pertain to 2201 systems. Refer to section 7.10.

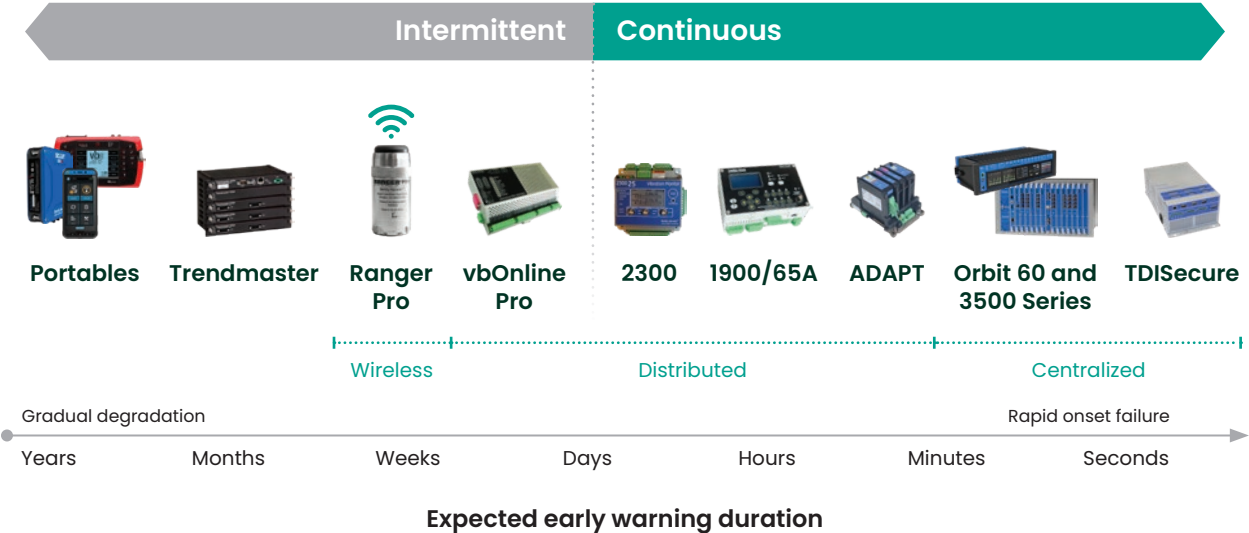
¹³ The majority of 1701 installations are on Solar® gas turbines but can also be found elsewhere. The channel types available in the 1701 are available in platforms such as Orbit 60 and 3500, but because the 1701 is often tightly integrated with the control system, replacement is not as straightforward as with a stand-alone system that does not impact the machinery controller. The 1701 also features modules with integral Proximito® signal conditioners, allowing direct connection of proximity probes without need of an external Proximito. When replacing a 1701 system with this option, external Proximito devices will need to be retrofit. Consult your Bently Nevada sales professional for guidance.

¹⁴ This system could be connected to *System 1 Classic* by means of a TDXnet communications processor. See Appendix D in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

¹⁵ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

8 Online condition monitoring systems

As discussed in section 2 of this guide, online condition monitoring systems range from those that collect and report data continuously to those that collect and report data only intermittently at discrete intervals—either based on user-configured times (hourly, daily, etc.) or based on user-configured events (machine exceeds an alarm threshold, machine starts or stops, machine changes state, etc.). The capabilities in an online condition monitoring system should be selected based on the types of failure modes expected on the asset, how rapidly the failures can progress (seconds, minutes, days, months), and the type of protection system present (if applicable). Below, the Bently Nevada product portfolio is shown as a function of the time between minimum measurable fault detection and potential functional failure of the asset. As can be seen, those assets for which a malfunction can progress to functional asset failure in seconds generally require a more expensive protection system and faster condition monitoring data acquisition intervals.



In some instances, the protection system’s inherent CM capabilities can be augmented by a different condition monitoring system. The most notable example is the use of a portable data collector connected to the buffered outputs. Another example is the 1900/65A where a Trendmaster system could be interfaced using Rack Buffered Output (RBO) TIMs. However, this is rarely an economical solution. For all other protection systems (Orbit 60, 3500, 3701 ADAPT, 2300) the integrated condition monitoring capabilities will generally be appropriate. Indeed, the protection system should be selected by considering not just its protection feature set, but also its condition monitoring feature set as the increased costs of connecting an external condition monitoring system will generally eclipse the costs of a more expensive protection system with the necessary integrated condition monitoring capabilities. Your Bently Nevada sales and application solution professionals can assist you in evaluating the various options and selecting a product that is optimal for your needs.

The table on the following page provides a summary comparison of selected features in various Bently Nevada online condition monitoring systems. Those in green integrate the protection and condition monitoring functionality. The others are stand-alone condition monitoring platforms. The companion Application Note *Online Periodic Condition Monitoring* (BHCS38948) should be consulted for more detailed information on these platforms, their capabilities, and selection criteria for specific machine and bearing types.

Selected condition monitoring capabilities for Bently Nevada online systems with System 1 connectivity

	Ranger Pro	vbOnline Pro	Trendmaster	TDISecure	2300	1900/65A ¹	ADAPT 3701/4X	3500	ORBIT 60
Asynchronous dynamic sampling	●	●	●	●	●		●	●	●
Synchronous dynamic sampling		●	●	●			●	●	●
Asynchronous Demod/Enveloping sampling	●	●	●		●		●		●
Synchronous Demod/Enveloping sampling		●					●		●
Direct (true peak)	●	●	●	●	●	●	●	●	●
Direct (RMS)		●	●	●	●	●	●	●	●
Spectrum Bands (from the device)			●	●	●	●	●	●	●
Spectral Averaging	4		8						
Normal Trended variable min collection interval (seconds)	600	30	Note ²	1	10	1	1	1	1
Normal Dynamic min collection interval (minutes)	360	10	Note ²	10	10	Note ¹	10	10	10
State change data set		●		●			●	●	●
Alarm data set		●	●	●			●	●	●

Notes:

1. No dynamic data is available from the 1900/65A unless separate condition monitoring hardware such as TDISecure or Trendmaster is connected. Static data is available via the Modbus interface and is updated every second. There is no upper limit on the max collection interval as this is set within the host DCS or control system. Refer to section 8.9 for additional information.
2. The Trendmaster architecture takes approximately 15 seconds per point to collect data from each SPA (Signal Processing Adapter) line. Thus, if 100 sensors are connected to the SPA line, 1500 seconds (25 minutes) will elapse between waveform and trended variable collection intervals. The collection interval is thus a function of the number of connected sensors on that SPA line.

When a protection system is used, condition monitoring connectivity to System 1 is as per the table below:

Platform	Method
Orbit 60	Inclusion of one or two condition monitoring processor modules—separate from protection processors. Condition Monitoring is enabled via licensing in System 1.
3500	Inclusion of Transient Data Interface (TDI) module (3500/22M). Condition Monitoring is enabled via licensing in System 1.
3701	Condition Monitoring is enabled via licensing in System 1; no additional hardware is required.
2300	Condition Monitoring is enabled via licensing in System 1; no additional hardware is required.
1900/65A	Condition monitoring beyond trending of selected variables and status available via Modbus requires separate hardware, such as Trendmaster or TDISecure.

When a protection system is not used, there are three primary options for online condition monitoring as follows:

Data acquisition intervals	Remarks
Trendmaster (wired or hybrid¹)	
Configurable: <ul style="list-style-type: none"> • Minimum²: 6 seconds per connected sensor (waveforms and static data) • Maximum: depends on signal processing configuration such as lowest frequency collected in spectrum, number of spectral averages, etc. Could be as much as several minutes • Typical: 15 seconds 	A sensor bus with 120 connected sensors and configured to scan all 120 sensors before repeating would typically result in a collection interval of 1800 seconds (30 minutes) for each sensor. Most customers do not configure the system for the shortest collection intervals possible and instead configure the system to take only several readings per day—such as every 6 hours (4 readings per day). This is often sufficient to proactively detect developing problems in the class of machinery monitored by Trendmaster.
Ranger Pro (wireless)	
Configurable: <ul style="list-style-type: none"> • Minimum: <ul style="list-style-type: none"> – 6 hours (waveforms) – 10 minutes (static data) • Maximum: <ul style="list-style-type: none"> – 672 hours (waveforms) – 6 hours (static data) • Typical: <ul style="list-style-type: none"> – 24 hours (waveforms) – 1 hour (static data) 	The Trendmaster system was developed in the late 1980s at a time when industrial wireless sensing was not a viable condition monitoring option. With the release of the Ranger Pro system, customers that do not require the synchronous sampling capabilities of Trendmaster (X-Y probes with Keyphasor® or individual sensors with Keyphasor®) will often prefer to use Ranger Pro instead due to its lower installation costs and similar or superior asynchronous signal processing capabilities (3200-line spectrum, Peak Demod, fmax up to 10 kHz).
vbOnline Pro (wired or hybrid¹)	
Configurable: <ul style="list-style-type: none"> • Minimum: <ul style="list-style-type: none"> – 10 minutes (waveforms) – 30 seconds (static data) • Maximum: <ul style="list-style-type: none"> – 30 days (waveforms) – 30 days (static data) • Typical: <ul style="list-style-type: none"> – 4 hours (waveforms) 	vbOnline Pro is a 12-channel device (plus two Keyphasor® inputs) that uses persistent, wired sensor connections ³ and is capable of collecting data at faster intervals than Ranger Pro or Trendmaster. vbOnline Pro supports up to 12,800 spectral lines, fmax of up to 40 kHz, and collection of up to 12 channels in parallel ⁴ . Like Trendmaster, it is able to collect synchronous data, but not from X-Y probe pairs as it is only compatible with constant-current accelerometer input types ⁵ . Because it only supports accelerometer vibration inputs, it is primarily intended for rolling element bearing machinery and gearboxes and is used when the collection intervals of Trendmaster or Ranger Pro are too long, or when the superior signal processing capabilities of vbOnline Pro for rolling element bearings or gears are required.

Notes:

1. A hybrid system consists of hardwired sensors to the data acquisition hardware and then wireless network links between the hardware and the System 1 server.
2. For a typical vibration point in Trendmaster, 15 seconds is a good rule-of-thumb to collect the desired data, but can be longer or shorter depending on configuration details such as machine speed, number of spectral averages, synchronous versus asynchronous data collection, etc. Extremely slow-speed machines require long sample times to collect low frequency data. Spectral averaging will also increase the time to collect data as multiple spectra must be collected and averaged versus only a single spectrum.
3. vbOnline Pro does not currently support connection to protection system buffered outputs as an input source.
4. Ranger Pro can only collect a single channel at a time; Trendmaster up to two-channels channels (plus KPH) at a time.
5. Supported Keyphasor® sensors for synchronous sampling include Bently Nevada proximity probes and selected third-party proximity switches. Up to two Keyphasor inputs are allowed per vbOnline Pro.

8.1 Orbit 60 with CM processor(s)

Connectivity: System 1 only (not System 1 Classic)

The Orbit 60 Series began shipping in 2021 and features Bently Nevada's most advanced condition monitoring capabilities. In instances where an underlying, older protection system is in place, Orbit 60 can be used initially only for condition monitoring by connecting to the buffered outputs of the underlying protection system, and then later upgrading to protection functionality by adding protection processors and relays. This can be an effective strategy when replacement of the machinery protection system needs to wait for an opportune time—such as a planned maintenance outage of the machine—but advanced condition monitoring and System 1 connectivity is needed in the interim. In this sense, Orbit 60 can be used in a manner similar to TDISecure (see section 8.4) and then the protection functionality can be enabled at a later date.

8.2 3500 with TDXnet

Connectivity: System 1 Classic only

The 3500 series system was released in 1995 and until mid-1999, required an external communications processor (CP) such as TDXnet (see Appendix D¹⁶). The TDXnet CP sampled the analog waveform signals available at the rack's buffered outputs and collected static data such as alarm statuses and current values using digital information already computed in the 3500 rack. There was thus an analog connection to the buffered outputs (available at a DYNAMIC connector on the back of the 3500 rack) and a digital connection to the status and current values (available at a STATIC connector on the back of the 3500 rack). The TDXnet in turn provided communications with *System 1 Classic*. TDXnet is not supported in System 1 (v17.1 and later) without use of the Classic Connector “middleware”. The Classic Connector is designed as an interim bridging strategy until such time as 3500 racks can be replaced with Orbit 60. This is generally preferable to upgrading older 3500 racks to use TDI (see 8.3).

8.3 3500 with TDI

Connectivity: System 1 and System 1 Classic

In mid-1999, the 3500 series was upgraded with a new backplane, new M-series¹⁷ modules, and a new version of the 3500 Rack Interface Module (RIM) that carried model 3500/22M. This eliminated the need for an external communications processor such as TDXnet (see Appendix D¹⁶). By inclusion of a Transient Data Interface (TDI) in the 3500/22M Rack Interface Module, the condition monitoring functionality was entirely self-contained in the rack. If you have a newer 3500 rack supplied after July 1999, System 1 connectivity is generally straightforward and consists merely of turning on the TDI functionality resident in the 3500/22M RIM and obtaining the proper license in System 1. In some cases, the firmware in modules must be upgraded and M-series modules must be supplied. Retrofitting an original 3500 rack with this enhanced functionality can be quite involved and as most such 3500 racks are now 20 years old, a better option is usually to replace the racks with Orbit 60 or to use an external condition monitoring interface such as TDISecure (see section 8.4).



¹⁶ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

¹⁷ M-Series modules are those with Machinery Management enabled. This means they are capable of streaming dynamic (waveform) data to System 1. Not all modules are capable of dynamic data and are thus not available in M-Series designations. Refer to Appendix A for additional details.

8.4 TDISecure

Connectivity: System 1 and System 1 Classic

TDISecure is an external communications processor that delivers similar capabilities to TDI (see 8.3) but can be used with any machinery protection system, whether Bently Nevada or another supplier. In instances where a Bently Nevada rack has engineered Static and Dynamic connectors (such as 3300, 2201, and 3500), TDISecure can be connected without need of additional wiring. In instances where these pre-engineered connectors are not available, it can use the buffered outputs, relays, and 4-20mA outputs of any monitoring system. A field wiring drawing package showing connectivity to 3500, 3300, 1900/65A, and third-party monitoring systems is available as Bently Nevada document 102M7347.



8.5 1701 with FMIM

Connectivity: System 1 Classic only

The 1701/22 FieldMonitor Management Interface Module (FMIM) is an optional module that resides in a 1701 terminal base and provides communications with *System 1 Classic* and Data Manager 2000 software. It is not currently supported in System 1 except by means of the Classic Connector (see 6.1). It provides functionality similar to a TDXnet communications processor and can handle both dynamic and static data under steady-state and transient conditions. The 1701 terminal base also contains STATIC and DYNAMIC connectors for use with external communications processors such as TDISecure as well as several of those listed in Appendix D¹⁸.



8.6 2300

Connectivity: System 1 only (not System 1 Classic)

The 2300 provides native connectivity to System 1 via its Ethernet port and does not require additional hardware.



8.7 3701 ADAPT

Connectivity: System 1 only (not System 1 Classic)

The 3701 ADAPT series¹⁹ provides native connectivity to System 1 and does not require additional hardware. It can collect data under both steady-state and transient (changing speed and operating state) conditions. It is particularly well-suited for machinery using rolling element bearings and/or gearboxes due to its superior signal processing capabilities (3701/40). It is also particularly well-suited for aeroderivative gas turbines (3701/44).



¹⁸ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

¹⁹ Models 3701/40, 3701/44, and 3701/46 only. Models 3701/55, 3701/60, 3701/60A, and 3701/68 do not provide communications with System 1 except static data via Modbus. Models 3701/60 and 3701/60A are used on wind turbines and communicate only with adapt.wind software.

8.8 Ranger Pro

Connectivity: System 1 only (not System 1 Classic)

The Ranger Pro is a truly wireless condition monitoring system that features stand-alone, battery powered sensors capable of making combined vibration and temperature measurements and communicating wirelessly with an appropriate network gateway. Models with either uniaxial or triaxial embedded accelerometers are available along with integral temperature measurement. The system supports both ISA100 and WirelessHART™ wireless standards and can be intermixed with other wireless sensors (flow, level, pressure, etc.) from other vendor systems conforming to these industry standards. The Ranger Pro system is often suitable for applications that would have previously been addressed by Trendmaster (see 8.13) because it can be configured to take readings in intervals as short as every 10 minutes yet eliminates the installation costs associated with hardwired systems. The system replaces the older COMMTEST Ranger wireless products (see D.¹²⁰) that were only supported in Ascent software. When upgrading from Ranger hardware and Ascent software to Ranger Pro hardware and System 1 software, the historical data from Ranger that is resident in the Ascent database can be retained and migrated into System 1. Software upgrade p/n 3071/65 with BB=02 and FF=01 is available specifically for performing such migrations and covers COMMTEST Ranger wireless products, COMMTEST portable data collector products, and COMMTEST vbOnline 16/32 products.



8.9 1900/65 and /65A

Connectivity: System 1 and System 1 Classic via Trendmaster ProTIM and DSM hardware/infrastructure

This 4-channel monitor provides protection capabilities only and is primarily intended for customer that need machinery protection but will employ only offline condition monitoring strategies using a portable data collector and connecting to the 1900/65's programmable buffered output. The use scenario is to send overall and selected frequency band data to a DCS, PLC, or other process automation system via Modbus communications where the data can be trended. When an alarm from the 1900/65 or an undesirable trend occurs, personnel can go to the device, collect additional data with a portable instrument, and conduct diagnostics. There may be some instances in which connectivity to an online condition monitoring system is desired. The Bently Nevada Trendmaster system can be used for this purpose by means of a buffered output ProTIM (Transducer Interface Module), part number 200200-07-07 (DIN rail-mount version) or 200250-07-07 (conduit-mount version). Trendmaster has the ability to sample 3 points in parallel (X sensor, Y sensor, Keyphasor®) which is especially useful on machinery monitored with X-Y proximity probes and a phase reference sensor. Trendmaster is also suitable for rolling element bearing machinery monitored with seismic sensors. Refer to section 8.13 for additional information.



20 The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

8.10 vbOnline Pro (60M500)

Connectivity: System 1 (not System 1 Classic)

This 12-channel system (10 channels of hardwired IEPE accelerometers and 2 channels of hardwired phase or speed sensors) is designed for machinery that can benefit from condition monitoring measurement intervals as small as every 30 seconds (overall static data) and every 10 minutes (waveform data). vbOnline Pro is purely for condition monitoring and does not provide machinery protection functionality. It can be connected to System 1 using conventional network cable or can be used with wireless Ethernet. It is intended for rolling element bearing machinery, machinery with gears, and wind turbines. However, when such machinery requires protection in addition to condition monitoring, use the 3701 ADAPT platform instead with integrated protection and condition monitoring functionality.



8.11 vbOnline 16/32²¹

Connectivity: COMMTEST Ascent software and System 1 (not System 1 Classic)

This is a legacy platform that came to Bently Nevada as part of its COMMTEST acquisition in 2011. It is the predecessor to vbOnline Pro (8.10) and was available in both 32-channel (top photo) and 16-channel (bottom photo) versions. The platform supported a wider range of transducer and input types than vbOnline Pro and for this reason customers with installed systems may wish to retain them. vbOnline32 can be connected to its host condition monitoring software using wired or wireless Ethernet. The 16-channel version supports only wired Ethernet. If you decide to replace the hardware, your local Bently Nevada sales and application solutions professionals can assist you in selecting suitable alternatives.



8.12 60M100

Connectivity: Bently Nevada adapt.wind software only

This platform is nearly identical to vbOnline Pro and differs physically only in that it has blue rather than black markings. It is intended for monitoring wind turbines and is designed to replace older 3701/60 and 3701/60A hardware. The 60M100 is capable of communicating only with adapt.wind software, used for monitoring wind turbine parks. For customers that wish to migrate from older adapt.wind software to System 1 without replacing their hardware, a field firmware upgrade can be performed to the 60M100, converting it to model 60M500 (vbOnline Pro—see section 8.10). This upgrade can be performed remotely without the need to climb the wind turbine tower and physically access the hardware. After the upgrade, the hardware remains compatible with all connected sensors but can communicate with System 1 (the 60M500 cannot communicate with adapt.wind).



²¹ This hardware was also branded as TurningPoint® when supplied for use on wind turbines. It was identical in all other respects.

8.13 Trendmaster

Connectivity: System 1 and System 1 Classic

The Trendmaster system was introduced in 1990 and employed a multiplexing strategy whereby hundreds of sensors on a single “bus” cable could be energized—one at a time—and the resulting data from each sensor collected and stored on a condition monitoring server. This reduced or eliminated the need to collect data manually using a route-based portable instrument. The sampling hardware resided centrally at the condition monitoring host computer while the sensors were spread throughout the plant and communicated with the sampling hardware by means of TIMs (transducer interface modules) that assigned a unique address to each sensor on the bus. The sensors were sampled sequentially and then the process repeated itself. The time to collect data from each sensor was generally about 15 seconds, and thus it took about 30 minutes to collect data from 120 sensors. Temperature, proximity, velocity, acceleration, pressure, and process variable signals were supported. The system could also accept buffered output signals from machinery protection systems.



The first generation system was known as Trendmaster 2000 and the sensor bus cable came directly into a desktop PC where the sampling cards were installed. The TIMs were called simply “TIMs”. The software ran on MS-DOS.

The second generation system, Trendmaster 2000 for Windows, made improvements in the TIMs and changed the operating system from DOS to Windows. These second generation TIMs were known as flexiTIMs. The 1900 series monitors were also introduced in this timeframe with native connectivity to the Trendmaster sensor bus. This allowed protective functions to be mixed and matches with purely condition monitoring functions. See sections 7.6 and 7.8 for additional information on the 1900 series and its connectivity to Trendmaster infrastructure cable. The 1900 series single-channel monitors described in 7.6 can be replaced by the 2300/20 and 2300/25 monitors described in 7.4. The 2300/25 offers native connectivity to Trendmaster infrastructure cable. Both the 2300/20 and 2300/25 feature native connectivity to System 1.

The third generation system (originally “Trendmaster Pro” but now just called Trendmaster), introduced more improvements to TIMs (called ProTIMs), moved the sampling hardware from the condition monitoring server to an external chassis (called a Trendmaster DSM²² rack), and changed the host software from a standalone Trendmaster for Windows application to *System 1 Classic*. Today, all first and second generation TIMs are in phase 5 obsolescence and have been replaced by ProTIMs. Many of the sensors used with the original Trendmaster system have likewise been replaced by more robust models, compatible with ProTIMs. Refer to the table in section 10.0 for TIM, flexiTIM, ProTIM, and corresponding sensor compatibility information. Refer to sections B.8 and B.9 for additional information on legacy *Trendmaster 2000* and *Trendmaster 2000 for Windows* software²³. The Trendmaster DSM and all connected ProTIMs are fully supported under both *System 1 Classic* and System 1. A series of direct input cards that could reside in a DSM chassis and accept direct-wired sensors has since been made obsolete. The affected cards carried part numbers 149811-01 (24V vibration sensors) and 149799-01 (process variable signals). Such sensors can instead be connected via appropriate ProTIMs or via other monitors such as the 2300 or vbOnline Pro.

When the Trendmaster system was introduced 30 years ago, wireless sensing was not a viable option. Today, however, many installations that would have previously been addressed by Trendmaster can now be addressed by Ranger Pro. Regardless, there will be some condition monitoring scenarios for which Trendmaster is still the right fit from both a functionality and economic aspect. Your local Bently Nevada sales and application solutions professionals can assist you in determining the optimal approach for your specific situations.

Consult the table on the following pages for a comprehensive list of all TIMs, corresponding sensors, lifecycle phases, and System 1 compatibility.

²² DSM stands for “Dynamic Scanning Module”. A single DSM chassis can accommodate up to six sensor busses.

²³ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

Trendmaster TIMs, flexiTIMs, and ProTIMs

Sensor or input type	Part number	TIM type	Lifecycle phase	S1 compatible
Buffered Dynamic Output	101281-01	TIM	P5	●
	200200-07-07	ProTIM-R	P1	●
	200250-07-07	ProTIM-C	P1	●
Buffered Keyphasor® Output	101282-01	TIM	P5	●
	200200-10-10	ProTIM-R	P1	●
	200250-10-10	ProTIM-C	P1	●
3300XL 5mm and 8mm radial vibration	85018-01	TIM	P5	●
	88269-01	TIM	P5	●
	200200-11-11	ProTIM-R	P1	●
	200250-11-11	ProTIM-C	P1	●
7200 5mm and 8mm REBAM®	85019-01	TIM	P4	
	88262-01	TIM	P4	
3300XL 5mm and 8mm Keyphasor®	85020-01	TIM	P5	●
	88255-01	TIM	P5	●
86205 Velocity Seismoprobe®	86950-01	TIM	P5	●
	88276-01	TIM	P5	●
47633/9200/74712 Seismoprobe®	85013-01	TIM	P5	●
	85023-01	TIM	P5	●
89129/190520 Accelerometer	89130-01	TIM	P5	●
200150 Accelerometer	200100	flexiTIM	P5	●
	89130-01	TIM	P5	●
	89546-01	TIM	P5	●
	200200-01-01	ProTIM-R	P1	●
	200250-01-01	ProTIM-C	P1	●
200155 Low-Frequency Accelerometer	200200-05-05	ProTIM-R	P1	●
	200250-05-05	ProTIM-C	P1	●
200157 Acceleration Enveloping Accelerometer	200200-06-06	ProTIM-R	P1	●
	200250-06-06	ProTIM-C	P1	●
4-20mA and 1-5Vdc process variable	85014-01	TIM	P5	●
	200200-08-08	ProTIM-R	P1	●
	200250-08-08	ProTIM-C	P1	●
0 – 5 Vdc process variable	200140	flexiTIM	P5	
0 to -10V process variable	101283-01	TIM	P5	
2-, 3-, and 4-wire 100Ω Pt RTDs	85015-01	TIM	P5	
	85025-01	TIM	P5	
	200122	flexiTIM	P5	●

Sensor or input type	Part number	TIM type	Lifecycle phase	S1 compatible
2- or 3-wire 100Ω Pt RTDs	200200-03-03	ProTIM-R	P1	●
	200250-03-03	ProTIM-C	P1	●
4-wire 100Ω Pt RTDs	200200-04-04	ProTIM-R	P1	●
	200250-04-04	ProTIM-C	P1	●
J-Type Thermocouple	85016-01	TIM	P5	●
	85026-01	TIM	P5	●
	200120	flexiTIM	P5	●
Trendmaster J-Type Thermocouple (p/n 200125)	200200-02-02	ProTIM-R	P1	●
	200250-02-02	ProTIM-C	P1	●
K-Type Thermocouple	85017-01	TIM	P5	●
	85027-01	TIM	P5	●
	200121	flexiTIM	P5	●
200136 Seal Leak Detection	200135	flexiTIM	P5	
200132 Static Pressure	200130	flexiTIM	P4	
120M1644 Static Pressure	200200-09-09	ProTIM-R	P1	●
	200250-09-09	ProTIM-C	P1	●

8.14 AnomAlert™

Connectivity: System 1 and System 1 Classic (static data only via OPC)

The AnomAlert system uses embedded Artificial Intelligence (AI) to monitor the condition of three-phase electrical motors, allowing detection of numerous malfunctions in not only the motor, but also in its driven equipment. The sensors used with AnomAlert consist of current transformers, current sensors, or voltage transformers on each phase to address low-voltage line-driven motors, low-voltage inverter-driven motors, and medium-/high-voltage motors. Static data is sent to System 1 using OPC-DA protocol for status and trending. Stand-alone AnomAlert software is used for viewing waveforms and performing deeper diagnostics.



9 Portable systems

Bently Nevada has manufactured many portable instruments during the last 60 years. The focus of this section will be primarily on route-based portable data collectors that are compatible with System 1 and produced since 2000; those produced prior to 2000 are covered in Appendix E²⁴. However, a few words about portable instruments that are not route-based are in order first.

The Bently Nevada ADRE system is a session-based instrument that is not designed to address route-based collection on smaller machines. It is instead designed to collect data from large machines without installed condition monitoring where the number of measurement points exceeds that which can be addressed by a portable data collector. A single ADRE 408 data acquisition instrument is able to collect data from up to 32 points simultaneously. It is designed primarily for critical machinery without installed online condition monitoring, or when the installed condition monitoring is insufficient. You can read more about the ADRE system in section 6.9.

Another class of portable instruments are Bently Nevada's TK-series instruments where TK stands for Test Kit. The table in section 5.4 summarizes most of the Bently Nevada TK-series instruments released during the last 40 years and as can be seen, most can be replaced by functionality now resident in many of our route-based portable data collectors. The Test Kits today rarely play a part in online and offline plantwide condition monitoring. As such, detailed descriptions are not included in this Guide.

The remainder of this section focuses on Bently Nevada's route-based portable data collectors, their accompanying software, and today's recommended offerings for connectivity to System 1 along with a world-class feature set suitable for intensive diagnostics and early warning on rolling element bearing machinery, bump testing, balancing, and other condition monitoring functionality.

²⁴ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

9.1 SCOUT200- and COMMTEST200-series portable data collectors

Connectivity: System 1 only (not System 1 Classic or Ascent)

These are our premier data collectors and are available in 2-channel plus tach (220) and 4-channel plus tach (240) versions. The SCOUT and COMMTEST models offer identical functionality and the only difference is that the SCOUT units are intrinsically safe for use in hazardous areas up to Div 1/Zone 1 while the COMMTEST units carry no hazardous area approvals. The innovative design consists of a wearable data acquisition module that can be shoulder- or belt-mounted. This is paired via Bluetooth with a handheld unit that serves as the user interface and can be tablet-sized or phone-sized. The handheld can be any off-the-shelf device running the Android operating system but when used with SCOUT models in hazardous areas, the device must carry the appropriate approvals—just like the data acquisition module. Considerable effort has gone into making Bently Nevada’s portable data collectors both ergonomically designed and feature rich. It is no longer necessary to choose between full integration with System 1 and industry-leading capabilities for collection and analysis. Your local Bently Nevada sales and application solutions professionals can assist you understanding the capabilities of these devices and how they compare to other competitive offerings. We believe you will be very favorably impressed. In addition, the ability to have both online and offline instruments integrated into the same condition monitoring ecosystem means that you can augment the data collected by your online systems with supplemental data collected by your portable instruments when necessary, keeping all of the data organized by asset in the same database and navigational structure.

The 200-series platforms are our newest offerings and are receiving the majority of our focus for enhancements and improved functionality. As such, they are recommended for most users that are starting a portable condition monitoring program, or looking to move from a stand-alone portable system to one that is fully integrated with System 1.



Off-the-shelf Android user interface



Data collector

9.2 SCOUT100- and COMMTEST vb-series portable data collectors

Connectivity: System 1 only (not System 1 Classic) and COMMTEST Ascent software

These data collectors feature a one-piece form factor with integrated display rather than the two-piece designs of their 200-series counterparts in section 9.1. The SCOUT100-series models are intended for use outside of North America. They are ATEX-rated for use in Zone 2 areas and available in 2-channel plus tach (100) and 4-channel plus tach (140) versions. In contrast, the COMMTEST vbX series data collectors are intended for use within North America and are approved for use in Class 1 Div 2 hazardous areas. They are available in 2-channel plus tach (vb7) and 4-channel plus tach (vb8) versions. Both the SCOUT and COMMTEST offerings provide integrated balancing capabilities²⁵. Customers using Ascent software are encouraged to migrate to System 1 using the built-in migration tool: **System 1 > Tools > Database Manager > Tools > Data Migration > Data Source=Ascent 2015+**. This software utility covers COMMTEST Ranger wireless products, COMMTEST portable data collector products, and COMMTEST vbOnline 16/32 products.



²⁵ The SCOUT and COMMTEST offerings described in section 9.2 feature integrated balancing capabilities, data collection capabilities, and real time analyzer capabilities. If only balancing and collection capabilities are required, but not analyzer capabilities, the vb5 (2 channels plus tach) and vb6 (4 channels plus tach) are available. They feature identical connectivity to System 1 and to Ascent software.

9.3 Snapshot CE/IS/Clipboard portable data collectors

Connectivity: System 1 Classic (not System 1)

Snapshot CE was a 2-channel (plus tach) data collector that ran on the Windows CE operating system. A balancing utility called Snapshot Balance could be loaded onto the data collector, giving it 1- and 2-plane integrated balancing capabilities. It was rated for Class 1 Div 2 areas. Recommended replacements²⁶ are the COMMTEST220 or SCOUT220. If a 4-channel device is desired, use the COMMTEST240 or SCOUT240.



Snapshot IS was an intrinsically safe ATEX-certified data collector that used a different physical form factor and had only a single channel (plus tach). Like Snapshot CE, it also ran on the Windows CE operating system. The SCOUT220 is the recommended replacement and carries ATEX approvals along with two channels of data capture capabilities.



Snapshot Clipboard was designed to be used by process operators rather than vibration specialists and thus did not have a facility for connecting to vibration sensors or monitors. It was used only for manually recording observations and readings from gauges and indicators when the operator left the control room to walk down assigned areas of the plant. Recommended replacement is the SCOUT220 or COMMTEST220.



Snapshot CE, IS, and Clipboard are all in phase 5 obsolescence and it is recommended that they be replaced with the offerings in 9.1 and/or 9.2 above.

9.4 Third-party portable data collectors

Many customers interested in a plantwide condition monitoring program are using a third-party data collection system. Historically, this has been because Bently Nevada competitors had technically stronger offerings with advanced features and functions not found in our data collection hardware or software. However, with the acquisition of COMMTEST in 2011, that has changed and we now have offerings that are considered industry leading, both in terms of ergonomics and functionality. System 1 software has improved dramatically during the last ten years as well and is now just as capable for spectrum-based diagnostics on rolling element bearing machinery as it is for diagnostics on fluid-film bearing machinery. Below are several of the more common portable data collection offerings and remarks on migration options that can ease the transition to new hardware and System 1 software.

When switching from other portable data collectors and their accompanying software to System 1, one of the most common concerns is the ability to preserve historical data. The need to access data that is more than one year old, however, is rarely as important as the need to access historical maintenance records, and such records are unaffected by a change in data collector software. While we have provided varying degrees of migration assistance to preserve historical data and migrate configuration settings when switching from selected third-party systems, a general best practice is to retain your existing system's software for 12 months after switching to Bently Nevada products, allowing time for sufficient new trends to be built up in System 1. During this interim period, historical trends can be accessed in the old system while collecting data with the new system and storing it in System 1.

²⁶ Snapshot CE also had the ability to test and configure TIMs used with the Trendmaster system. This feature is no longer available in the newer SCOUT and COMMTEST portable offerings.

9.4.1 Legacy COMMTEST portable data collectors

Ascent 2015 software is used with the following legacy COMMTEST devices:

- vb1000, vb2000, and vb3000 data collectors
- vb5, vb6, vb7, and vb8 data collectors
- SCOUT100 and SCOUT140 data collectors
- Ranger wireless system (see D.1²⁷)
- vbOnline 16/32 (see 8.11)



Customers using Ascent software are encouraged to migrate to System 1 using the built-in migration tool: **System 1 > Tools > Database Manager > Tools > Data Migration > Data Source=Ascent 2015+**. This software utility covers COMMTEST Ranger wireless products, COMMTEST portable data collector products, and COMMTEST vbOnline 16/32 products. If you are using an older version of Ascent, first upgrade to 2015; then, use the System 1 upgrade utility.

9.4.2 Emerson/CSI portable data collectors

Many customers use Emerson/CSI data collectors and AMS Machinery Health Management software. We recommend any of our COMMTEST and SCOUT offerings as replacements. To aid in the transition, we offer a service that provides database migration, allowing you to retain your historical data in System 1. These services can also manually migrate selected other data that is not moved programmatically, such as alarms, bearing fault frequencies, and notes.



9.4.3 SKF portable data collectors

For customers using SKF data collectors and @aptitude Analyst software, we do not offer a database migration capability; however, we provide services to efficiently set up your new System 1 database with a table of asset hierarchies, measurements, alarm bands, bearing fault frequencies, and bearing makes/models. This eases the effort of replicating configuration in System 1.



9.4.4 Other portable data collectors

For customers using other data collectors and software beyond those listed above, Bently Nevada may be able to offer services similar to those described in 9.4.3. Consult your local Bently Nevada sales and application solutions professionals for additional details.



²⁷ The referenced appendix is included only in the comprehensive version of this document (BHDW00002) available upon request from your local Bently Nevada sales professional.

10 Sensors/transducers

In general, System 1 condition monitoring software is sensor-agnostic. As long as the signal can come into the corresponding System 1-supported condition monitoring hardware, System 1 will be able to display the data generated by the sensor with only a few exceptions.

The content of this section allows users to determine the lifecycle status of their sensor/transducer system and its connectivity to currently Bently Nevada hardware offerings. Refer to the table on the following pages. The implications for condition monitoring are generally when the user needs to upgrade to a newer hardware platform supported by System 1 and needs to ascertain whether the installed sensors can be retained or must be replaced.

Following this table, additional content is provided for those unfamiliar with the various types of sensors and the specifics of Bently Nevada's offerings.

Sensor/ Input type	Part number(s) ¹	Lifecycle phase	Lifecycle phase						Trendmaster	vbOnline Pro	1900/65A	TDISecure ^{7,8}
			Orbit 60	3500	3701/40	3701/44	3701/46	2300				
Proximity												
Buffered Outputs			● ¹¹	● ¹¹							●	
3300 5mm and 8mm	330100	P1	●	●	●	●	●	●		● ²	●	
3300 XL 5mm and 8mm	330180	P1	●	●	●	●	●	●		● ²	●	
3300XL 11mm	330780	P1	●	●	●	●	●	●		● ²	●	
3300 16mm	330300	P4	●	●	●	●	●	●		● ²	●	
3300XL 16mm	330380	P1	●	●	●	●	●	●		● ²	●	
3300XL 25mm	330850	P1	●	●	●	●	●	●		● ²	●	
3300XL 50mm	330878	P1	●	●	●	●	●	●		● ²	●	
3300 RAM ³	330900	P5	●	●	●	●	●	●		● ²	●	
3300XL NSv ³	330980	P1	●	●	●	●	●	●		● ²	●	
7200 5mm and 8mm	18745	P3	●	●	●	●	●	●		● ²	●	
7200 11mm	19049	P3	●	●	●	●	●	●		● ²	●	
7200 14mm	81725	P3	●	●	●	●	●	●		● ²	●	
7200 25mm	24654	P3	●	●	●	●	●	●		● ²	●	
7200 35mm	76683	P3	●	●	●	●	●	●		● ²	●	
7200 50mm	24583	P3	●	●	●	●	●	●		● ²	●	
7200 MicroPROX	40892	P5	●	●	●	●	●	●		● ²		
3300 REBAM	330600	P5										
3300 PROXPAC	33080X	P4	●	●							●	
3300 PROXPAC XL	33088X	P1	●	●							●	
25mm DE transducer	10224X	P5	●	●							●	
50mm DE transducer	130713	P5	●	●							●	
Radiation Resistant System	33028X	P1	●	●							●	
3000 series (.190" and .300" tip) ⁴	20929	P5	● ¹²	●							●	
7000 series (.300" tip) ⁴	12237	P5	● ¹²	●							●	
990/991 Transmitters	990/991	P2										

Refer to the table in section 8.13

via connected monitoring system (not directly into TDISecure)

See notes on page 55.

Sensor/ Input type	Part number(s) ¹	Lifecycle phase	Lifecycle phase						Trendmaster	vbOnline Pro	1900/65A	TDISecure ^{7,9}
			Orbit 60	3500	3701/40	3701/44	3701/46	2300				
Piezo-Velocity												
Buffered Outputs			● ¹¹	● ¹¹							●	
IEPE self-integrating (A-V) velocity transducer ¹³					●	●	●	●			●	
Velomitor®	330500	P1	●	●	●	●	●	●			●	
Velomitor XA	330525	P1	●	●	●	●	●	●			●	
Radiation Resistant Velomitor	330530	P1	●	●	●	●	●	●			●	
Hi-Temp Velomitor	330750 & 752	P1	●	●	●	●	●	●			●	
Velomitor CT	190501	P1	●	●	●	●	●	●			●	
Velocity Transmitter	177230	P1										
Moving-Coil Velocity												
Buffered outputs			● ¹¹	● ¹¹							●	
2-wire Velocity Seismoprobe®	9200	P1	●	●	●	●	●	●				
High-Temp version of 9200	74712	P1	●	●	●	●	●	●				
Low-Cost Velocity Seismoprobe®	47633	P5	●	●	●	●	●	●				
Same as 47633 but w/ 6' cable	39158	P5	●	●	●	●	●	●				
Trendmaster Seismoprobe®	86205	P5										
3-wire Velocity Seismoprobe®	16699	P5			●	●	●	●				
Hi-Temp version of 16699	24646	P5			●	●	●	●				
Radiation Resistant ver. of 24646	26233	P3			●	●	●	●				
Vel to Displacement Convertor	14386	P5	●	●	●	●	●	●				
Vel to Displacement Convertor	9513	P5	● ¹²	● ¹²	●	●	●	●				
Vel to Displacement Convertor	46687	P5	● ¹⁴	● ¹⁴	●	●	●	●				
Low-Frequency Velocity	330505	P1	●	●	●	●	●	●				
Low-Cost, Low-Frequency Velocity	26862	P5	●	●	●	●	●	●				

Refer to the table in section 8.13

Refer to the table in section 8.13

via connected monitoring system (not directly into TDISecure)

via connected monitoring system (not directly into TDISecure)

See notes on page 55.

Sensor/ Input type	Part number(s) ¹	Lifecycle phase	Lifecycle phase						Trendmaster	vbOnline Pro	1900/65A	TDIsecure ^{7,8}
			Orbit 60	3500	3701/40	3701/44	3701/46	2300				
Acceleration												
Buffered outputs			● ¹¹	● ¹¹							●	
IEPE accelerometer ⁵			●	●	●	●	●	●		●	●	
IEPE Accel, top exit, 100mV/g, Zn 2 ⁵	AM3100T2-Z2	P1	●	●	●	●	●	●		●	●	
IEPE Accel, side exit, 100mV/g, Zn 2 ⁵	AS3100S2-Z2	P1	●	●	●	●	●	●		●	●	
IEPE Accel, top exit, 500 mV/g, Zn 1 ⁵	AP3500T2-Z1	P1	●	●	●	●	●	●		●	●	
IEPE Accel, side exit, 500 mV/g, Zn 1 ⁵	AP3500S2-Z1	P1	●	●	●	●	●	●		●	●	
IEPE Accel, top exit, 100mV/g, Zn 0 ⁵	AM3100T2-Z0	P1	●	●	●	●	●	●		●	●	
IEPE Accel, side exit, 100mV/g, Zn 0 ⁵	AS3100S2-Z0	P1	●	●	●	●	●	●		●	●	
API 670 Accelerometer (50g)	330400	P1	●	●	●	●	●	●		●	●	
75g version of 330400	330425	P1	●	●	●	●	●	●		●	●	
Hi-Temp Accel	330450	P1	●	●	●	●	●	●		●	●	
Hi-Temp Velocity and Accel	350900	P1	●	●	●	●	●	●		●		
Stator End Winding	330446 & 47	P1	●	●	●	●	●	●		●		
Trendmaster Accelerometer	89129	P5										
Trendmaster Accel, integral cable	190520	P5										
Trendmaster (Accel-to-Vel)	200150	P1										
Same as 150 except low-freq	200155	P1										
Same as 150 except accel. envl.	200157	P1										
IEPE Accel, top exit, 100mV/g, Zn 0	200350	P1	●	●	●	●	●	●		●	●	
Low-Freq Version of 200350	200355	P1	●	●	●	●	●	●		●	●	
GE Aero Interface Module	86517	P1	●	●	●	●	●	●				
Rolls-Royce Aero Int. Module	86497	P5	●	●	●	●	●	●				
GE Aeroderivative Accel	45357	P1	●	●	●	●	●	●				
Charge amp for 45357 Accel	350501	P1	●	●	●	●	●	●				
Accelerometer/Interface Module	23732 & 33	P5	●	●	●	●	●	●				
Hi-Frequency version of 23732	24147 & 45	P4	●	●	●	●	●	●				
Hi-Frequency Interface Module	350610	P1	●	●	●	●	●	●				
Wind Turbine Drive Train Accel	370300	P1			●	●	●	●		●		

Refer to the table in section 8.13

via connected monitoring system (not directly into TDIsecure)

See notes on page 55.

Sensor/ Input type	Part number(s) ¹	Lifecycle phase	Lifecycle phase					Trendmaster	vbOnline Pro	1900/65A	TDISecure ^{7,9}
			Orbit 60	3500	3701/40	3701/44	3701/46				
Pressure											
Buffered outputs			● ¹¹	● ¹¹						●	
Trendmaster Pressure Sensor (Static)	200132	P5					Refer to the table in section 8.13				
Trendmaster Pressure Sensor (Static)	120M1644	P1									
Dynamic Cylinder Pressure (Recip)	165855	P1	●	●	●	●		●	●		
Dynamic Pressure Sensor (Hydro)	350300	P1	●	●	●	●		●	●		
Dynamic Pressure Charge Amp (GT)	350500	P1	●	●	●	●		●	●		
Process Variable											
+4 to +20mA				●			● ¹⁵			●	
-4 to -20mA				●			● ¹⁵			●	
+1 to +5 Vdc				●			● ¹⁵			●	
-1 to -5 Vdc				●			● ¹⁵			●	
0 to +10 Vdc				●			● ¹⁵			●	
0 to -10 Vdc				●			● ¹⁵			●	
0 to + 5 Vdc				●			● ¹⁵			●	
Temperature: 2-, 3- and 4-wire RTDs											
100Ω platinum RTD (.00385α)			●	●			● ¹⁵		● ¹⁰	via 4-20mA signal from monitor or xmitter	
100Ω platinum RTD (.00392α)			●	●			● ¹⁵		● ¹⁰		
120Ω nickel RTD			●	●			● ¹⁵		● ¹⁰		
10Ω copper RTD			●	●			● ¹⁵		● ¹⁰		
Temperature: Thermocouples											
E-Type			●	●			● ¹⁵		●	via 4-20mA signal from monitor or xmitter	
J-Type			●	●			● ¹⁵		●		
K-Type			●	●			● ¹⁵		●		
T-Type			●	●			● ¹⁵		●		
Trendmaster K-Type	200125	P1							●		

See notes on page 55.

Sensor/Input type	Part number(s) ¹	Lifecycle phase						Trendmaster	vbOnline Pro	1900/65A	TDISecure ^{7,9}
			Orbit 60	3500	3701/40	3701/44	3701/46				
Linear/Rotary Position											
3300XL Rotary Position Transducer	330165	P1	●	●							via connected monitoring system (not directly into TDISecure)
Valve Position LVDT, AC	18639	P1	●	●							
Case Expansion LVDT, DC	24765	P1	●	●							
Hi-Temp Case Expansion LVDT, DC	135613	P1	●	●							
Valve Position Potentiometer	77206	P5	● ¹²	●							
Valve Position Potentiometer	10881	P5	● ¹²	●							
Specialty											
Hydro Air Gap: Stator-Mounted	400100 & 200	P1		●							Note ⁸
Dynamic Power Transducer ⁶	136212	P5									
Torximitor [®] (first generation)	85609	P5									
Torximitor [®] (second generation)	132570	P5									

Notes:

- For Proximity, only the Proximitor[®] part number is shown as there are too many different part numbers for probes and cables used with a particular Proximitor. For other sensors types, the actual sensor part number is shown and, where applicable, the accompanying signal conditioner.
- Can only be used for speed channels—not vibration or position measurements. vbOnline Pro supplies -24Vdc transducer power for the speed channels. Other speed sensors, such as magnetic and capacitive devices that require positive voltage excitation, must be powered externally.
- RAM (Robust Air Machine) probes and cables can be identified by the gray coaxial cable. They are physically and electrically interchangeable with NSv (Narrow Sideview) probes and cables, which can be identified by lavender coaxial cable. RAM (330900) and NSv XL (330980) Proximitor[®] signal conditioners are also interchangeable. RAM probes, cables, and Proximitors have been discontinued; NSv components should be used instead.
- 3000 series probes use -18Vdc excitation that was available on older monitoring systems such as 5000 and 7200, but is not available on most newer Bently Nevada monitoring systems without special modifications. Users are encouraged to upgrade to newer -24Vdc probe systems such as 3300XL. Consult your Bently Nevada sales and application solution professionals for assistance.
- These devices use excitation of +24Vdc with constant current (typically 3mA) and conform to standard IEP (Integrated Electronic Piezo-Electric) specifications. They are available from a variety of suppliers and are often used with Bently Nevada monitoring systems.
- AnomAlert is designed for electric motors and replaces the Dynamic Power Transducer.
- TDI Secure is designed to accept buffered output signals for dynamic (waveform) inputs. It also accepts alarm relays for alarm statuses and proportional 4-20mA (and DC voltages) for static (non-waveform) data. Temperature signals can be introduced either by use of a temperature transmitter or by using the recorder output (i.e., 4-20mA) signal from a connected machinery protection system.
- Air gap sensors are compatible but only via a connected monitoring system such as 3500 series.
- Standard field wiring diagrams are provided in Bently Nevada document 102M7347 for connecting TDISecure to 3500, 3300, 1900/65, and generic third-party protection systems with buffered outputs, alarm relays, and 4-20mA (recorder) outputs.
- 4-wire RTDs are not supported by the 1900/65 and /65A.
- Verify input impedance requirement.
- Requires product modification.
- Verify specification.
- Firmware and software modification required.
- Requires external signal conditioning—see process variable supplement to 2300 O&M Manual.

10.1 Proximity probe overview

Bently Nevada proximity probe systems consist of three fundamental components in the measurement chain:

The probe and its integral cable



This is the part that is embedded into the machine and observes the rotating shaft. The probe contains a coil, and the shape and diameter of this coil determines the linear range it can observe (anywhere from 40 mils to 1100 mils). A small length of cable (usually 0.5 m or 1.0m) is attached to the probe and is called the probe's "integral" cable. The remainder of the required cable between the probe and its signal conditioner (Proximator® sensor) is by means of a separate extension cable. This results in easier installation and removal of the probe when threading/unthreading into the machine because the entire 5m or 9m cable length does not need to turn with the probe—only the shorter integral amount.

An extension cable



This uses the same type of cable as the probe and connects the probe to the Proximator. The Proximator is tuned for a particular total length of cable—usually either 5m or 9m. Older systems (3000 series and 7000 series) used English measurements and specify length in feet; newer systems (7200 series and 3300 series) specify length in meters. For a system with a tuned electrical length of 5m and a probe with 1m of integral cable, a 4m extension cable would be used. For a 9m system, an 8m extension cable would be used. Many other permutations are permitted, as long as the probe and its integral cable lengths sum to the calibrated length of the Proximator.

A Proximator® sensor



This component excites the probe at a characteristic frequency to generate an electromagnetic field and corresponding eddy currents in the observed surface (usually the machine's rotating shaft). Changes in these eddy currents are detected and are converted to a voltage that is proportional to the probe gap. Probes can measure fixed gap as well as variable (vibrating) gap and typically have a frequency response from 0–10kHz. The upper end of this frequency response is rarely needed for vibration measurements; it is instead primarily important when the probe is observing a key, keyway, or toothed surface for phase and tachometer applications.

Bently Nevada proximity systems are generally characterized by their top-level family and the tip diameter (5mm, 11mm, 16mm, etc.). Components are not interchangeable between families. For example, a 5mm 7200 series proximity probe chain is not interchangeable with components in a 5mm 3300 series chain. Further, probes within the same family but with different tip diameters use different extension cables and Proximator® sensors. This means, for example, that a 3300XL 11mm probe does not use the same extension cables and Proximator® sensors as a 7200 11mm probe. The only exceptions are as follows:

- 7200 5mm and 8mm probes use identical coils and are simply embedded in different tip encapsulations. Although they are electrically identical, and therefore use the same cables and Proximator sensors, an 8mm probe has more tip encapsulation than a 5mm and is therefore more physically robust and uses a stronger threaded case due to the larger size. For this simple reason, customers are encouraged to use 8mm probes instead of 5mm whenever the physical mounting constraints do not preclude the use of larger 8mm probes
- 3300 5mm and 8mm probes use identical coils and thus the same extension cables and Proximator sensors
- 3300 and 3300XL components are fully interchangeable. 3300XL components are essentially second generation versions and were designed for backward compatibility with first generation versions of measurement chain components (3300). Section 10.1.1 covers XL versus non-XL in more detail
- RAM and NSv probes use 5mm tip sizes but a different coil than standard 3300 5mm probes. RAM and NSv components are thus interchangeable with one another, but not with standard 3300/3300XL 5mm probes, extension cables, or Proximator sensors

There have been seven (7) top-level families of proximity transducers over the years as summarized in the following table:

Family	Tip diameters available	Range (mils)	Sensitivity (mV/mil)	Cable color	Excitation voltage	System lengths	I.S. Barrier compatibility
3000 Series	.190"	40	200	clear/white	-18 Vdc	15 & 20 ft	
	.300"	50	200	clear/white	-24Vdc	15, 40, & 110 ft	
	.300" RR ¹	50	100	clear/white	-24Vdc	15, 40, & 110 ft	
	.420" RR ¹	90	100	clear/white	-24Vdc	15 ft	
7000 Series	.300"	60	100	clear/white	-24Vdc	15 & 20 ft	●
7200 Series	5mm	80	200	light yellow	-24Vdc	5 & 9 m	●
	8mm	80	200	light yellow	-24Vdc	5 & 9 m	●
	11mm	160	100	light yellow	-24Vdc	5 & 9 m	●
	14mm	160	100	light yellow	-24Vdc	5 & 9 m	●
	25mm	500	20	light yellow	-24Vdc	5 & 9 m	●
	35 mm	500	20	light yellow	-24Vdc	5 & 9 m	
	50 mm	1,000	10	light yellow	-24Vdc	5 & 9 m	
3300 Series	5mm	80	200	light blue	-24Vdc	1, 5, & 9 m	●
	8mm	80	200	light blue	-24Vdc	1, 5, & 9 m	●
	16mm	160	100	light blue ⁴	-24Vdc	9 m	
RAM Series	5mm	60	200	gray	-24Vdc	5 & 7 m	
NSv Series	5mm	60	200	light blue ²	-24Vdc	5 & 7 m	●
3300XL Series	5mm	80	200	light blue	-24Vdc	1, 5, & 9 m	●
	8mm	80	200	light blue	-24Vdc	1, 5, & 9 m	●
	11mm	160	100	light blue ³	-24Vdc	5 & 9 m	●
	16mm	160	100	light blue ⁴	-24Vdc	9 m	
	25mm	500	20	light blue ⁵	-24Vdc	5 & 9 m	●
	50mm	1,100	10	light blue ⁶	-24Vdc	5 & 9 m	●

Notes:

1. RR=Radiation Resistant
2. NSv probe systems use light blue cable but have gray heat shrink at the connector locations. The Proximitors sensors also use gray color coding on the labels.
3. 11mm probe systems use light blue cable but have purple heat shrink at the connector locations. The Proximitors sensors also use purple color coding on the labels.
4. 16mm probe systems use light blue cable but have orange heat shrink at the connector locations. The Proximitors sensors also use orange color coding on the labels.
5. 25mm probe systems use light blue cable but have lime-green heat shrink at the connector locations. The Proximitors sensors also use lime-green color coding on the labels.
6. 50mm probe systems use light blue cable but have brown heat shrink at the connector locations. The Proximitors sensors also use brown color coding on the labels.

10.1.1 3300 and 3300XL Series proximity probe systems

Lifecycle phase: P1

These are Bently Nevada's premier proximity probe systems and are used for all installations except when spare parts are required on legacy transducer installations such as 7200. 3300 probes and cables used coaxial extension cable, like all prior probe systems. 3300XL introduced triaxial cable and other improvements resulting in more mechanically robust components that can tolerate nicks and cuts to the cable jacket without creating electrical ground problems. The 3300XL system also introduced improvements to the mechanical packaging of Proximitor sensors with a DIN-rail mounting option instead of 4-hole mounting and spring-type wiring terminals rather than screw terminals. Older non-XL 3300 systems used a distinctive Proximitor shape but with a 4-hole mounting and conventional screw terminals.

The XL designation signifies an electrically identical system to non-XL 3300 and the XL and non-XL parts are electrically and mechanically interchangeable.



10.1.2 RAM and NSv Series proximity probe systems

Lifecycle phase: P1 (NSv) P5 (RAM)

The RAM probe system is the predecessor to the NSv probe system. Both are specifically designed for use in applications where the normal probe tip spacing, sidewall clearance, and other constraints cannot be satisfied to prevent interference with the larger electromagnetic field emitted by a conventional 5mm/8mm 3300 probe. Most of the applications for these probes are in air compressors with small pinions and constricted mounting options. This class of machines conforms to API specification 672: *Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services*. Many people refer to these simply as “air machines” and the RAM system stood for Robust Air Machine. Later, Bently Nevada introduced improved versions of the RAM probes, cables, and Proximitor sensors. This system was a form/fit/function replacement for RAM components but was called NSv for “Narrow Sideview”. RAM components used gray cables and are no longer produced. NSv components used light blue cable and are interchangeable with RAM probes/cables while offering better performance. RAM Proximitor sensors (p/n 330900) are no longer produced and NSv Proximitor sensors are used instead (p/n 330980). RAM and NSv probes are frequently used with 990/991 transmitters instead of Proximitor sensors as discussed in 10.1.3.

10.1.3 990/991 proximity transmitters

Lifecycle phase: P2

API 672 (see 10.1.2) specifies that proximity probe vibration transmitters are the default method for protecting this class of machinery. As a result, in 1993 Bently Nevada introduced the 990 (radial vibration) and 991 (thrust position) transmitters along with RAM probes/cables (later superseded by NSV probes/cables). Indeed, most installations of RAM and NSV probes/cables involve transmitters—not conventional Proximitors sensors with a “raw” signal output designed for connection to a monitor instead of directly to the 4–20mA input capabilities of a control system.

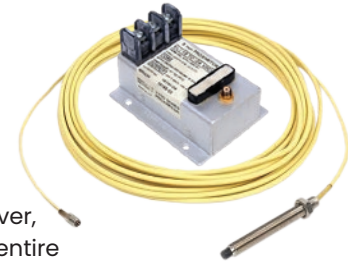


Transmitters rely on connection to a machinery control system where the 4–20mA signal (proportional to either radial vibration amplitude or thrust position) is converted to engineering units and compared against alarm setpoints for pre-shutdown (Alert) and shutdown (Danger) functionality. A major drawback of loop-powered transmitters such as the 990 and 991 is that they do not provide adequate isolation between the buffered output and connected systems, nor are these outputs designed for wiring lengths exceeding 16 feet (5 m) unless special signal isolators and line amplifiers are used. Also, because the 990/991 devices are powered by +24Vdc, their signal polarity is opposite that of proximity systems energized with –24Vdc power, complicating diagnostics by inverting all plots where signal polarity is relevant. Installation of loop-powered transmitters on a machine generally assumes that the user has decided to rely entirely on a portable data collector for condition monitoring on that machine and will not be attempting to connect an online condition monitoring system. The complications and costs of such a connection will generally exceed the costs of simply replacing the transmitters with a self-contained monitoring system and feeding the monitor’s 4–20mA outputs into the machinery control system. Your Bently Nevada sales and applications solutions specialists can assist you in selecting an appropriate protection platform that combines the necessary condition monitoring functionality with an output format (4–20mA w/ NOT OK clamping) compatible with the machine’s control system. This allows the machine control system to continue to provide vibration protection while providing suitable condition monitoring capabilities and connectivity to System 1.

10.1.4 7200 Series proximity probe systems

Lifecycle phase: P3

7200 series proximity systems began production in the mid-1970s and were available in the tip diameters summarized in the table of section 10.1. Many can still be found in service today and can be identified by the distinctive light yellow color of the cable²⁸. In almost all instances, equivalent 3300XL series offerings are available and are recommended as suitable replacements. However, 3300/3300XL series components are not interchangeable with 7200 series. The entire measurement chain (probe, cable, Proximitor®) must be replaced, but the accessories (probe holders/brackets, Proximitor Housings, conduit) can generally be reused. The OK limits on 7200 series probes will also differ from their 3300 equivalents and the affected monitoring system channels will need to have their configuration updated to reflect 3300 instead of 7200 probes.



²⁸ Beginning in 2004, the older 4-hole “brick” style Proximitor sensors for 7200 5mm/8mm probes were discontinued and replaced with a form factor that is the same as 3300XL. However, they do not provide 3300XL performance and are still 7200 series systems conforming to 7200 series specifications.

10.1.5 7000 Series Proximator® sensors

Lifecycle phase: P5

The 7000 Series did not introduce its own probes and cables; it was simply a new Proximator® that was backward compatible with 3000 Series .300" tip diameter probes and extension cables. Unlike earlier proximity probe systems, 7000 Series was the first to use -24Vdc power instead of -18Vdc power. This increased voltage was to allow the 7000 series to be used with intrinsic safety (I.S.) Zener barriers for hazardous areas²⁹. The 7000 series also provided an output that was 100 mV/mil instead of 200 mV/mil. The 7200 series system was quickly introduced with its own probes, cables, and Proximator® sensors that provided a standard 200mV/mil output, used -24Vdc excitation, and were compatible with I.S. barriers. They quickly displaced 7000 Series proximity systems and consequently very few 7000 series Proximator sensors are encountered in the field any longer. When encountered, they should be upgraded to an equivalent 3300XL measurement chain because both the 7000 series Proximator® sensor (p/n 12237) and its companion .300" probes and extension cables are obsolete and no longer manufactured.



10.1.6 3000 Series proximity probe systems

Lifecycle phase: P5

3000 Series proximity systems began production in the mid-1960s and were available in the tip diameters summarized in the table in section 10.1. The cables used a clear jacket, and the outer coaxial braid was thus visible. When .300" tip diameter probes are encountered, they should be replaced with 3300XL series. When .190" tip diameters are encountered, you should review the application with your local Bently Nevada sales and application solution professionals to determine whether a conventional 3300 5mm probe can be used or if a 5mm NSv system is required instead. The entire measurement chain must be replaced (probe, cable, Proximator®) because 3000 series components are not interchangeable with 3300 or NSv. Also, because 3000 series systems were energized with -18Vdc, the monitoring system must be capable of providing -24Vdc excitation for the 3300 or NSv probe systems. Lastly, the OK limits on 3000 series probes will differ from their 3300/NSv equivalents and the affected monitoring system channels will need to have their configuration updated to reflect these new probes instead of the older 3000 probes.



²⁹ Approximately 4 volts are dropped across I.S. barriers in proximity probe systems, leaving only -14Vdc for Proximator excitation in a -18Vdc system. This is not enough to allow the full linear range of the probe and with introduction of 7000 series, all subsequent Bently Nevada proximity systems switched to -24Vdc excitation to allow use with I.S. barriers.

10.2 Velocity transducer overview

Bently Nevada has produced moving-coil velocity sensors for many years. These sensors are self-powered and do not require external excitation. Many use the Bently Nevada Seismoprobe® trademark. Beginning in the early 1990s, however, another type of velocity sensor began to see widespread acceptance: self-integrating piezo-electric accelerometers that produced a velocity output instead of acceleration. The so-called “piezo-velocity” sensors were entirely solid-state and thus did not have moving parts that wear out like moving-coil designs. Also, because the mechanisms inside of moving-coil designs are sensitive to orientation and the direction in which gravity acts, most designs cannot be mounted at any angle and are constructed for a particular orientation, such as vertical or horizontal.

	Advantages	Disadvantages
Moving-coil	<ul style="list-style-type: none"> • Better at extremely low-frequency measurements (below 1.5 Hz) • Self-powered • Do not produce an erroneous output signal when excited by transient impulsive mechanical forces like knocks or pings 	<ul style="list-style-type: none"> • Utilizes moving parts that wear out • More difficult to do robust OK checks without 3-wire designs • Cannot usually be mounted at any orientation necessitating different models for vertical vs. horizontal and complicating spare parts requirements
Piezo-velocity	<ul style="list-style-type: none"> • Can be mounted in any orientation; fewer spares • No moving parts to wear out • Most designs conform to industry-standard IEPE specifications and are broadly compatible with many monitoring systems • Bias current allows more robust sensor integrity (i.e., OK) checks than moving-coil designs 	<ul style="list-style-type: none"> • Sensor is inherently an accelerometer, not a velocity device; transient impulsive mechanical forces can result in a slowly decaying “step function” output as a result of integration • Not as good for measuring extremely low frequencies (below 1.5 Hz) • Not self-powered; typical excitation requirements are 24Vdc @ 3mA

10.2.1 Moving-Coil (Seismoprobe®) velocity sensors

Lifecycle phase: P5 (except 9200, 74712, and 26233)

Bently Nevada moving-coil Seismoprobe® velocity sensors were available in both 2-wire and 3-wire designs. The 3-wire designs were introduced to allow more robust sensor OK checks than was possible from a 2-wire moving-coil design. All 3-wire Seismoprobe velocity sensors and many 2-wire designs have now moved to phase 5 obsolescence. Only the 2-wire 9200 and its equivalent high-temperature version (74712) remain as active P1 products. A radiation resistant velocity seismoprobe (26233) also remains available for spare parts only. The low-frequency 330505 sensor, used primarily for seismic measurements on hydro turbine/generator machines, also remains an active product. Refer to the table of section 10.0 for additional information.

10.2.2 Piezo-Velocity (Velomitor®) sensors

Lifecycle phase: P1

Bently Nevada refers to its family of self-integrating accelerometers as Velomitor® sensors, which are available in five models.

Model	Name	Applications	Notes
330500	Velomitor®	General-purpose	Usually mounted in a protective housing and requiring a specially machined surface, similar to an accelerometer.
330525	Velomitor® XA	Harsh environments	XA stands for eXtended Applications; designed for mounting without a protective housing or cable conduit, and without a specially prepared mounting surface (requires only a hole with pipe threads).
330530	Radiation Resistant Velomitor®	Machinery in nuclear plants	Same form factor as a standard Velomitor® (330500) but designed for exposure to elevated levels of gamma radiation.
330750	HTVS (High-Temperature Velomitor® System)	Temperatures above 250°F (121°C)	Consists of an accelerometer and separate electronics connected by hardline (mineral insulated) cable.
190510	Velomitor® CT	Cooling Towers and other low-frequency applications	Designed for machines with running speeds as low as 90 rpm.

10.2.3 Loop-powered Piezo-velocity transmitter (177230)

Lifecycle phase: P1

This product is essentially a Velomitor with an integrated RMS detector, providing a 4-20 mA output proportional to the RMS amplitude of velocity. It is a 3-pin device with pins 1 and 2 used for +24Vdc loop power and carrying the 4-20mA signal proportional to RMS velocity. The 3rd pin contains the raw acceleration signal for connection to a patch panel and use by portable data collectors. This transmitter is suitable for machinery that requires minimal machinery protection capabilities and for which only offline (portable) condition monitoring will be used. Connection of loop-powered vibration transmitters such as the 177230, or 990/991 products (refer to 10.1.3) to online condition monitoring systems generally introduces a level of complexity and additional costs that eclipse the costs of a more expensive protection system with integral condition monitoring capabilities.

10.3 Accelerometer overview

Bently Nevada has produced both voltage-mode and IEPE³⁰ accelerometers. Early models were charge-type and required a separate charge amplifier. Later models were piezo-electric and did not require a separate charge amplifier but were still 3-wire voltage-mode devices for backward compatibility with older 3-wire systems. Still other models conform to the IEPE specifications and are 2-wire devices.

10.3.1 23732 and 24147 acclerometer systems

Lifecycle phase: P5 (23732) and P4 (24147)

These systems consisted of a charge-type accelerometer with integral charge amplifier, a coaxial extension cable that was light yellow in color (similar to 7200 series proximity probes), and an interface module that looked similar to a 7200 series Proximitor®. The interface module required a supply voltage of -24Vdc (identical to a Proximitor) and produced an output of 100 mV/g. The systems were designed primarily for monitoring gearbox casing vibration as described in API 670.

System	Accelerometer	Extension cable	Interface module
Standard	23732	18622	23733
High-frequency	24147	21165	24145

Both systems are now obsolete. The 23732 system can generally be replaced by Bently Nevada accelerometer 330400 (50g) or 330425 (75g). For replacement of the high-frequency version (24147), consult your local Bently Nevada sales and application solution professionals for guidance. Repair services may also be available when a suitable replacement is not available.

10.3.2 330400 and 330425 acclerometers

Lifecycle phase: P1

These systems are 3-wire devices designed primarily for the same applications as the older 23732 (see 10.3.1). They produce an output identical to the 23732 system (100 mV/g) and use identical excitation voltages (-24Vdc) but consume only 2mA (nominal) instead of 10mA (nominal).

10.3.3 High-temperature accelerometer systems

Component part numbers 43537, 350900, 330450, 350501, 86517, 83387, 145536, 145693, 49578, 86497, 139506

Lifecycle phase: P1 (except 139606 and 86497³¹ which are P5)

High-temperature accelerometer systems are designed for mounting on machines such as aeroderivative gas turbines where surface temperatures exceeding 750°F (400°C) can be encountered. These systems do not combine the signal conditioning electronics with the piezo-electric element; they are instead separated, often by means of hardline (mineral insulated) cable. This removes the signal conditioning electronics from the most extreme temperatures on the surface of the turbine, placing them instead in environments that do not typically exceed 250°F (121°C). A variety of accelerometers, softline and hardline connection cables, and interface modules are used, depending on the make and model of gas turbine. All of the listed components, including the 86497, are compatible with Bently Nevada protection systems suitable for aeroderivative gas turbines; namely, Orbit 60, 3500, and 3701/44. Consult your local Bently Nevada sales and application solutions professionals for assistance in selecting the appropriate platform if upgrading from 7200, 3300, or third-party machinery protection systems.

30 Integrated Electronics Piezo-Electric. This is an industry standard that defines piezo-electric sensors, including those producing acceleration and/or integrated acceleration (i.e. velocity) outputs. They are constant current, 2-wire devices that are normally excited with a supply voltage of 24-30 Vdc and a constant current of between 2 and 20 mA. +24Vdc @ 3mA is a commonly used excitation.

31 Interface modules 139506 and 86497 are used on Rolls-Royce RB-211, Avon, and certain other aeroderivative gas turbine engines. The functionality provided externally by the 86497 and 139506 can now be provided inside the machinery protection system with 3500/44, 3701/44, and Orbit 60. Your local Bently Nevada sales and application solutions professional can assist you in finding a suitable replacement system.

10.3.4 Trendmaster accelerometer systems

Part numbers 200150, 200155, 200157, 89129, 190520

Lifecycle phase: P1 (except 89129 and 190520 which are P5)

These accelerometers supply a special differential signal and utilize a 4-wire connection. They are not compatible with any systems except Trendmaster (utilizing the appropriate TIMs) and the 1900/25 and 1900/27 monitors.

10.3.5 IEPE accelerometer systems

Bently Nevada part numbers 200350, 200355, AM3100T2-Z2, AS3100S2-Z2, AP3500T2-Z1, AP3500S2-Z1, AM3100T2-Z0, AS3100S2-Z0; and any accelerometers from other suppliers fully compliant with IEPE specifications

Lifecycle phase: P1

These constant current accelerometers comply with IEPE specifications and are normally energized with +24Vdc @ 3mA. Bently Nevada monitoring systems without the native ability to supply +24 Vdc power required modifications to accommodate these sensors. Examples include 7200 series, 3300 series, and 3500 series. Systems that can accept standard IEPE accelerometers include:

- vbOnline Pro/vbOnline 32/vbOnline 16
- Orbit 60
- 1900/65 & /65A
- 2300
- 3701
- SCOUT100/SCOUT200/vbX Series Portables

10.4 Specialty sensors

Static and dynamic pressure, generator/motor air gap, motor stator winding insulation, dynamic power, cavitation, torque, temperature, hazardous gas detection, overspeed, turbine blade health, tower sway, etc.

Lifecycle phase: varies

Bently Nevada has provided a number of specialized sensors that work in conjunction with our monitoring systems to provide machinery condition information and protection. Consult your local Bently Nevada sales and application solutions professionals for assistance with such systems.

11 Services

Bently Nevada can assist you in migrating to a Plantwide Condition Monitoring infrastructure with all of the necessary services you may need. We can provide them fully or augment your own in-house capabilities as required. Our services include:

- **Audits of your machinery to categorize it** according to criticality along with recommendations for the appropriate protection and/or condition monitoring hardware
- **Audits of your installed monitoring systems and transducers** to prepare recommendations for upgrading to System 1 and which systems and transducers can be retained and which must be replaced.
- **Outsourcing of your condition monitoring program**, whether portable and/or online
- [Hosted SaaS solutions](#) where System 1 is installed on Bently Nevada's cloud-based IT infrastructure rather than on your own servers and infrastructure
- [Remote monitoring services](#) to regularly review data collected by your online and offline systems, flag anomalies, and provide recommended corrective actions
- **Product installation and commissioning services**, including full project management where required
- [Design and installation services](#) to retrofit transducers to machines without existing provisions for mounting sensors. Includes full project management, drawings, documentation, sourcing, machining, and delivery of a commissioned, fully functional protection and monitoring system at project completion, whether or not additional transducers are required
- [On-site and remote machinery diagnostic services](#) to collect data and provide expert advice on malfunctions found and recommended corrective actions. Machines without installed condition monitoring systems are addressed with our ADRE® portable data acquisition instrumentation. Machines with System 1 installed can frequently be addressed remotely
- [Cybersecurity services](#) to ensure your condition monitoring ecosystem remains secure from intrusion
- [Training](#) on how to implement and operate a condition monitoring program. Product-specific training is also available along with fundamentals training such as transducers and measurements, machinery diagnostics, and balancing. Training can be delivered in-person or remotely and can use standard curricula or custom-developed curricula tailored to your needs. Many basic courses are available on-demand via the web

Appendix A: Compatibility guide for M-Series 3500 systems

M-series 3500 Series systems combine the fundamental machinery protection functions of the rack with the high-speed data acquisition functions of Bently Nevada’s external communications processors. This effectively reduces the space required for such a combined system by a factor of two (or more) by eliminating the need for an external communications processor and instead integrating online condition monitoring functionality internal to the rack. Because these monitors contain both Machinery Protection and Machinery Management functions, they are referred to as M-series monitors. A special M² logo on the front of affected monitor modules denotes this “Machinery Management Inside” functionality.

A.1 The introduction of M-series 3500 systems

Beginning in July 1999, the 3500 rack backplane was redesigned to support these enhanced monitor functionality and computer interface capabilities. At the same time, M-series monitors were introduced for those monitor types that measure dynamic (waveform) inputs. Table A-1 summarizes the monitor types currently available in the 3500 series. Prior to July 1999, the 3500/40, 3500/42, and 3500/44 monitors were supplied as non-M-series versions. However, all /40, /42, and /44 monitors shipped since that time are M-series.

Table A-1: Summary of M-series and non-M-series monitors	
M-series	Non-M-series
<ul style="list-style-type: none"> • 3500/22M Rack Interface with TDI • 3500/32M Relay • 3500/40M Proximity • 3500/42M Proximity/Seismic • 3500/44M Aeroderivative • 3500/46M Hydro • 3500/50M Tachometer • 3500/53M Overspeed Detection Tachometer • 3500/54M Overspeed Detection Tachometer • 3500/64M Dynamic Pressure • 3500/70M Impulse/Velocity • 3500/72M Rod Position • 3500/77M Cylinder Pressure • 3500/91M EGD Communication Gateway • 3500/94M VGA Display 	<ul style="list-style-type: none"> • 3500/15 Power Supply • 3500/20 Rack Interface • 3500/25 Keyphasor • 3500/33 16-Channel Relay • 3500/34 TMR Relay • 3500/45 Position • 3500/60 Temperature • 3500/61 Temperature • 3500/62 Process Variable • 3500/63 Hazardous Gas Detection • 3500/65 16-Channel Temperature • 3500/82 Motor Stator Insulation • 3500/92 Communication Gateway • 3500/95 Integrated PC Display

A.2 Identifying M-series systems

M-series racks can be easily identified by the presence of an embossed orbit logo on the lower left-hand corner of the rack's gray plastic bezel (non-M-series racks have no embossed orbit). If the bezel is missing, contact your nearest Bently Nevada sales professional who can assist you in other visual inspection methods for identifying M-series racks.

M-series monitor modules can be identified by the printing on the monitor's front panel. All M-series monitors have the M² logo and/or an "M" after the module number.



Embossed orbit logo



M² logo



"M" after module number

A.3 The capabilities of M-series monitors

M-series monitor modules retain the machinery protection functions of their predecessor non-M-series versions, but are enhanced with special high-speed waveform data acquisition functions needed for interfacing to our System 1 software. When our 3500/22M Transient Data Interface is installed in the rack, it replaces the need for an external communications processor (such as TDIX or TDXnet™). Depending on the type of monitor modules in the rack, and how they are configured, the 3500 system is then capable of collecting waveform and/or non-waveform (static) data and supplying this to our System 1™ software. Table A-2 summarizes the capabilities.

Table A-2: Data types collected by 3500/22M as a function of monitor type and configuration

	Transient	Steady-state	Static
M-series configured for transient (sampling as a function of machine RPM) data capture	●	●	●
M-series configured for steady-state (sampling as a fixed function of time) data capture		●	●
M-series monitors not configured for either transient or steady-state data capture, OR non-M-series monitors			●

A.4 3500 monitor compatibility with TDI

All 3500 monitor modules currently being shipped, and those produced since Spring 2001, are compatible with TDI. 3500/40M, 3500/42M, 3500/44M, 3500/46M, and 3500/64M modules produced between July 1999 and Spring 2001 may require an upgrade to the PWA (printed wiring assembly) if it carries revision F or earlier. All other modules are compatible, regardless of when they were produced. See Table A-3.

Table A-3: 3500 monitor compatibility with TDI		
Compatible, supplies static data only	Compatible, can be configured to supply transient and/or steady-state and/or static data	Not Compatible (requires PWA upgrade)
<ul style="list-style-type: none"> • 3500/40 (non-M-series) • 3500/42 (non-M-series) • 3500/44 (non-M-series) • 3500/45 • 3500/50 • 3500/53 • 3500/60 • 3500/61 • 3500/62 • 3500/63 • 3500/65 • 3500/82 	<ul style="list-style-type: none"> • 3500/40M with revision G or later PWA • 3500/42M with revision G or later PWA • 3500/44M with revision G or later PWA • 3500/46M with revision G or later PWA • 3500/53M • 3500/54M • 3500/64M with revision G or later PWA • 3500/70M • 3500/72M • 3500/77M 	<ul style="list-style-type: none"> • 3500/40M with revision F or earlier PWA • 3500/42M with revision F or earlier PWA • 3500/44M with revision F or earlier PWA • 3500/46M with revision F or earlier PWA • 3500/64M with revision F or earlier PWA

A.5 How to determine if an affected monitor has a Printed Wiring Assembly (PWA) with revision G or later

Only those monitor types in the right-hand column of Table A-3 are potentially incompatible with TDI. In most cases, checking the revision level can be done using 3500 configuration software and does not require removal of the monitoring module from the rack for visual inspection. Contact your Bently Nevada sales professional for assistance.

A.6 Upgrading affected modules

The monitors in the left-hand and middle columns of Table A-3 are compatible with TDI as-is and require no upgrades. If you only want to obtain static data from the non-M-series 3500/40, 3500/42, or 3500/44 monitors, or do not want to use TDI in the rack, they do not need to be upgraded. However, if you want waveform data from these monitors, they must be upgraded to M-series. Contact your Bently Nevada sales professional for upgrading assistance.

The monitors in the right-hand column of Table A-1 are not produced as M-series modules and therefore they are compatible with TDI as-is. They require no upgrades.

The monitors in the right-hand column of Table A-3 are not compatible with TDI and must be upgraded if they are to be used in the same rack as TDI, even if the TDI functions are not enabled. Contact your Bently Nevada sales professional for instructions on how to upgrade these monitor modules.

Consult the factory or your local Bently Nevada sales professional for further details on upgrading monitor modules as well as the compatibility and interchangeability of M-series and non-M-series racks and modules.

