Bently Nevada
a Baker Hughes business

Online Periodic Condition Monitoring

Background

Technology based machinery condition monitoring and evaluation became mainstream across multiple industries and plantwide machinery assets in the late 1980s and early 1990s. This was precipitated by the development of the route based portable vibration data collector with data evaluation applications run on personal computers. 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, otherwise invisible damage or degradation so that it could be corrected in advance of surprise operational failure. This worked well in many cases, however monitored machinery still experienced failures that developed and progressed in between scheduled monitoring intervals.

Online monitoring became the solution for addressing machinery that exhibited failures more rapidly than could be detected using portable systems on a monthly basis and were of high enough value to the business to justify the expense of a permanent installation. The original online monitoring systems were developed from potable data collectors with a controllable multiplexer and were permanently connected to the data collection and evaluation software. The term "On-Line Scanning" describes the periodic nature of multiplexed systems, where sensor channels are "scanned" or cycled through individually or in small groups. These systems were always monitoring data, but the individual channels themselves were not being monitored continuously. Another term for this use case is "On-Line Surveillance."

Technology has advanced significantly since the original online periodic monitoring systems were developed and released. Today, nearly all wired vibration-based condition monitoring systems monitor all channels simultaneously and at a near continuous rate.

General considerations

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. 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.

The three primary considerations for installing an online monitoring system are:

1. The data needs to be collected and evaluated more frequently than it is cost effective for a person to go out and do it 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 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 monitoring 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 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 cost consequence technology implementation relationship.

Consequence based technology implementation

Machinery protection, which requires continuous, permanent connection to sensors for shut-down and control purposes, is out of scope for this document, except for the fact that many machinery protection systems also offer continuous high-resolution data, ideal for condition monitoring purposes. Machine criticality and machine protection are not directly related. Figure 2 shows the generalized relationship between Bently Nevada instruments in terms of initial detection to failure intervals.

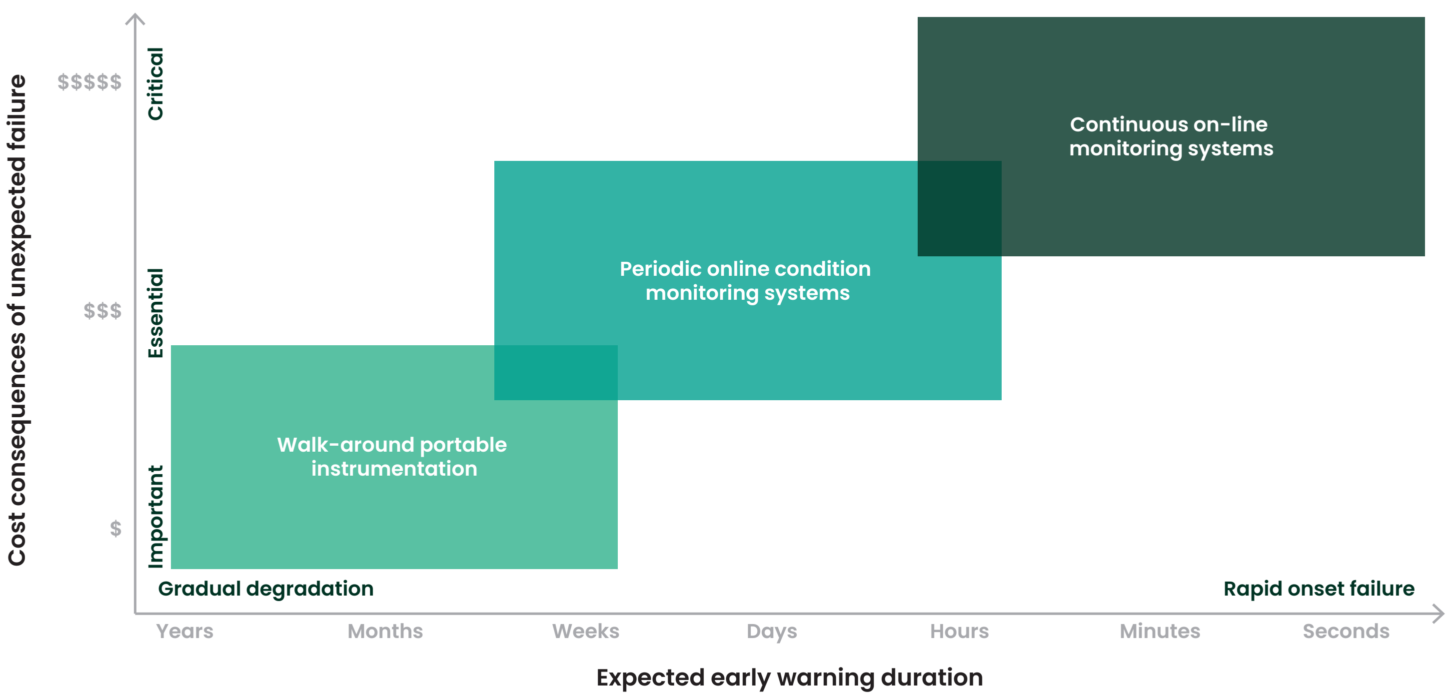

Figure 1 – Cost consequences vs. required data collection time

Our instruments for earliest detection-to-failure intervals

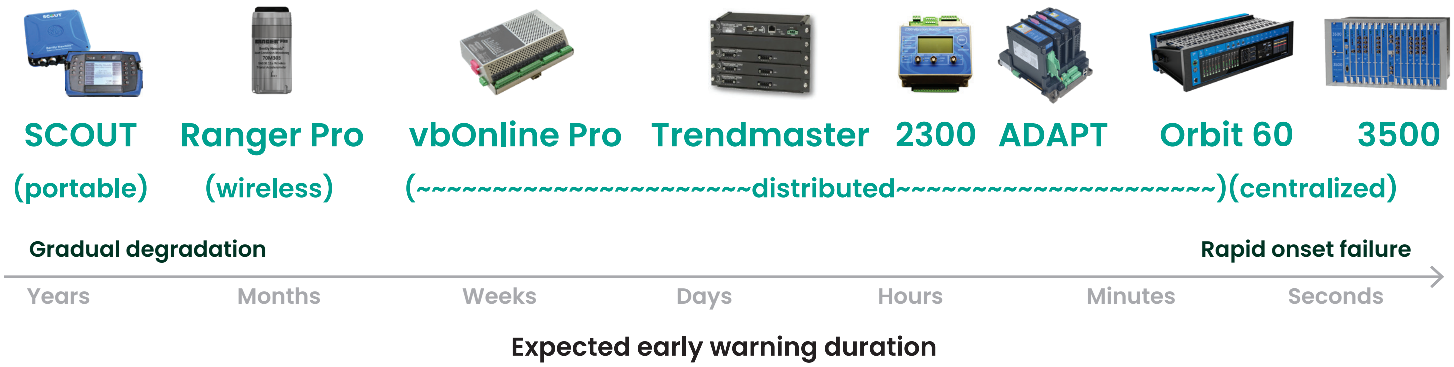

Figure 2 – Instrumentation vs. detection-to-failure interval

Bently Nevada online periodic condition monitoring instrument solutions

Online periodic condition monitoring absolutely requires System 1 because the instruments themselves generally do not have a direct mechanism for alerting users to the earliest indication of a problem. These instruments collect high resolution data but have minimal to no onboard capabilities to interpret the data into meaningful information. System 1 is required to add the deep analysis into the “what the data is trying to tell us” early warning capability via software alarms.

Specific considerations

Understanding the operating nature and physical make-up of the machines to be monitored is critical. Several questions need to be answered about each individual machine to be monitored because the answers lead to specific instrument selection.

For example, all reading this document should understand the differences between monitoring machines with journal bearings and monitoring machines with rolling element bearings – the primary differences being the sensors. The sensor selection drives the online monitoring instrument selection by initially eliminating those instruments that do not support them. Journal bearings require proximity probes while rolling element bearings require accelerometers. Table 1 below shows which online monitoring instruments support measurements on which bearing types and which sensors are supported.

Instrument	Journal bearing	Rolling element bearing and/or gearbox	Supported sensor types					
			Acceleration	Velocity	Displacement	Temperature	Process	Tach
Ranger Pro	No	Yes	Built-in	Built-in	No	Built-in	No	No
vbOnline Pro	No	Yes	IEPE/ICP	No	No	No	No	Yes
Trendmaster	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
2300	Partial	Yes	Yes	Yes	Yes	Yes	Yes	Yes[1]
Adapt MDM	Yes	Yes	Yes	Yes	Yes	No	No	Yes
3500	Yes	Partial	Yes[2]	Yes	Yes	Yes	Yes	Yes
Orbit60	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] 2300 supports pulse-based speed measurements but des not use it for synchronous sampling or order-based processing

[2] While 3500 can take input from any type of accelerometer, it does not support the advanced signal processing required for early rolling element bearing defect detection, such as DEMOD

Table 1 – instrument by bearing and sensor type

Signal processing capabilities need to be considered to ensure that the selected instrument will be capable of providing the data necessary to properly determine and characterize machine operating health. Table 2 presents the most important signal processing capabilities of each BN online monitoring type.

Signal processing parameter	Ranger Pro	vbOnline Pro	Trendmaster	2300	Adapt MDM	3500	Orbit 60
Asynchronous dynamic sampling	☑	☑	☑	☑	☑	☑	☑
Synchronous dynamic sampling	☒	☑	☑	☒	☑	☑	☑
Asynchronous DEMOD sampling	☑	☑	☑	☑	☑	☒	☑
Synchronous DEMOD sampling	☒	☑	☒	☒	☑	☒	☑
Direct (overall, wfm pk)	☑	☑	☑	☑	☑	☑	☑
Direct (overall RMS)	☑*	☑	☑	☑	☑	☑	☑
Spectrum Bands (from the device)	☒	☒	☑	☑	☑	☑	☑
Normal trended variable max data rate	10 minutes	30 seconds	10 minutes	1 second	1 second	1 second	1 second
Normal dynamic min data rate	6 hours	10 minutes	24 hours	10 minutes	10 minutes	10 minutes	10 minutes
State change data set	☒	☑	☒	☒	☑	☑	☑
Alarm data set	☑**	☑	☑	☒	☑	☑	☑

* RMS spectrums only

** Collection rates based on user set limits

Table 2 – signal processing by instrument

The next most important consideration for how to monitor a machine using BN's online monitoring instruments is how the machine normally operates. The questions that need to be considered are:

- What is the operating history of the machine?
  - What failure modes are expected to be targeted?
  - What is the expected duration from initial detection of the failure modes to actual machine functional failure
- What is the customer's expected data repetition interval for condition monitoring?
- Is some level of summary data expected to be made available to
- Operating speed:
  - Constant, or
  - Variable
- Operating load:
  - Constant, or
  - Variable
- Operating nature:
  - Constant
  - Intermittent
  - Transient by nature
  - Transient by exception, or
  - Cyclic (meaning multiple discrete operating states throughout its normal use)
- If the operating nature of the machine is variable:
  - How many operating states can be defined such that meaningful, consistent data can be collected to support machine health determination
  - What digital data is available to support determining machine operating state
  - What sensors are available to support determining machine operating state, and
  - What sensors could be added to support determining machine operating state

Table 3 shows a generalized set of capabilities to monitor based on various machine operating characteristics by instrument.

Machine operating characteristic	Ranger Pro	vbOnline Pro	Trendmaster	2300	Adapt MDM	3500	Orbit 60
Constant speed	☑	☑	☑	☑	☑	☑	☑
Variable speed	☑	☑	☑	☑	☑	☑	☑
Constant load	☑	☑	☑	☑	☑	☑	☑
Variable load	☑	☑	☑	☑	☑	☑	☑
Intermittent	☑	☑	☑	☒	☒	☒	☑
Cyclic	☑	☑	☒	☒	☒	☒	☑
Transient by nature	☒	☑	☒	☒	☒	☒	☑
Transient by exception	☒	☑	☒	☒	☑	☑	☑

Table 3 – instrument applicability by machine operating characteristics

The final set of considerations relate to the customer's preferred IT infrastructure and the "quality" of connectivity to the planned instruments.

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