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New Piston Rod Condition Monitoring Functionality for Bently Nevada 3500/72M Rod Position Monitor

The 3500/72M Recip Rod Position Monitor is a four-channel device that accepts input from Proximity probes. The sensor(s) measure the position of the reciprocating piston rod relative to the pressure packing case on a revolution to revolution basis. The monitor uses the signals to drive alarms and protect assets. The 3500/72M Rod Position Monitor provides waveform data to System 1 via a 3500 Transient Data Interface Module (TDI).

Abstract

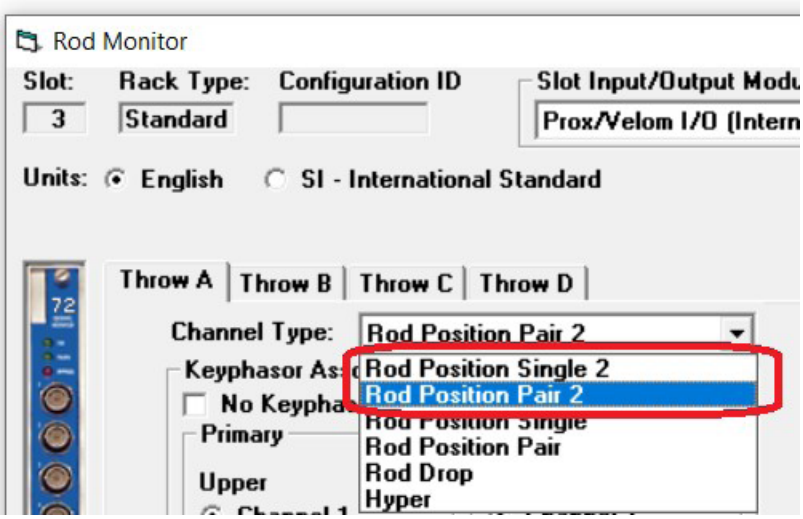
In the past, customers had to choose to measure either the rider band wear by configuring rod drop or they had to choose to monitor the piston rod position, which includes the important peak to peak displacement for rod vibration measurement for machinery protection. Some customers chose to have the incoming transducer signal divided to import it to one channel configured as rod drop and one channel as piston rod position. Bently Nevada is now introducing new channel types for the 3500/72M which combine measurements from both rod drop AND rod position.

Previously, this monitor had four channel types each with various options for monitoring piston rods or hyper plungers. These four channel types are:

- Rod Position Pair
- Rod Position Single
- Rod Drop
- Hyper (Plunger)

Enhancements

The enhanced functionality in 3500 configuration version 6.0 and newer adds two channels: **Rod Position Single 2** and **Rod Position Pair 2**. Each of these new channels combines measurements from the Rod Drop Channel type with select measurements from Rod Position Single and Rod Position Pair channel types respectively.



These new channel types are compatible with System 1 Evo version 18.2 and newer. These new channel types are not compatible with any previous version of System 1.

The two new channel types incorporate the following measurements from the original Rod Position Pair and Rod Position Single channel types:

- Pk Displacement (piston rod vibration)
  - This is the primary variable for the monitor channel. This measurement is recommended for machinery protection by Bently Nevada.
- Position Magnitude
  - The maximum displacement with respect to the calculated hot bore center reference.
- Position Angle
  - The angle made by the vector representation of the maximum position magnitude referenced from the top of the piston rod in clockwise direction when viewed from the crank end of the cylinder.
- Crank Angle
  - The point in the stroke where the maximum position magnitude occurs.
- Gap
  - Voltage.

In addition, the new channel types incorporate the following measurements from the Rod Drop channel type:

- Average Piston Position,
- Instantaneous Piston Position, and
- Instantaneous Probe Gap.

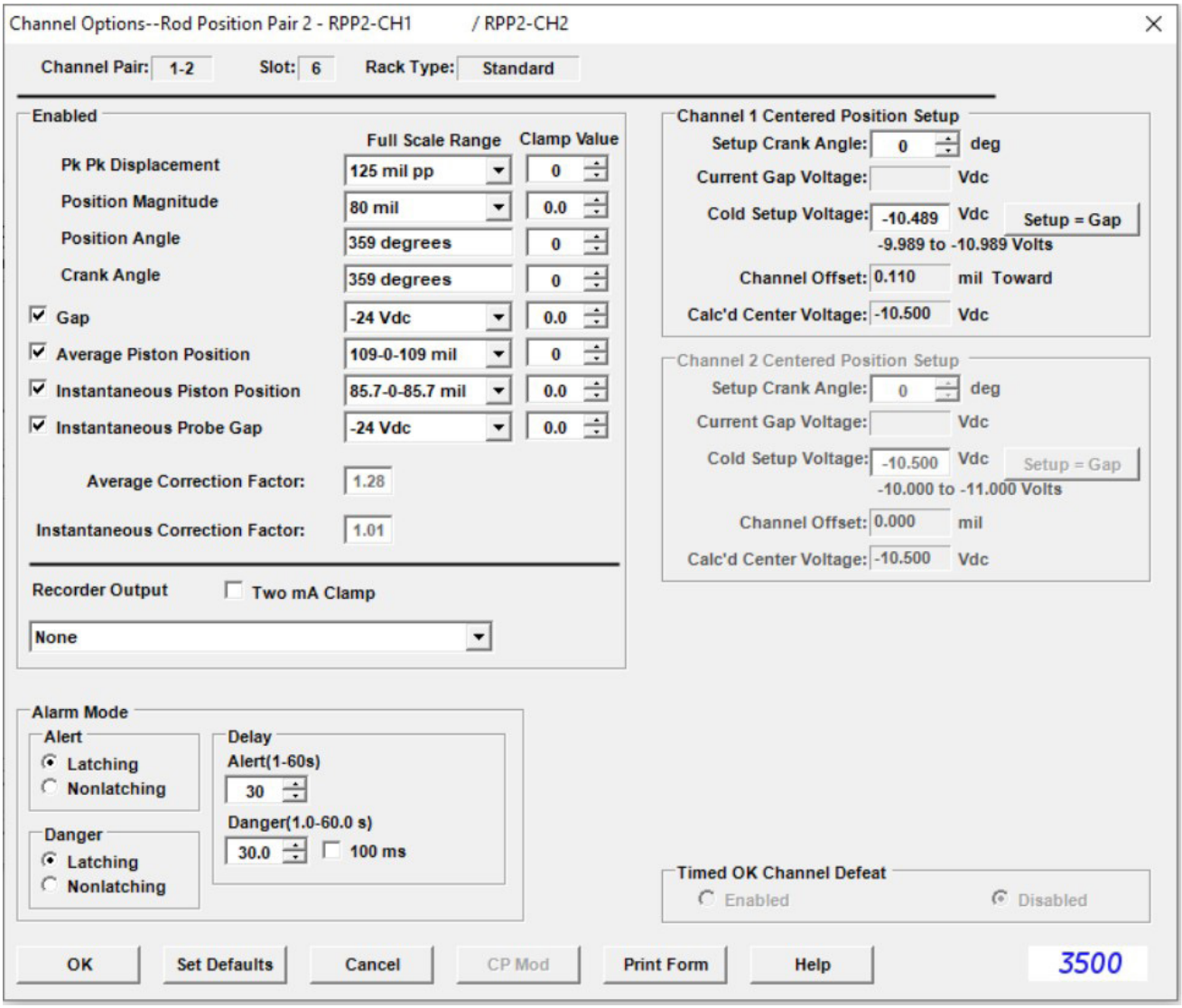
This combination of measurements allows a single channel to provide both the extrapolated rider band wear indication from the Rod Drop channel and the piston rod vibration measurements from the Rod Position Single and Rod Position Pair channels.

A summary of the measurements available for each channel type are:

Rod Position Pair 2:	Rod Position Single 2:
Pk-Pk Displacement	Pk-Pk Displacement
Position Magnitude	Position Magnitude
Position Angle	Position Angle
Crank Angle	Crank Angle
Gap	Gap
Average Piston Position	Average Piston Position
Instantaneous Piston Position	Instantaneous Piston Position
Instantaneous Probe Gap	Instantaneous Probe Gap

Rod Position Pair:	Rod Position Single:
Position Magnitude	Position Magnitude
Position Angle	Position Angle
Crank Angle	Crank Angle
Pk-Pk Displacement	Pk-Pk Displacement
Gap	Gap
1X Amplitude	1X Amplitude
2X Amplitude	2X Amplitude
Not 1X Amplitude	Not 1X Amplitude

Rod Drop:	Hyper:
Average Piston Position	pp Disp
Average Probe Gap	Gap
Instantaneous Piston Position	1X Ampl
Instantaneous Probe Gap	2X Ampl
	Not 1X Ampl



A Hot Zero setting process must not be attempted for the rod drop measurements on Rod Position Single 2 and Rod Position Pair 2 channel types. The new channel types use the calculated center voltage for the hot bore center and the zero position reference for select rod position measurements and the rod drop measurements. Thus, the Zero Reference setting process must be performed under cold conditions when the piston top and bottom clearances are acquired (the compressor is stopped).

There are restrictions for these combined measurements in how the proximity probes are to be configured. The Rod Position Single 2 is the same as Rod Position Single in that it is always a vertical probe orientation, either directly above the piston rod with a 0° transducer orientation angle or directly below the piston rod with a 180° transducer orientation angle. The only restriction is that the channels must be configured in channel pairs; channels 1&2 must be configured as the same channel type and channels 3&4 must be configured as the same channel type. This restriction has always been present.

The restrictions for the Rod Position Pair 2 relate to probe assignment to channels. The Rod Drop measurements of the Rod Position Pair 2 channel type are taken from the true vertical probe so the vertical probe (either directly above the piston rod with a 0° transducer orientation angle or directly below the piston rod with a 180° transducer orientation angle) must be assigned to (connected to) the odd number channel of the channel pair. This is either channel 1 of the 1&2 channel pair or channel 3 of the 3&4 channel pair. Then the horizontal probe is mounted orthogonal (90°) from the vertical probe and is connected to the even number channel of the channel pair (channel 2 for the 1&2 channel pair or channel 4 for the 3&4 channel pair). The horizontal probe is to be mounted in the true horizontal plane and can either be mounted 90° L or 90° R, referenced from the top of the piston rod in clockwise direction when viewed from the crank end of the cylinder.

History

The use of proximity probes as a condition monitoring input has its origins in the mid 1960's. However, the Rod Drop measurement was formalized in the 1990's [1] well before the introduction of the 3500 monitoring system. The proximity probe mounts in the true vertical orientation, either directly above the piston rod or directly below the piston rod. The rod drop measurement attempts to provide users with an indication of rider band wear inside the cylinder by measuring the probe voltage, subtracting this relative value from a reference voltage taken with the rider bands in new condition, and using similar triangles to extrapolate the change in piston position inside the cylinder. This approach makes assumptions which must be validated against the actual machine configuration. For more details see [2, 3, 4].

Rod Position Single uses one proximity probe and is also mounted in the vertical plane either directly above the piston rod or directly below the piston rod. This channel type provides a method to position magnitude value referenced to the hot center of the cylinder bore which is determined within the monitor. With one probe, the position angle would either be 0° (indicating the piston rod was above the center) or the position angle was 180° (indicating the piston rod was below the center of the cylinder bore). Additionally, this channel type provides the piston rod vibration (Pk-Pk Displacement).

Rod Position Pair uses two proximity probes mounted orthogonally at the pressure packing case to give users a perspective of the piston rod maximum movement during a stroke. This is the Position Magnitude variable of the position vector. This channel type calculates the hot center location for the cylinder bore and references the position magnitude to this center value. Additionally, this channel type provides piston rod vibration for both probes. Pk-Pk displacement values have proven to provide an early indication of issues with piston rod due to unusual flex motion and is generally the primary warning indicator of a potential piston rod or crosshead break. When combined with the System 1 condition monitoring software, changes in the location of the rod position waveform with respect to the center reference could also provide indications of rider band wear. But there was no direct trendable variable to reflect this. Adding the Average Piston Position and Instantaneous Piston Position variables from the Rod Drop channel type to the Rod Position channel types provides a means for trending possible changes in rider band wear.

References

1. De Waal, Cornelis G. Apparatus for Measuring The Thickness of Piston Rider Rings. Bently Nevada Europa B.V., assignee. Patent 4,987,774. Jan. 29, 1991.
2. Schultheis, S. M., and Howard, B. F., Rod Drop Monitoring, Does It Really Work?, Proceedings of the 29th Turbomachinery Symposium, Texas A&M University, Houston, TX, 2000.
3. Howard, Brian. "Rod Drop – Getting It Right." Orbit, pp55-61, first Quarter 2004.
4. Hala, Roger. "Is Rod Drop the Right Measurement for My Reciprocating Compressor?" General Electric. GER-4274, August 2006.

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