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Wireless Connecting Rod Temperature Measurements for Reciprocating Compressor Monitoring

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Reciprocating Compressor Condition Monitoring

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Introduction

Undetected bearing failures result in long outages and extensive repairs for reciprocating machinery. In slow speed reciprocating compressors and engines, main bearing temperature monitoring has proven to be valuable in assessing bearing condition^{1,2}. Monitoring of the moving bearings at either end of the connecting rod has proven to be more difficult. As the crankpin bearing often shares design features with the main bearing, temperature measurements on this bearing would have the same benefits as it does on the main bearings. On the other end of the connecting rod, industry experience in operating reciprocating compressors has shown how important loads and reversal can be in determining the crosshead pin bushing condition^{3,4,5}. The ability to correlate these loads with temperature results in improved ability to determine crosshead pin bushing condition.

Eutectic devices have provided one method for indicating bearing temperature. In recent years a radar-based wireless temperature system has come to the market that enables end-users to make connecting rod bearing temperature measurements on-line. This application note provides background on the radar measurement, legacy discrete measurement technology, detail on the installation arrangements and describes how to interface it with GE's Bently Nevada* 3500 Series Monitoring Systems and System 1* Condition Monitoring Software (referred to as 3500/S1 hereafter).

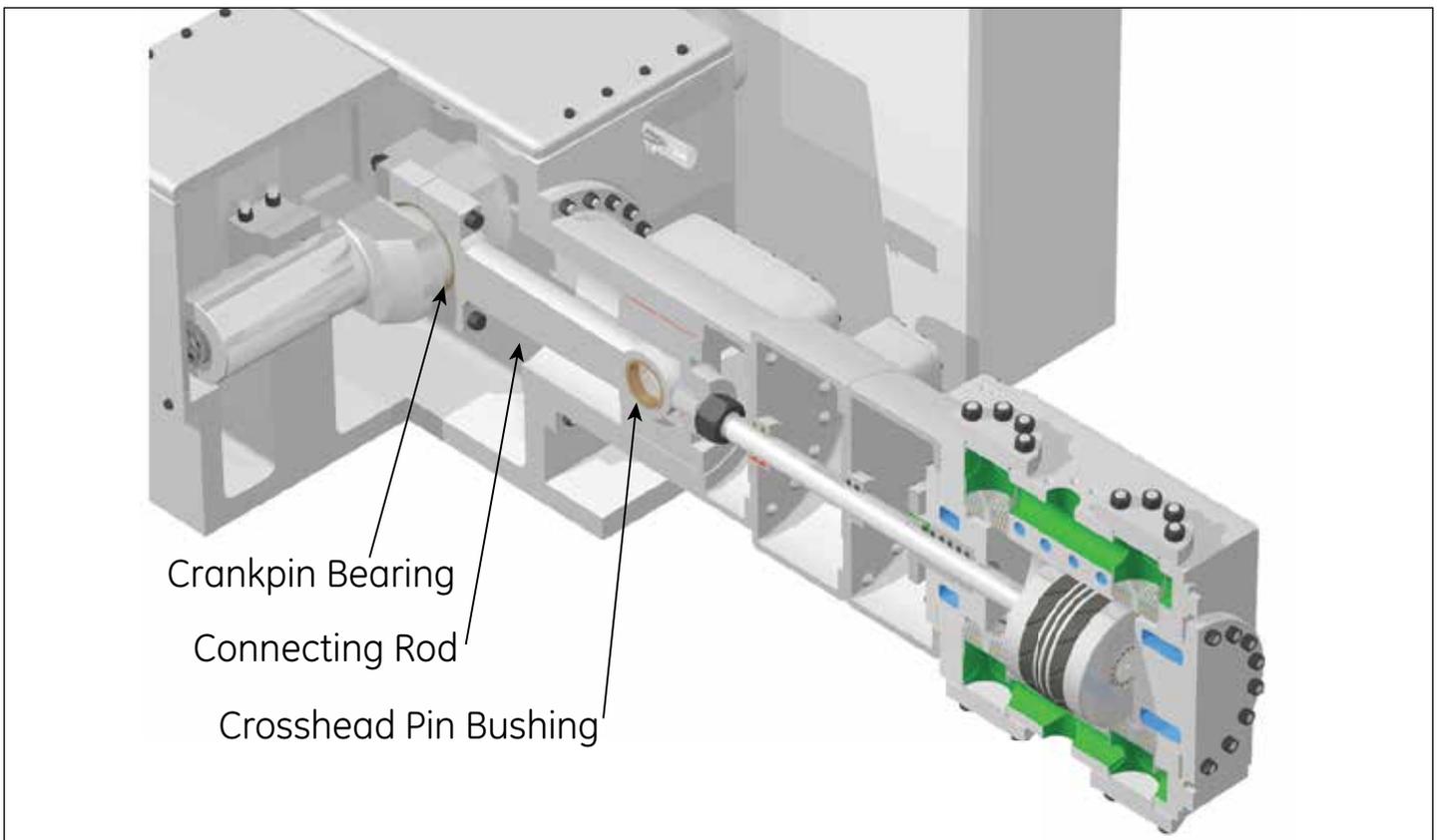


Figure 1. Reciprocating Compressor Assembly.

Eutectic-Style Connecting Rod Bearing Temperature Installation Arrangements

The relative motion between the connecting rod and compressor frame presents a special challenge to those trying to make a temperature measurement on the main connecting rod bearing and crosshead pin bushing. One technique that has been used for decades involves installing a device assembled with a eutectic alloy weld that melts at a pre-determined temperature⁶.

When the local temperature reaches the melting point of the fusible alloy used to weld the actuator rod to the spring retainer end, the inner spring forces the actuator rod out through the detector body (See Figure 2 and Figure 3 for installation details).

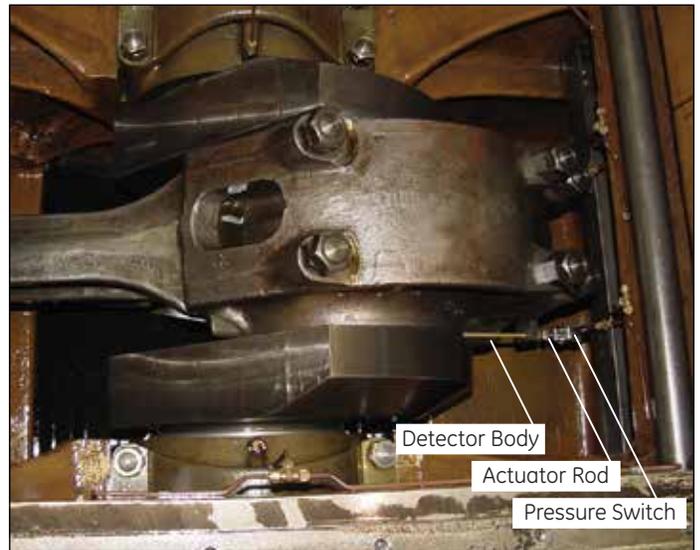


Figure 3. Crankpin Eutectic Switch Installation.

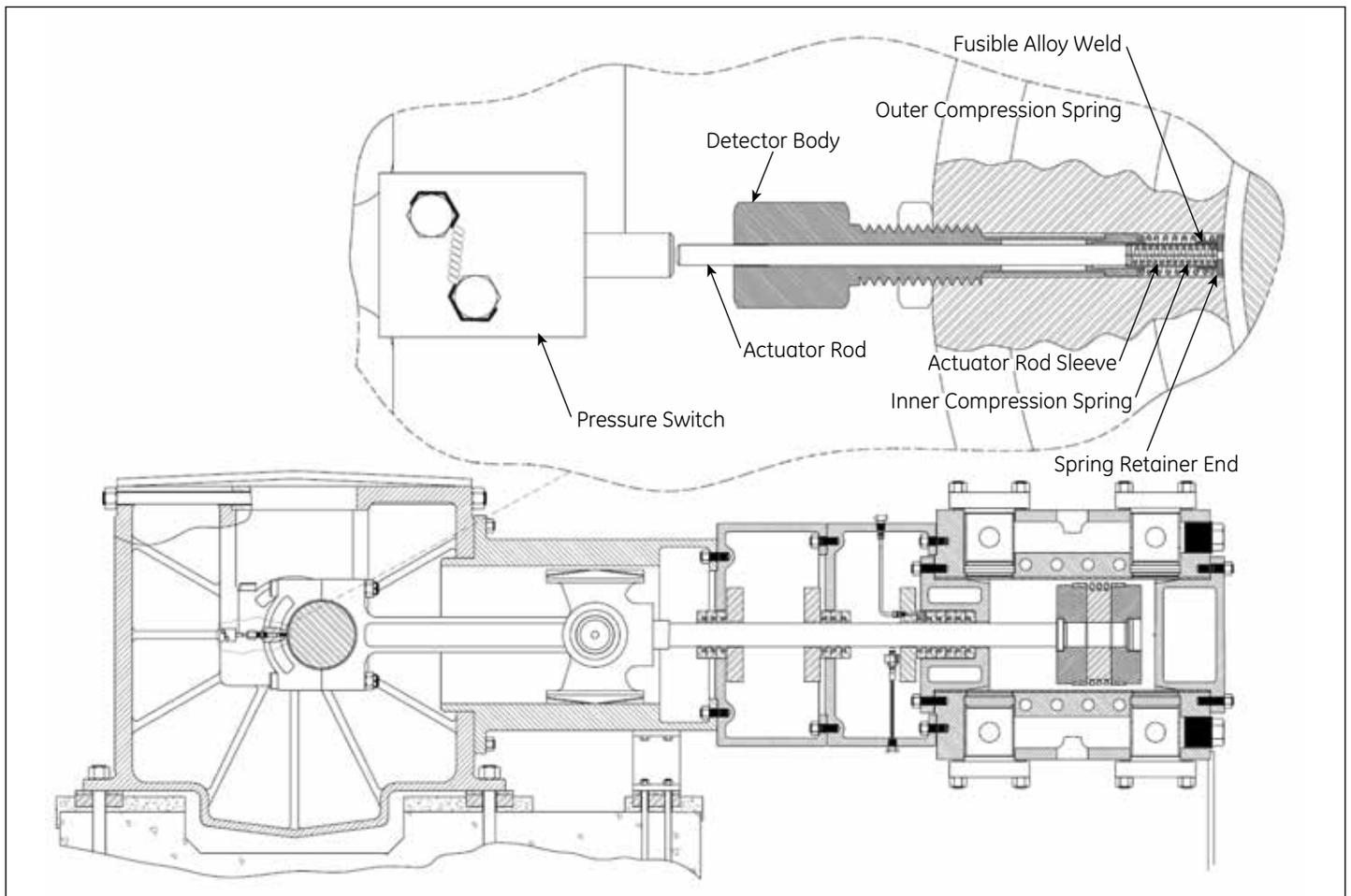


Figure 2. Eutectic-Type Wireless Switch Arrangement. Re-drawn from (6).

The extension of the actuator rod allows contact with a pressure switch. The contact with the pressure switch opens the line to atmosphere, releasing air pressure in the sensing line. The drop in pressure causes a pressure switch connected to this line to change state. This switch, in turn, provides an alarm for the operators.

Integration to Reciprocating Compressor Condition Monitoring System

The 3500/62 Process Variable monitor, combined with an external power supply, can be used to detect a change in state

of the pressure switch as shown in Figure 4. Although this method involves more cost than using the discrete input of a PLC or DCS, it has the advantage of driving data collection directly on the 3500 rack when an alarm condition is reached. This high-resolution alarm event dataset includes the static and dynamic data from the compressor and is very useful when trying to understand what led to a change in machine condition. In particular, when the condition monitoring system includes crosshead pin bushing temperature and cylinder pressure data, the effects of overload and/or lack of reversal can be effectively assessed.

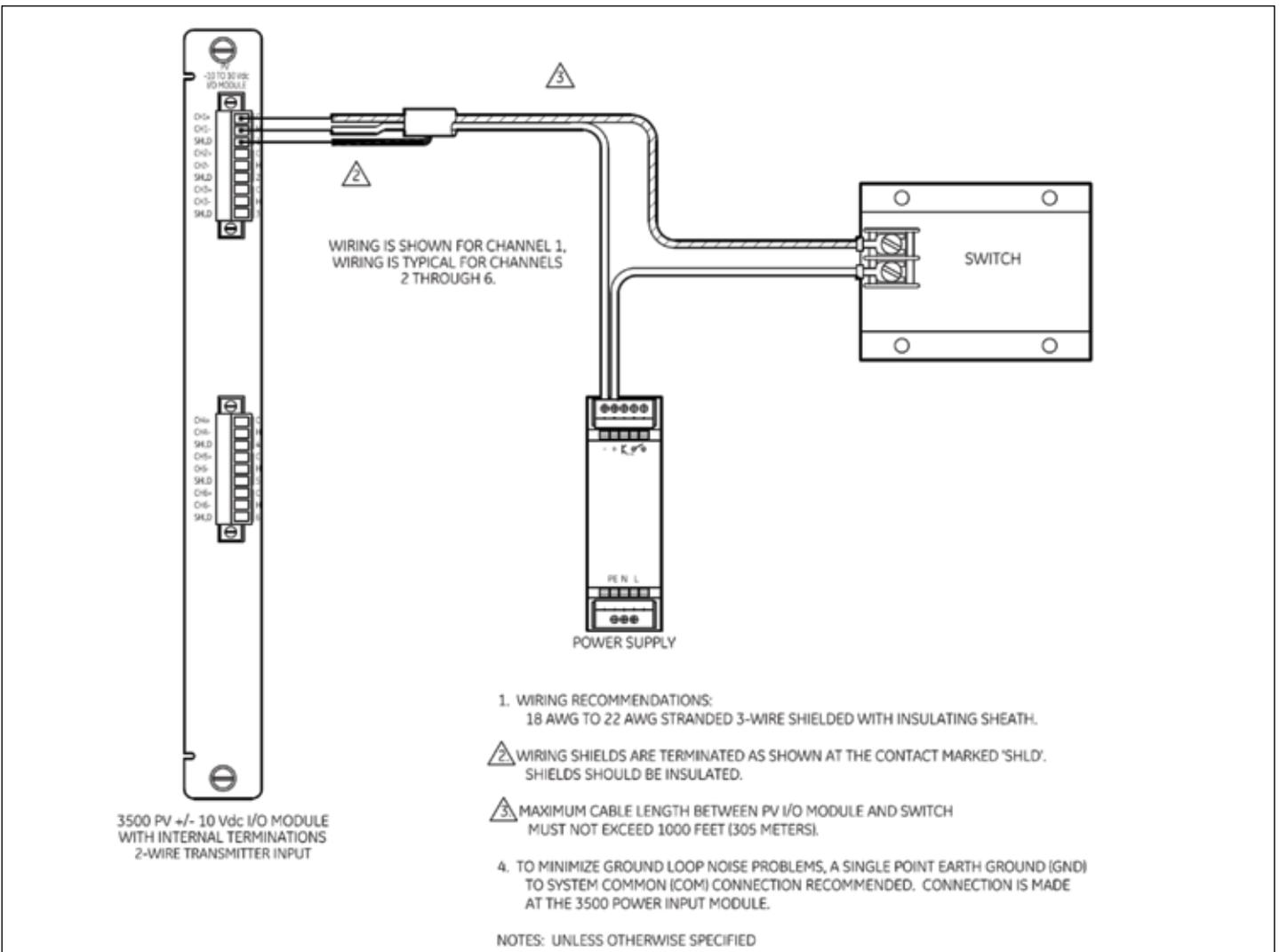


Figure 4. 3500/62 Process Variable Monitor Field Wiring (Internal Terminations Shown, External Terminations Similar).

Wireless Connecting Rod Bearing Temperature Installation Arrangements

Radar-based wireless temperature sensors have gained acceptance in application to low speed reciprocating compressors. These systems enable trending of moving bearing temperature, rather than the discrete values provided by the eutectic systems.

The concept for radar-based sensors grew out of technology used for tagging automobiles as they pass through automated toll collecting systems⁷. Initial testing of these toll identification systems revealed an appreciable sensitivity to temperature. While this made reading the tags difficult, it turned out that the system could be used to estimate temperature.

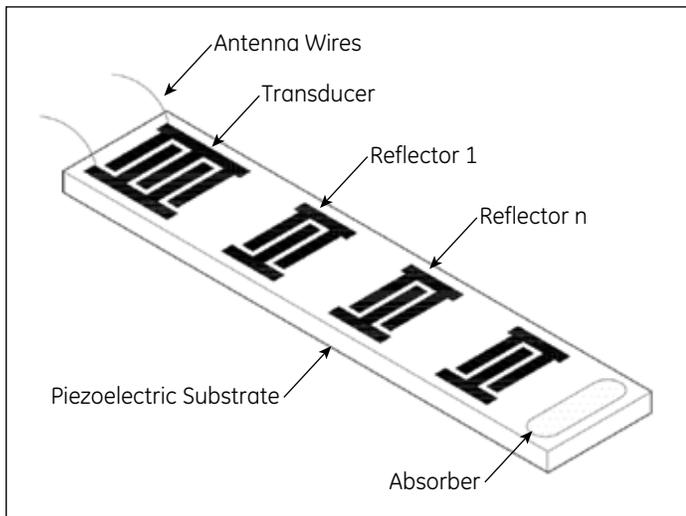


Figure 5. Radar Sensing Element. Re-drawn from (7).

Unlike traditional wireless radio frequency systems, which require power to transmit a signal, radar-based systems induce a signal in the moving component. This has the advantage of not requiring power for the moving component.

The measurement process begins when the stationary antenna outputs an interrogation pulse. When this pulse reaches the antenna wires, the electromagnetic energy excites elastic surface waves that radiate out from the transducer on the sensing element substrate. The acoustic waves travel from the transducer to each of the reflectors mounted on the substrate. When the waves reach a reflector, an electromagnetic pulse is generated that is then picked up by the stationary antenna.

The speed of the surface acoustic wave propagation through the substrate is much lower than the speed of light. The resulting delay between the interrogation pulse and pulse response from the moving sensors allows the signal processing equipment to separate out the valid sensor responses from electromagnetic echoes within the compressor frame⁷. The signal processing equipment then evaluates the shape and spacing interval of the pulse response from the sensing element to determine the temperature of the probe tip.

Figure 6 shows the typical packaging layout and radar signal path. The assembly on the left mounts in either the crank pin bearing or crosshead pin/crosshead pin bushing. The stationary antenna mounts to the compressor frame. The air gap between the moving and stationary elements can be as large as 50 mm (1.97 in)⁷. Figure 7 shows the mechanical installation of the wireless temperature sensor.

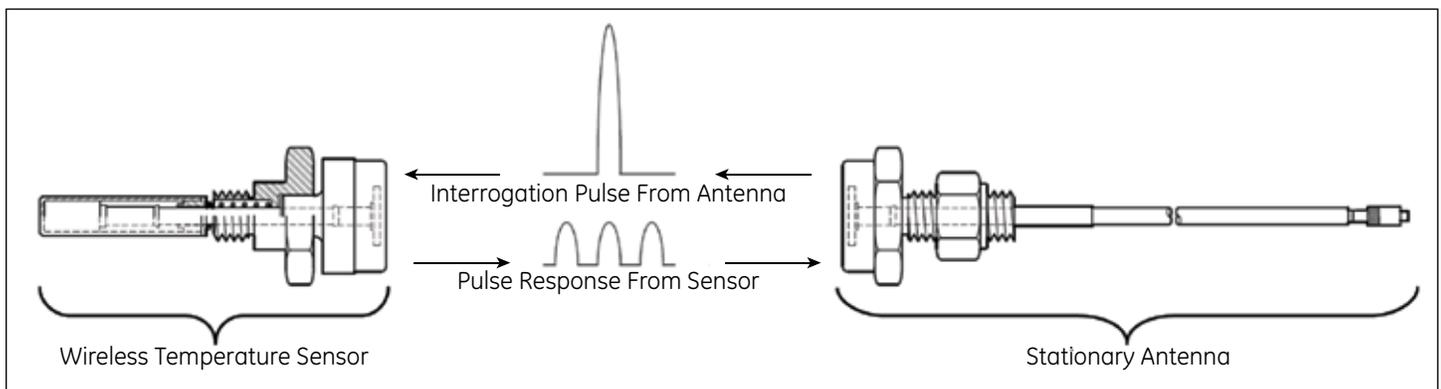


Figure 6. Radar-Based System Arrangement. Redrawn from (7).



Figure 7. Wireless Temperature Sensors Installation on Connecting Rod.

Integration to Reciprocating Compressor Condition Monitoring System

The radar-based systems provide a continuous signal, available for trending and analysis. Kongsberg's Sentry system has gained acceptance in reciprocating compressor application in the downstream/petrochemical segments and will be used as an example of integration to 3500/S1.

The Sentry system has the ability to output a 4-20mA signal that can be accepted by the 3500/62 process variable monitor. Figure 8 shows a field-wiring diagram for the Sentry system connected to a 3500/62 monitor. Figure 9 shows a sample of one of the channel configuration options. Table 1 outlines initial alarm and filter settings for the monitor.

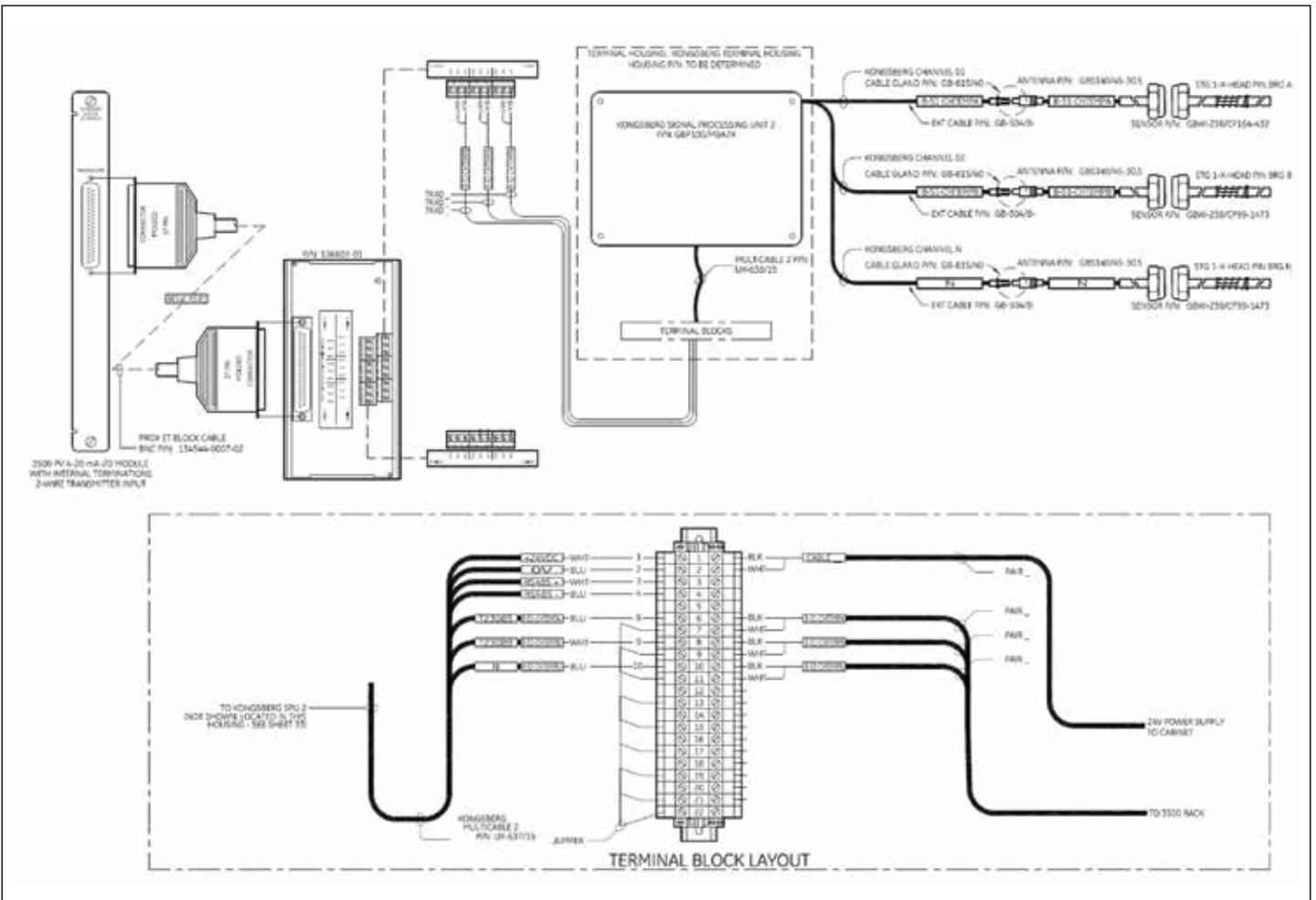


Figure 8. 3500/62 Process Variable Monitor Field Wiring (External Terminations Shown, Internal Terminations Similar).

Filtering 93°C)	Not Applicable
Alarm / Danger - In the absence of OEM recommendations or engineering data, these are the recommended* initial alarm and danger set points.	Alarm: 200°F (82°C)
	Danger: 220°F (
*These should be adjusted based on actual operating conditions	

Table 1. Initial Monitor Alarm and Filter Settings.

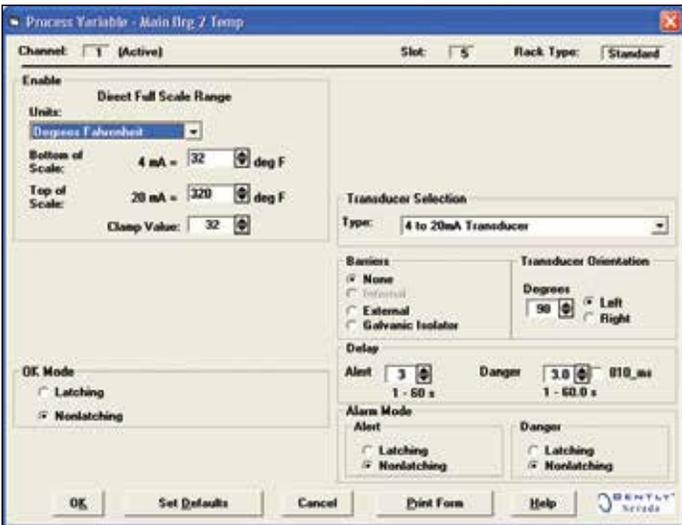


Figure 9. 3500/62 Process Variable Configuration Screen.

Within System 1 software, the points should be mapped to the respective throws as shown in Figure 10. No associations are required for these points.

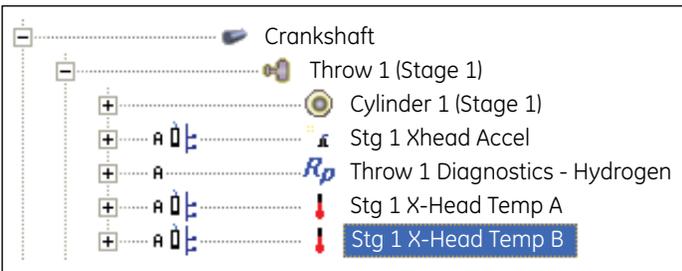


Figure 10. Radar-Based Temperature Mapping.

Software alarms can be set, if desired. In the case that the Cylinder Trim RulePak has been installed, the result of the crosshead pin condition rule can be combined with the temperature measurement to drive an alert specific to crosshead pin wear as shown in Figure 11.

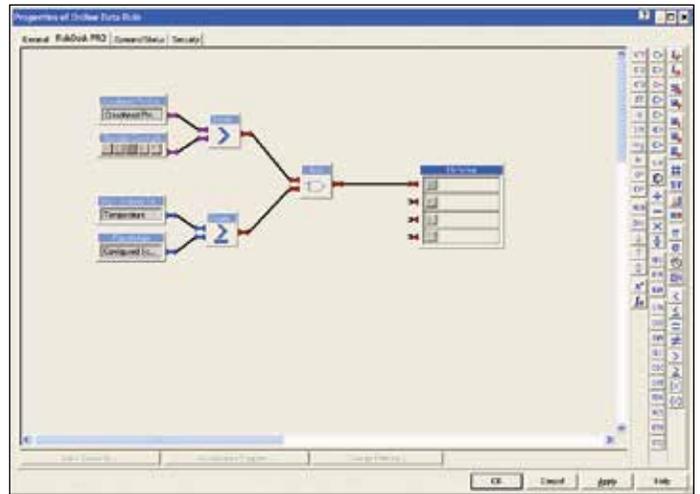


Figure 11. Sample Rule Combining Pin Load and Radar-Based Wireless Temperature.

System 1 Display client plot sessions should include a plot group with a trend of degrees of reversal, combined rod load tension/compression, crankpin bearing temperature and crosshead bushing temperature. Figure 12 shows a sample of this plot arrangement.

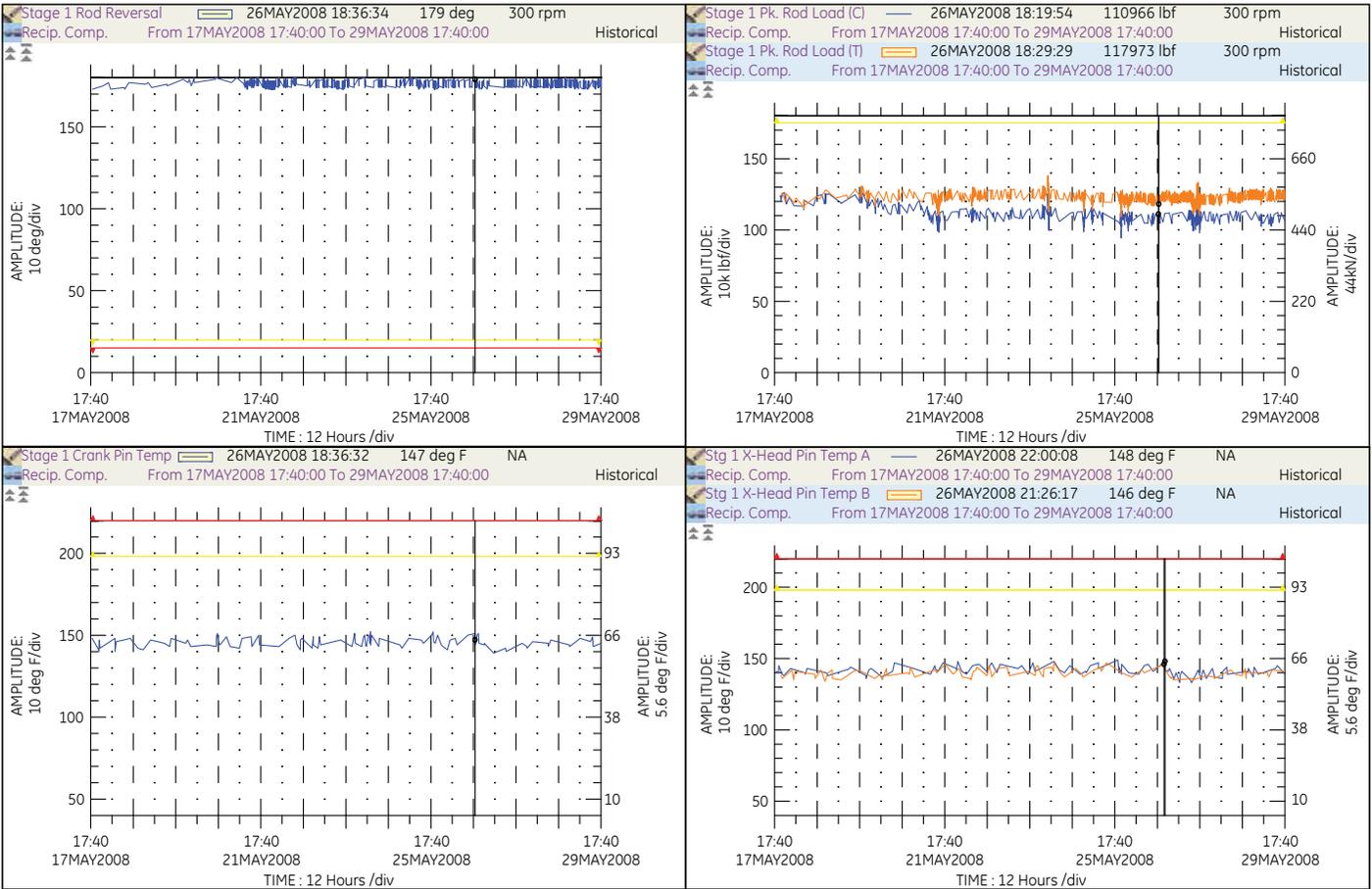


Figure 12. Radar-Based Temperature Plot Group Layout.

Conclusion

The wireless measurement systems provide critical information about the health of the connecting rod bearings. Combining this measurement with other condition monitoring parameters provides helpful insight into machine condition.

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