Case History:

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Carbon Seal Rub on a Steam Turbine

Summary – This article describes the effects and vibration responses when carbon seal rubs are experienced on a steam turbine and procedures for correction.

We received a call concerning a steam turbine unit driving a 32 inch gas blower at a chemical plant. The turbine had just undergone a yearly PM, replacing the bearings and seals. When the unit was brought back on line the vibration levels increased to trip conditions at 2920 rpm and shut the unit down. We found this to be quite odd since the critical speed of the turbine or blower is not at 2920 rpm. Several attempts to start the unit followed with the same results. We set up a multi-channel monitoring system to measure all of the X-Y proximity probes installed in a Bently Nevada 3300 system and the case vibration at all the bearing cap locations with magnetic base accelerometers.

The initial set of data, captured during the start up, revealed high vibration amplitudes at the drive end X turbine bearing probe that eventually increased to trip conditions and shut the unit down. During the excursion the amplitude overloaded our set point of 10 Mils on the data collector. The bearing clearances for the drive end bearing is .008 ″ and therefore we were concerned about the bearing condition after this 10 + mil excursion. Case vibration at the same bearing position was also extreme at .8 In/Sec pk. We also noted that the drive end Y probe was not working correctly.

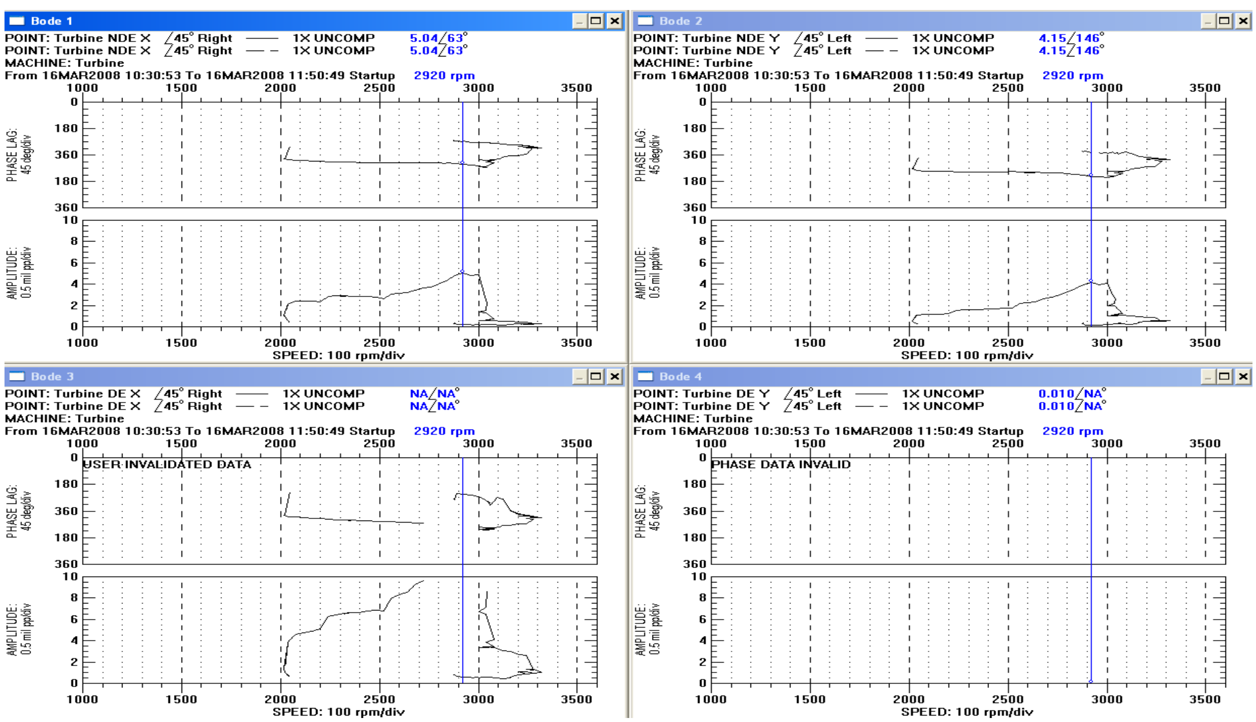

Figure 1 - Initial start up response on the turbine proximity probes.

After this initial start up we recommended an internal inspection of the turbine bearings and correction of the drive end Y probe. The proximity probe was found to have an incorrect gap setting and was corrected. The drive end turbine bearing was indeed damaged during the start up and replaced. During the inspection we also looked at the carbon seals and found several rub spots. When asked if they had an extra set of carbons we were given a set manufactured by a source other than the turbine manufacturer. After measuring the I.D. of the seals we found that the clearance was tighter than suggested by the turbine manufacturer and the temperature rating was not to the recommended specifications. The carbons used on the previous run were from the same manufacturer but had a little more clearance. Since we were under the gun to get this machine up and running we decided to go with the same seals used on the previous run.

The next run revealed a steady increase in amplitude with speed and eventually reached 5.02 mils on the drive end X probe at 2040 rpm. Since we did not want a repeat of the bearing failure we backed down in rpm and then started bringing the unit back up slowly. We did not experience a repeat of the 5.02 mil excursion but the amplitude did reach 3.37 mils at 2200 rpm and then leveled off to 2.88 mils at 2580 rpm.

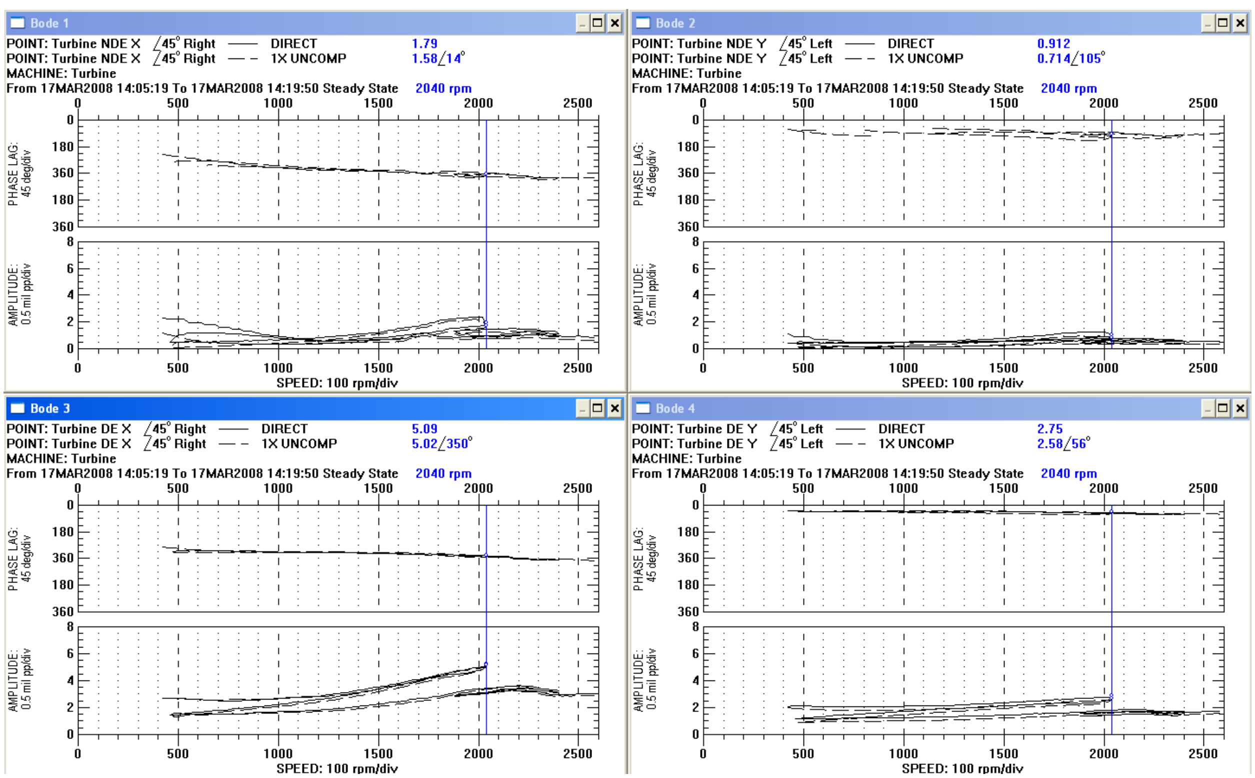

Figure 2 – Second start up after bearing replacement and probe corrections

When we came up in speed to 3329 rpm we also noticed the orbit plots would change in pattern, going into a compressed pre-loaded condition. When we would back down in speed a little the orbit would then open up into a low amplitude pattern. When we would come back up to approximately the speed we had previously seen the pre-load, the pattern would stay at low amplitudes.

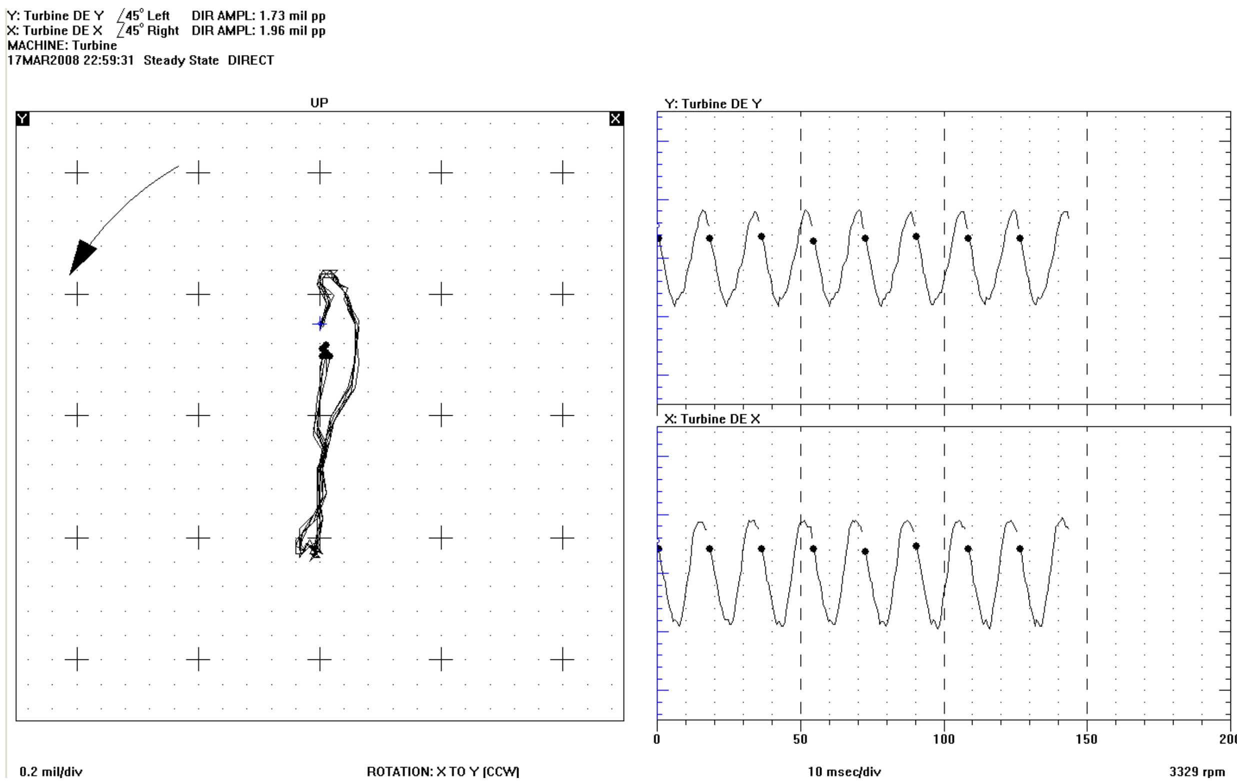

Figure 3 – Compressed pre-loaded condition at 3329 rpm

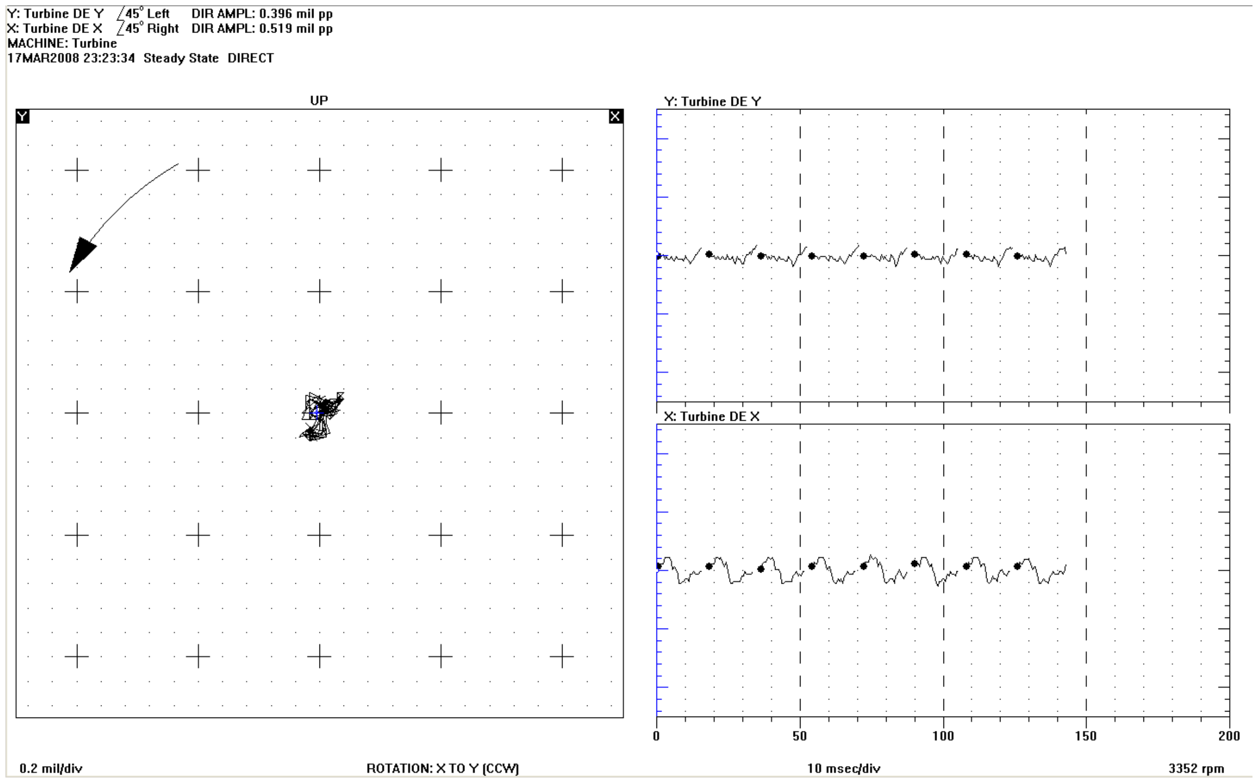

Figure 4 – Normal low amplitude condition at 3352 rpm

After watching this pattern several times during the speed increases we attributed the condition as a rub on the carbon seals. Although the orbit patterns were not typical rub patterns, we believe the carbons were grabbing the shaft and creating the pre-load condition. When the higher amplitudes were experienced during the rub conditions we backed off in speed and allowed the amplitude and rub to settle out. Then when we came back up to the speed we saw the rub at, the seals had been “rubbed in” enough to allow the shaft clearances and eliminate the rub. We proceeded with this “rub in” process until full operating speed (3880 rpm) was achieved. Our final amplitudes at operating speed was less than a mil at all of the turbine probes.

Although the standard correction for this problem would be to order the correct carbon seals for the specified application, we were able to get this machine back on line and operating until the proper seals could be ordered.

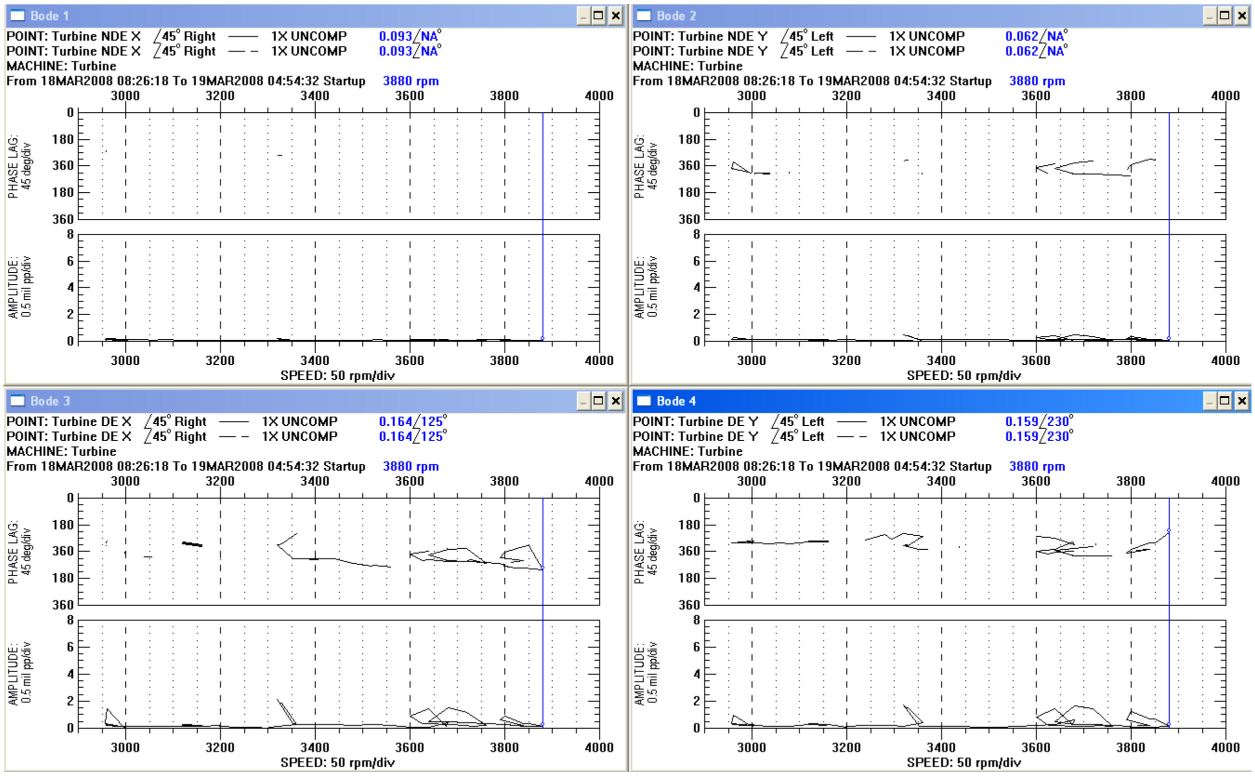

Figure 5 – "Rub in" process up to 3880 rpm