Brüel & Kjær Vibro

Application Note

Case study – Compass 6000™ detected a fault that avoided unnecessarily disassembling a pump in Europe's largest pumping station

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ABSTRACT

High vibration in the huge, newly commissioned propeller pump raised suspicions that it will have to be disassembled again to investigate the cause. "Stop, no need to do that!" The Brüel & Kjær Vibro diagnostic specialist quickly found out that the problem was in the control system, not the pump.

Figure 1. The IJmuiden pumping station.

The pumping station

Water management plays a critical role in the Netherlands. As a large part of the country is below sea level, discharging excess water during heavy rains is one of the important functions of the entire water management system administered by the Rijkswater-staat (Ministry of Infrastructure and the Environment).

The IJmuiden pumping station, situated at the outlet of the North Sea-canal in the Netherlands, is the largest pumping station in Europe (see Figure 1). It was constructed in 1975 and originally comprised four pumps with a total capacity of 150 m³/s.

Since that time flooding in the region has gradually increased due to a number of factors such as higher precipitation due to warmer climate, accelerated discharge due to increased paved surface area, more efficient drainage and reduced soil drainage area. This problem was also compounded by rising sea levels and dropping land levels, thus reducing the water discharge due to increased pump head requirements. In 2004, two Pentair Fairbanks Nijhuis pumps were added at the IJmuiden pumping station to increase water discharge capacity to 250 m³/s (see Figure 2). Currently, approximately 2/3 of the excess water is discharged by gravity alone, and 1/3 by pumping. Normally only a few of the pumps are working at the same time but there are at least 26 days every year where all six pumps are working simultaneously.

Maintenance strategy

The six pumps at the IJmuiden pumping station are maintained by the Pentair Fairbanks Nijhuis Service Center under a service contract with Rijkswaterstaat. Normal maintenance practices include cleaning the pumps once a year to remove biological growth and performing a major overhaul, which is done every four years for the four older pumps and every 10-12 years for the two newer ones.

Figure 2. The two new Pentair Fairbanks Nijhuis propeller pumps are type HP1- 4000.340, each with a capacity of 50 m³/s and a discharge head of 0.5 to 5 m. Variable speed direct drive 1500 kW motor with 80 RPM maximum speed

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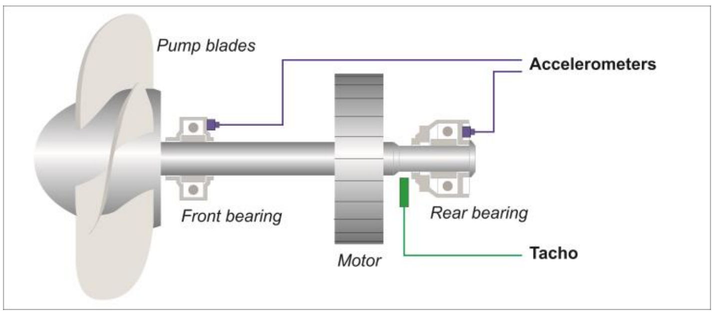

Figure 3. Sensor type and location for the Pentair Fairbanks Nijhuis propeller pump.

Figure 4. Sensor type and location for the Pentair Fairbanks Nijhuis propeller pump.

Two important maintenance actions of the overhaul are replacing the bearings and re-welding the blade tips to replace metal that has eroded away, in order to recover efficiency.

Online condition monitoring plays a particularly important part of the maintenance strategy at the pumping station for these reasons:

- Overhauls are done infrequently
- Pumps are completely submerged so there is no access during operation for monitoring with portable instruments
- Pumping station is unmanned
- Reliability of pump operation is vital, as there is no tolerance for flooding and there are penalties for insufficient performance
- At least 26 days/year all pumps are operating simultaneously, so there is no spare capacity during this time
- Motors are variable speed and pump loading is variable, so it would be difficult to predict when potential failure modes develop if time-based maintenance is used
- 2-3 hours needed to remove pump from water with overhead crane for inspection

Monitoring strategy

The Brüel & Kjær Vibro Compass 6000™ system was selected for this demanding application in 2005 for protection and condition monitoring of all pumps at the pumping station.

Figure 3 shows the typical sensor installation for one of the pumps and Figure 4 shows the actual mounting. The signals from the sensors are processed in the Brüel & Kjær Vibro VIBROCONTROL 6000® data acquisition units located in the pumping station instrument room and then sent to the monitoring system server located in the Pentair Fairbanks Nijhuis Service Center in Beverwijk, Netherlands.

All monitoring and diagnostics are done by the service group. Information is also remotely exported via the web to the pumping station control room located in the headquarters.

Observation

After a total of 26,000 operating hours and 11 years, pump unit 5 had to be overhauled. The bearings were replaced, blade tips re-welded, and then the pump was recommissioned. It operated around 360 hours when a new invertor module was installed in the variable speed drive (VSD) control system together with new software. Shortly after this the service group noticed high vibrations. A diagnostic engineer from Brüel & Kjær Vibro was called onsite to investigate. As the power supply unit of the online monitoring system was being replaced at that time, the diagnostic engineer did vibration analysis using a portable instrument running Brüel & Kjær Vibro Analyzer software.

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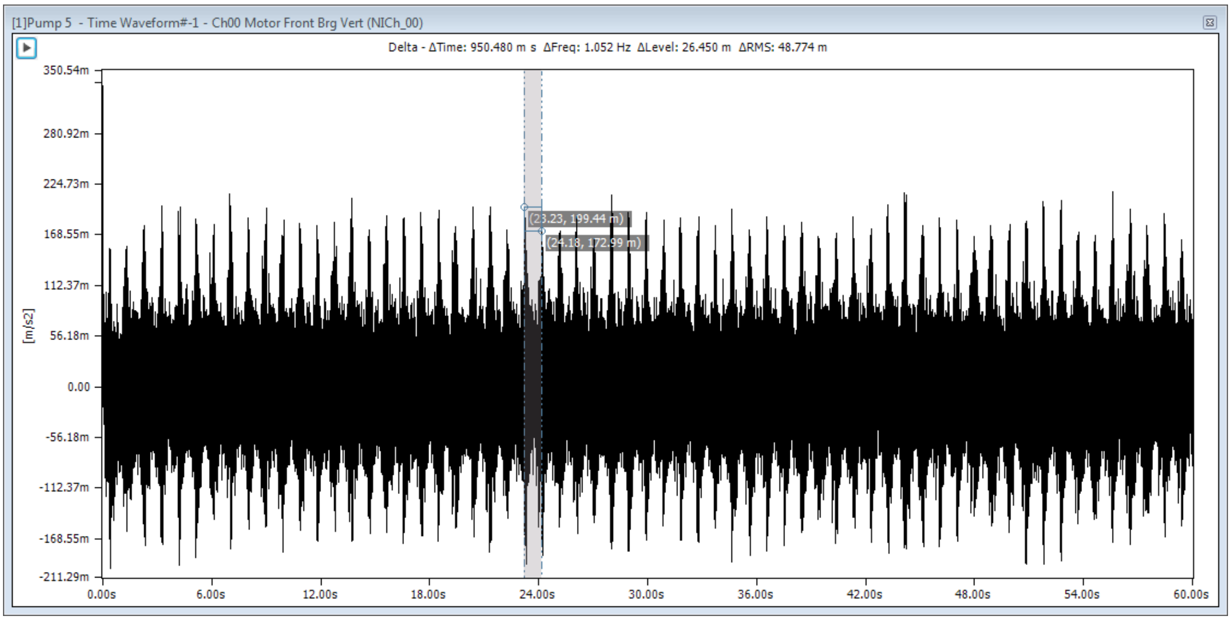
A once per revolution vibration spike was observed, together with a significant 2x line frequency component. An eccentric rotor, which results in variable air gap, can present similar symptoms, but this condition was regarded as unlikely. The pump had operated flawlessly for 11 years and the bearings are press fit so there is minimal risk of assembly errors. Moreover, the spike disappeared when the power was removed while the rotor was still turning at 60 RPM.

Diagnostics

Analysis of the data was performed to determine the cause of the once per revolution spike and the increased 2x line frequency component. The measurement plots shown in Figures 5 to 9 are some of the results of this analysis.

Conclusion

The conclusion from analyzing the measurements shown in Figures 5-9 was that the once per revolution vibration spike was not due to the condition of the pump or its machine components, but due to a problem with the variable speed drive system and/or the rotary encoder. Once this diagnosis was made, it was determined that it was not necessary to disassemble the pump to investigate the cause of the vibration spike, thus avoiding unneeded downtime and maintenance. Only the VSD and/or rotary encoder needed to be investigated and corrected. Moreover, since the detection and diagnosis of this problem was performed shortly after re-commissioning, the pump rotor and motor components were not unnecessarily subjected to spurious loading for a period of time. Once again, Brüel & Kjær Vibro diagnostics added value to a customer in need.



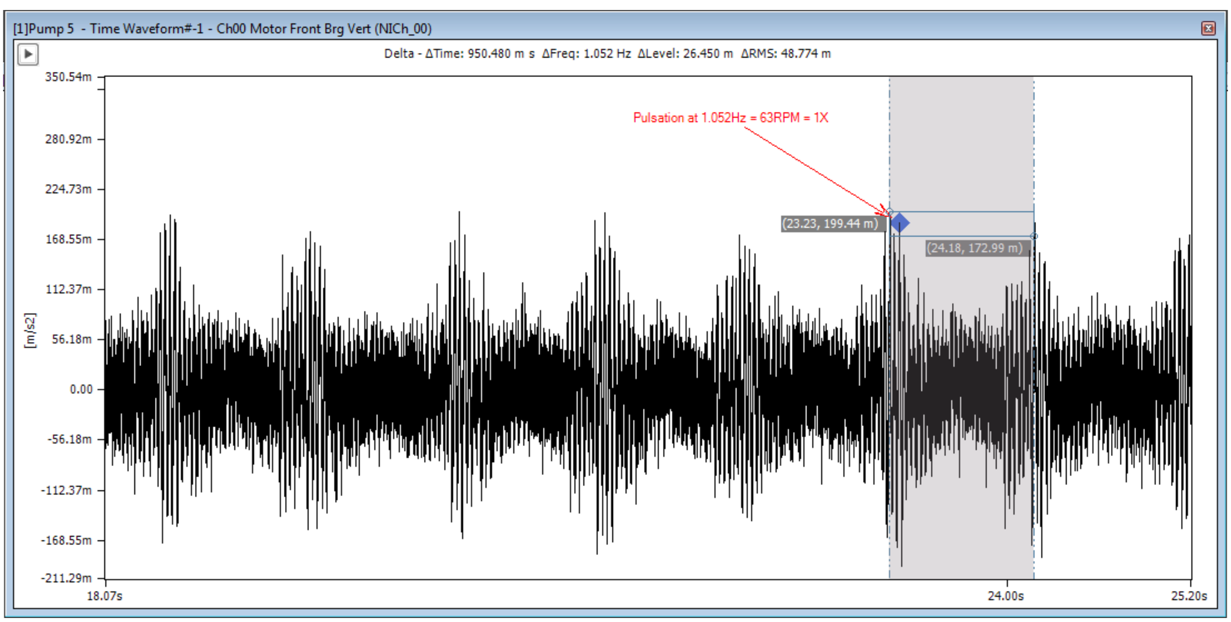


Figure 5. Time signal measurements are shown from the front bearing of the pump (similar signal for the rear bearing). The bottom picture is a zoom from the upper one. The once per revolution spikes are clearly seen.

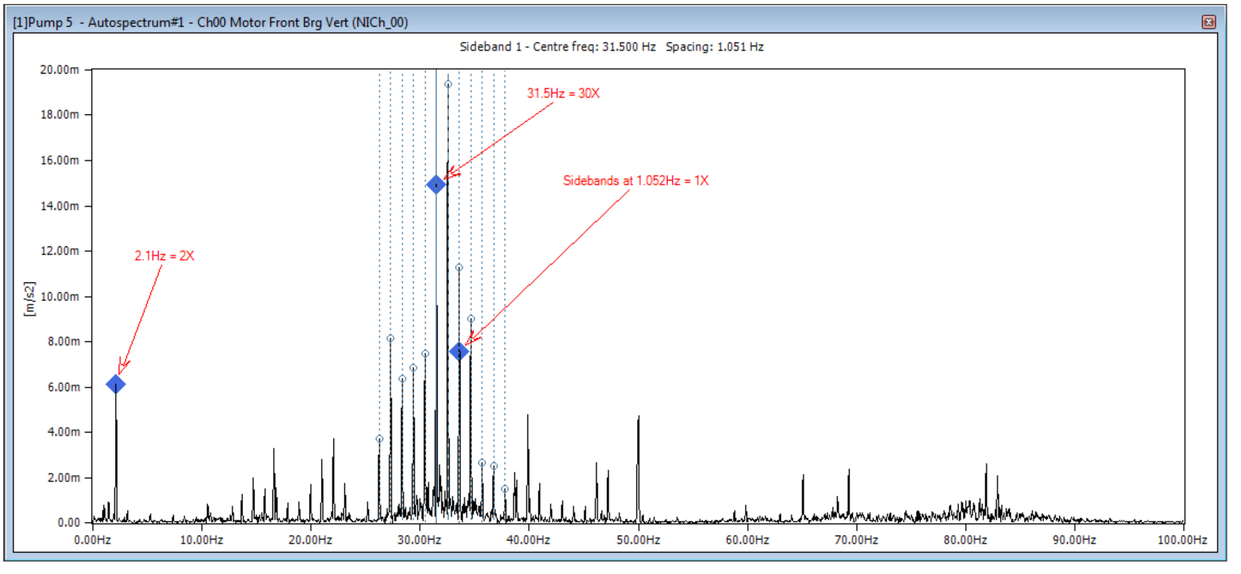


Figure 6. Spectrum from the front bearing (rear bearing similar).The 30x harmonic (not a known frequency, neither blade related) has been amplitude modulated to the running speed of the pump, resulting in strong sideband activity. The 2x harmonic has also increased significantly.

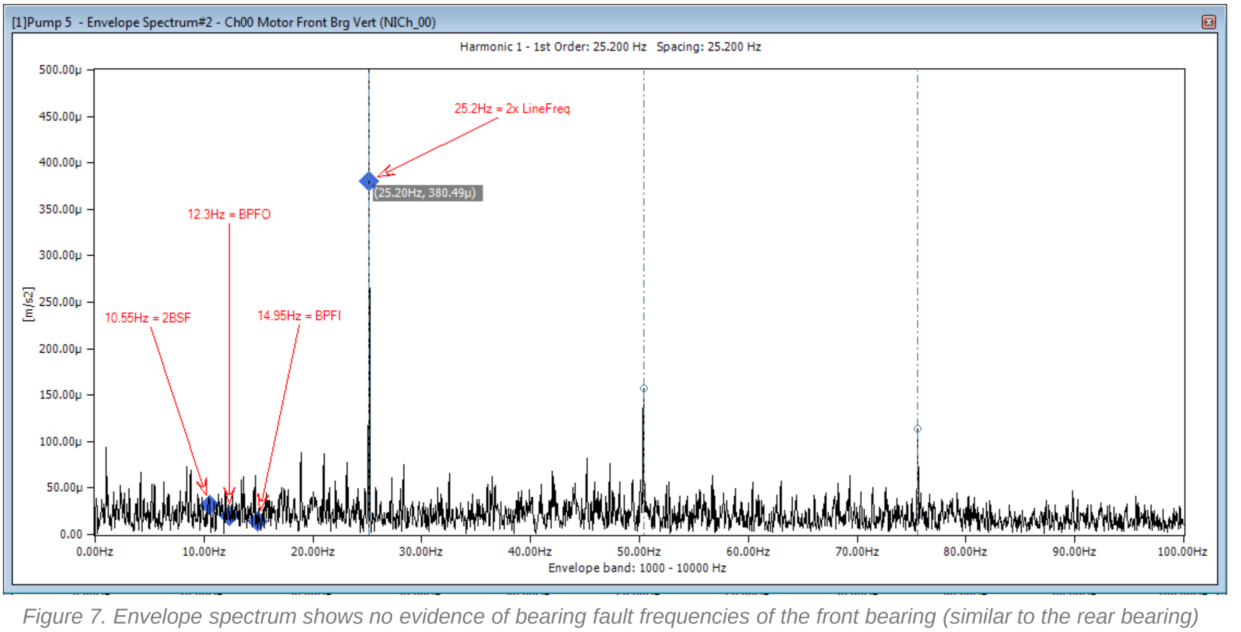


Figure 7. Envelope spectrum shows no evidence of bearing fault frequencies of the front bearing (similar to the rear bearing) but there is a high 2x frequency component, which is often an indicator of an electrical problem. (BPFO = outer race defect, BPFI = inner race defect, 2BSF = ball/roller defect).

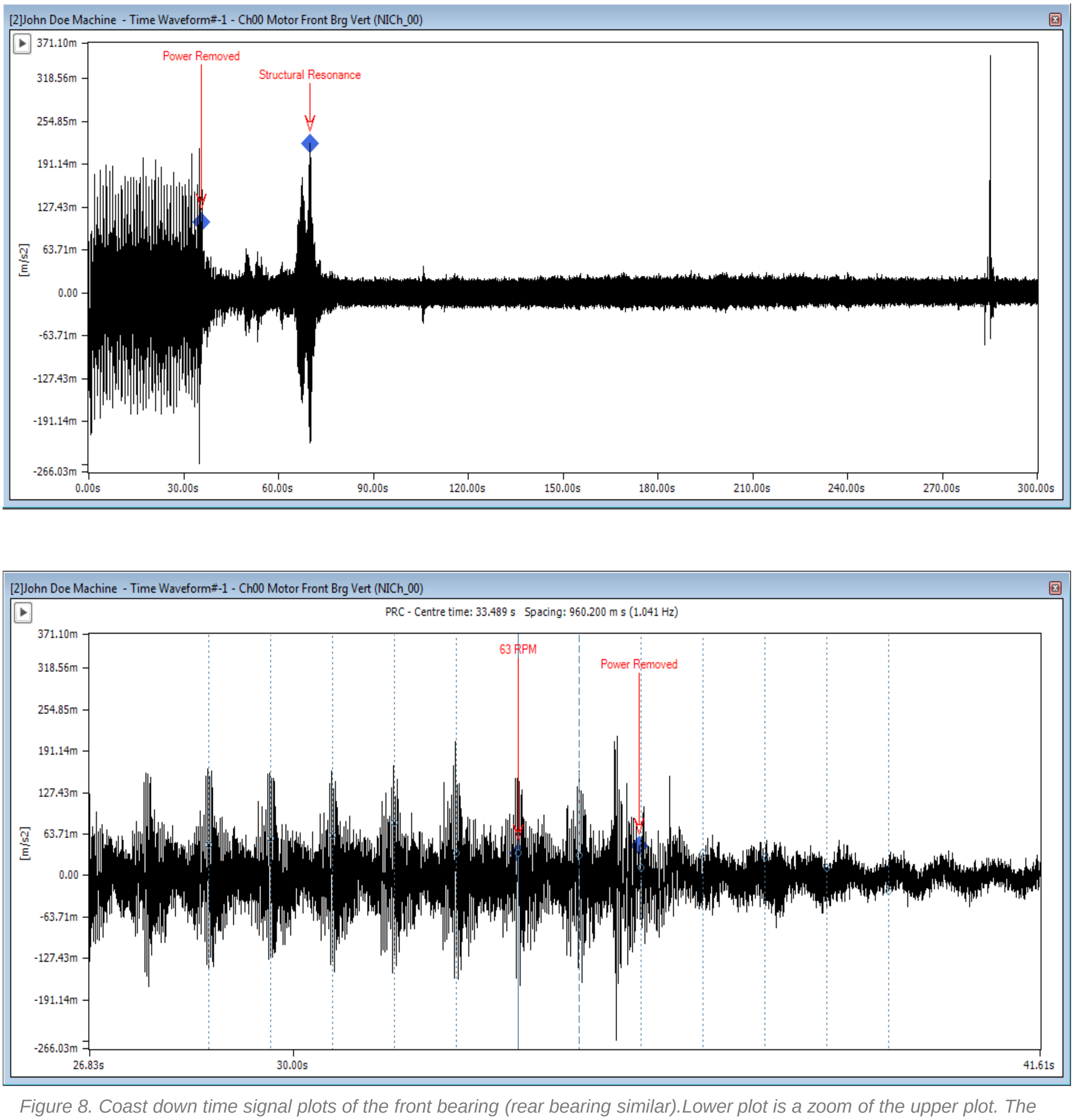


Figure 8. Coast down time signal plots of the front bearing (rear bearing similar).Lower plot is a zoom of the upper plot. The spikes disappear when the power is removed, suggesting an electrical fault.

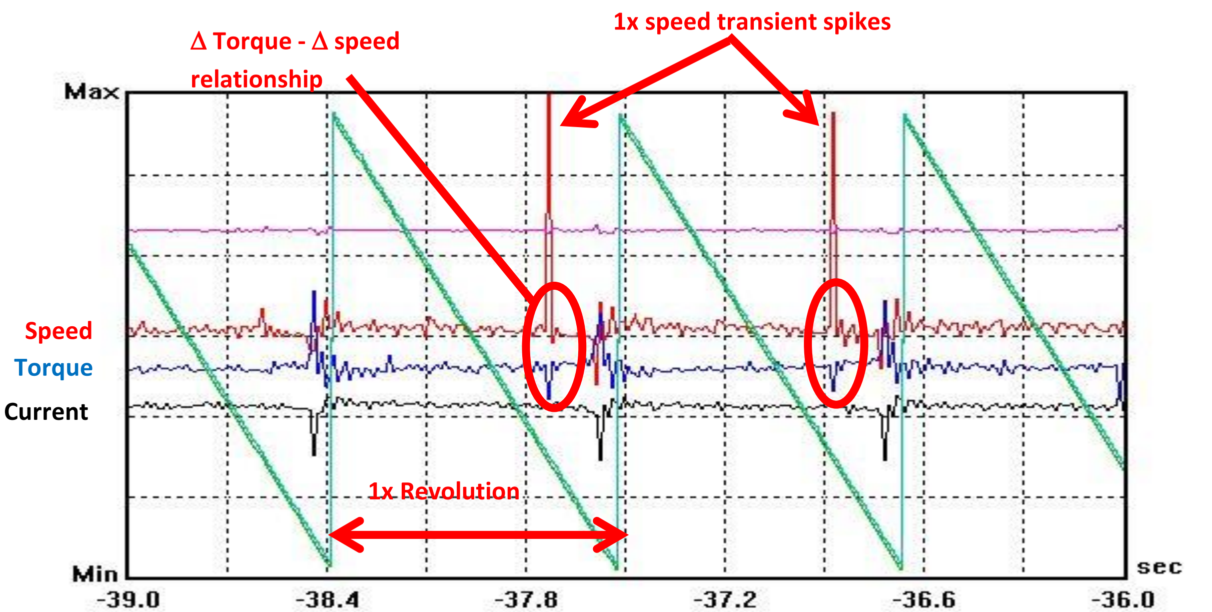


Figure 9. Signals from the VSD/encoder system showing speed, motor torque and motor current. A transient spike appears on the calculated motor speed every revolution. Each spike represents up to a 5 RPM instantaneous change in speed for every revolution. This incorrect speed transient forces the VSD to try to compensate, as seen by the torque measurement.

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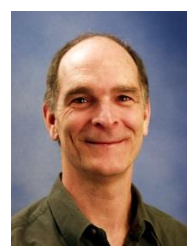

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