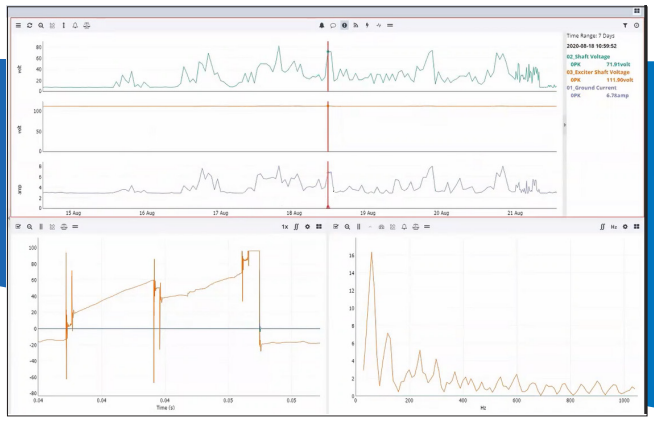

Shaft Ground Monitoring

Shaft Grounding Overview:

The objective of shaft grounding is to protect the bearings, and to establish a good electrical connection. Shaft voltage, if left unchecked, can cause failures in the bearing surfaces, stator insulation, exciter insulation, and grounding, leading to catastrophic failures. There are three main grounding techniques:

- *Carbon brushes*, which can end up being non-conductive with a little bit of oil on the shaft
- *Straps* can build up contaminant on the surface area
- *Copper or silver ropes* have a smaller contact area, but are able to cut contaminant very well resulting in greater shaft contact and current flow

The Cutsforth™ Series 3 Shaft Grounding Assembly installs in one-day and pairs with the Series 3 Premium Monitoring System

Shaft Ground Monitoring Overview:

A generator shaft is a violent environment, and attempting to maintain proper electrical contact and grounding is very challenging. Monitoring and measuring is crucial to have confidence that grounding is working as required giving personnel evidence to the root cause of a potential failure. Monitoring can detect several defects that can occur if grounding equipment is left unchecked:

- *Bearing damage*: stopping unwanted currents from discharging through bearings
- *Poor shaft contact:* making sure the grounding equipment is functioning properly

Predictive Maintenance:

Monitoring shaft grounding gives plants the ability to get the data and trend information to automatically detect failure modes. Waveform patterns can determine if there is poor shaft contact or other potential failures. Early detection allows plants to predict when to perform required maintenance without having to worry about costly, unplanned outages. Through predictive analysis, plants will have better control over their O&M budgets and will be able to better allocate manpower to other important tasks.

For more information, contact us:

Cutsforth.com/Contact
800.290.6458 x.1
info@Cutsforth.com

Waveform Example: Poor Shaft Contact

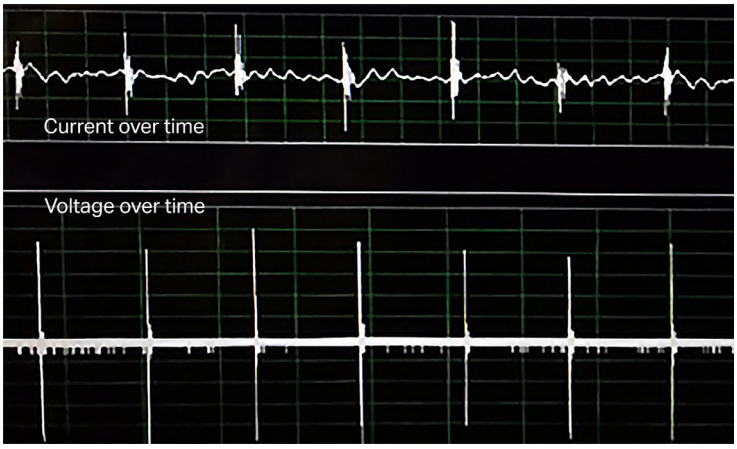

Figure 1) Example of an expected shaft grounding current and voltage waveforms over time.

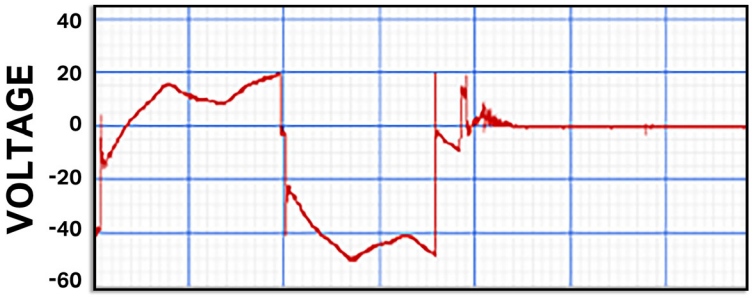

Figure 2) Example of poor shaft ground contact occuring when voltage goes away from zero, staying there until contact is reestablished.

Financial Impact:

Estimated Financial Assumptions

Risk Scenario: Bearing Failure

Assumptions for 6-year Outlook Period	
Premium Shaft Voltage & Current Monitoring System	$80,000
Bearing Failure Cost	$375,000
Failure Risk without Monitoring	2%
Discounted 6-year risk	$28,357
Average Outage Duration	10 Days
MW for Sample Generator (Avg.)	150 MW
Runtime Per Day (Avg.)	14 Hours
Average Revenue per MWh	$24
Lost Revenue	$504,000
Replacement Cost (25% Premium)	$630,000
Manpower savings	$36,000
Robotic Inspection vs. Rotor Out	$536,027

Estimated Return on Investment

With Cutsforth™ Premium Shaft Ground Monitoring

Financial Impact Over 6-Years	
Present Value • *Assumes 8% cost of capital*	$1,075,087
Return Multiple	13.4 x
Rate of Return	54%
• *Assumes only one "event" during outlook period and replacement of on*	

Conclusion:

Continuous monitoring of shaft voltage and current reduces operating costs. Plants are able to reduce both the risk of component failures that lead to unplanned outages, and the risk of injury to maintenance personnel. Condition based monitoring allows you to predict failures and plan accordingly giving plants more control over the outage cycle. Monitoring allows plants to optimize capital spending, allocating manpower and financial resources when and where necessary.

* Note: The results are estimates and illustrative only. Specific risks, costs, and prices will vary. This is not a guarantee of savings nor a guarantee of eliminating risk. Proper maintenance must be performed.