4000 Series Air Gap Sensor System
Bently Nevada* Asset Condition Monitoring

Description
Bently Nevada's air gap monitoring system provides monitoring and diagnostic capability for all new and existing hydro generators and motor/generators. Air gap monitoring is fully integrated with the 3500/System 1* platform and utilizes the 3500/46M Hydra Monitor. While the 4000 Series Air Gap 50 mm Sensor System targets applications requiring large machines, the 4000 Series Air Gap 20 mm Sensor System addresses small to medium machines.

Criticality
Air gap is a measure of the distance between rotor and stator in a hydroelectric generator. Monitoring of air gap is critically important because both the stator and the rotor on large hydroelectric machines can be quite flexible and their shape and location are affected by operating centrifugal, thermal, and magnetic forces. Off-center or out-of-round conditions will at least reduce operating efficiency and, in more severe cases, can lead to damage from magnetically induced heating or a rotor-to-stator rub.

Measuring Air Gap
Air gap monitoring utilizes multiple specially designed capacitive proximity probes that are mounted on the inner bore of the generator stator in one or more planes. Measurements are made from the stator bore to each rotor pole as the rotor turns. Minimum air gap dimension and location along with rotor shape are directly measured during unit operation. Stator shape is calculated utilizing the multiple air gap probes. The air gap monitoring system provides operations and maintenance personnel with early warning of impending problems with shape and concentricity of the generator rotor and stator.

Typical Benefits
Air gap dimensions along with rotor and stator shape cannot be effectively measured with the generator out of service because of the combined effects of centrifugal, thermal, and magnetic forces. Early detection of air gap anomalies will facilitate condition-based maintenance by allowing the user time to plan for repairs before scheduled outages. Long term trending of gap and shapes can be correlated with operating conditions and used in operational and rehabilitation planning. Knowing the rotor and stator shapes and minimum air gap dimensions will provide the operator with the information needed to remove a machine from service before serious damage like that from a rotor stator rub occurs.
Proximity Probe and Extension Cable

The 4000 series air gap probe is designed for maximum survivability in the harshest hydro generator environment. It can continually operate and maintain its accuracy in temperatures up to +125 °C (+257 °F). The probe can also continually operate and maintain its accuracy in the 1.5 Tesla magnetic field often experienced between the rotor pole and the stator. ClickLoc* connectors come standard on both the probe and extension cable to prevent loosening of the connectors.

Proximitor* Sensor

The 4000 series Air Gap Proximitor Sensor is based upon our best selling 3300 XL Proximitor Sensor technology. The Proximitor Sensor uses a DIN rail connection to ease installation and to minimize the number of cumbersome screws required when working around the hydro generator. The grounding stud on the Proximitor Sensor features a safety thread in order to ensure the locking nut does not inadvertently fall off during the installation of the ground wire on the extension cable.

Specifications

Unless otherwise noted, the following specifications are for a 4000 Series Air Gap Proximitor Sensor, extension cable, and probe between 0 °C and +50 °C (+32 °F to +122 °F), with a +24 Vdc power supply, and a 10kΩ load.

Electrical

Proximitor Sensor Input:
Accepts one non-contacting 4000 Series Capacitive Probe and Extension Cable.

Power:
Requires +23.25 Vdc to +24.75 Vdc at 85 mA maximum consumption.

Supply Sensitivity:
Less than 2 mV change in output voltage per volt change in input voltage.

Output Resistance:
50 Ω ± 5%.

Extension Cable capacitance:
75.5 pF/m (23.0 pF/ft) typical.

Field Wiring:
0.2 to 1.5 mm² (16 to 24 AWG). Recommend using two-conductor shielded cable. Recommended maximum length of 305 metres (1000 feet) between the 4000 Series Proximitor Sensor and the monitor.
Linear Range:

20 mm System

18.3 mm (720 mils). Linear range begins at approximately 2 mm (80 mils) from the face of the probe and is from 2 to 20.3 mm (80 to 800 mils) (approximately +1 to +10 Vdc).

50 mm System

45.7 mm (1800 mils). Linear range begins at approximately 5.1 mm (200 mils) from the face of the probe and is from 5.1 to 50.8 mm (200 to 2000 mils) (approximately +1 to +10 Vdc).

Average Scale Factor (ASF):

20 mm System

0.50 mV/μm (12.5 mV/mil), nominal

50 mm System

0.20 mV/μm (5.0 mV/mil), nominal

Deviation from a straight line:

20 mm System

Less than ±1.02 mm (±40 mils) with system between 0 °C and +50 °C (+32 °F and +122 °F).

50 mm System

Less than ±2.54 mm (±100 mils) with system between 0 °C and +50 °C (+32 °F and +122 °F).

Frequency Response:

0 to 2.0 kHz: +0, -3 dB typical with up to 305 metres (1000 feet) of field wiring.

Compliance & Certifications

EMC

European Community Directives:

EMC Directive 2004/108/EC

Standards:

EN 61000-6-2
EN 61000-6-4

For other approvals or certifications available on this product, refer to the Country and Regional Approvals Standard 323773.

Mechanical

Probe Material:

FR4 type material.

Probe & Extension Cable Material:

75 Ω triaxial, fluoroethylene propylene (FEP) cable.

Proximitor Sensor Material:

Aluminum.

Tensile Strength (maximum rated):

312 N (70 pounds) probe lead to probe. 89 N (20 pounds) at probe lead to extension cable connectors.

Connector Material:

Gold-plated brass and gold-plated beryllium copper.
Connector-to-connector torque:

**Recommended Torque:**

Finger tight.

**Maximum Torque:**

0.565 N•m (5 lbf•in).

**Minimum Bend Radius:**

25.4 mm (1.0 in).

**System Mass (typical):**

- **Probe:** Approximately 140 g (0.3 lbs).
- **Extension Cable:** Approximately 320 g (0.7 lbs).
- **Proximitor Sensor:** Approximately 380 g (0.8 lbs).

---

**Extension Cable Temperature Range:**

**Operating Temperature:** 0 to +125 ºC (+32 to +257 ºF).

**Storage Temperature:** -35 to +125 ºC (-31 to +257 ºF).

**Proximitor Sensor Temperature Range:**

**Operating Temperature:** 0 to +70 ºC (+32 to +158 ºF).

**Storage Temperature:** -35 to +85 ºC (-31 to +185 ºF).

**Relative Humidity**

Less than a 5% change in average scale factor when tested in 93% humidity in accordance with IEC standard 60068-2-78 for up to 56 days.

---

**Environmental Limits**

**Probe Temperature Range:**

**Operating Temperature:** 0 to +125 ºC (+32 to +257 ºF).

**Storage Temperature:** -35 to +125 ºC (-31 to +257 ºF).

---

**Patents**

Components or procedures described in one or more of the following patents apply to this product: 6,989,679; 7,084,643.
**Ordering Information**

For a detailed listing of country and product specific approvals, refer to the Approvals Quick Reference Guide (document 108M1756) located at the following website: [www.GEmeasurement.com](http://www.GEmeasurement.com).

**4000 Series Capacitive Proximity Probes**

400102  Air Gap 50 mm Sensor  
400202  Air Gap 20 mm Sensor  

Product Number-AXX  
A: Cable Length Option  
01  Standard, 18 inches

**4000 Series Air Gap Proximitor Sensor**

400100  Air Gap 50 mm Proximitor Sensor  

Product Number-AXXX-BXX  
A: Cable Length Option  
100  10.0 metres (33 feet) system length  
B: Linear Range Option  
02  50 mm (2 inches)

**400200  Air Gap 20 mm Proximitor Sensor**

Product Number-AXXX-BXX  
A: Cable Length Option  
100  10.0 metres (33 feet) system length  
B: Linear Range Option  
02  20 mm (0.8 inches)

**4000 Series Extension Cable**

400130  Air Gap 50mm Extension Cable  
400230  Air Gap 20mm Extension Cable  

Product Number-AXXX  
A: Cable Length Option  
100  10.0 metres (33 feet) system length

**Accessories**

- 167684-01  

- 02200627  
  +24 Vdc Power Supply. Typically 2 sensor systems will be powered by 1 power supply in each Proximitor Housing. The power supply is capable of running 4 sensor systems.

- 330181  
  3300 XL Proximitor Housing. Suggested configuration is 330181-01-00-01-00-00: a housing with DIN mount hardware, no conduit fitting, standard 2.34 mm (0.092 in) gland plate thickness, no terminal blocks, and no approvals. Typically 2 sensor systems and 1 power supply will be located in each housing. The housing is capable of holding 1 power supply and 4 Proximitor Sensors.

- 02173006  
  Bulk Cable (specify length in feet) 1.0 mm² (18 AWG), 2-conductor, twisted, shielded cable used for the PROX OUT signal on the Air Gap Proximitor Sensor terminal strip.

- 168448-01  
  Air Gap Verification Kit.

- 173873  
  7-inch PEEK® cable ties suitable for hydro generator environments, bag of 50
Graphs and Figures

Unless otherwise specified, dimensions are in mm (inches).

**Figure 1:** Typical Air Gap 20 mm ProximitoSensor Over Temperature
Figure 2: Typical Air Gap 50 mm Proximiton Sensor Over Temperature
Figure 3: Typical Air Gap 20 mm Probe Over Temperature
Figure 4: Typical Air Gap 50 mm Probe Over Temperature
Figure 5: Typical Air Gap 20 mm Cable Over Temperature
Figure 6: Typical Air Gap 50 mm Cable Over Temperature
Figure 7: Typical Air Gap 20 mm Sensor System Over Temperature
Figure 8: Typical Air Gap 50 mm Sensor System Over Temperature
Figure 9: Air Gap Frequency Response
Figure 10: Air Gap 20 mm Probe

Figure 11: Air Gap 50 mm Probe
Figure 12: Air Gap 20 mm or 50mm Extension Cable

Figure 13: Air Gap 20mm or 50 mm Proximitor Sensor
Figure 14: Air Gap Verification Fixture

* Denotes a trademark of Bently Nevada, Inc., a wholly owned subsidiary of General Electric Company.

PEEK® is a registered trademark of Victrex.

© 2004 – 2015 Bently Nevada, Inc. All rights reserved.

Printed in USA. Uncontrolled when transmitted electronically.

1631 Bently Parkway South, Minden, Nevada USA 89423
Phone: 775.782.3611 Fax: 775.215.2873
www.GEmeasurement.com