Air Gap: A critical measurement in hydroelectric generator performance

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Kaman's Static Air Gap Tool (AGT) is a portable measurement device that helps reduce downtime by providing a fast, repeatable and reliable means of measuring one of the most critical aspects of hydro-generator operation — the installed static air gap between the generator rotor and stator. Operating the AGT is designed to be simple: insert the device into the air gap to display and record measurement data, ensuring alignment of the generator rotor and stator.

The Kaman AGT significantly reduces the number of overhaul technician hours required to inspect and analyze this critical operating parameter. Recent field tests have proven that a reduction in hours of 90% is achievable.

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Generator air gap 101

An air gap is the distance between the rotor and stator of a large-scale hydroelectric generator. This gap is a very small distance in relation to the size of the rotor. Its measurement to tight tolerances is critical to prevent damage to and maintain efficiency of the generator. Static measurement of the air gap is required during initial installation, periodic maintenance checks and again at reassembly of the generator following major maintenance operations.

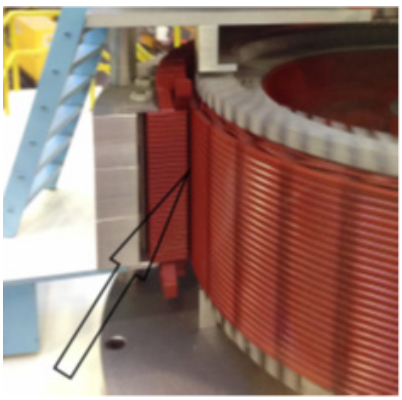

Figure 1. Air gaps are a small part of the overall system and must be set to a tight tolerance. Source: Kaman Measuring

Figure 1 is a cut-away view of a representative generator model. The arrow points to the air gap between the rectangular stator winding on the left, and the rotor on the right. This gap is typically measured at individual poles from above and again from the underside.

Figure 2 shows the upper side of a typical 100 KVA generator with the cover plate removed. Air gap measurements are taken between the black rotor poles on the left and red stator windings on the right.

Figure 2. Generator air gaps leave virtually no room for error or lack of precision. Source: Kaman Measuring

Taking a closer look at Kaman's AGT

There are many sensors available for dynamic monitoring of the air gap when the generator is rotating. However, typical tools for static measurement of the air gap prior to generator rotation called "parallels" take the measurement mechanically, which is a time-consuming process.

Kaman's new AGT has been developed to make this static measurement electronically simply by sliding the spring end of the robust measurement paddle into the gap between the rotor and stator. Compression of the springs to match the gap is measured in real time by an eddy current sensor coil located between the springs.

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The compression springs are wide enough to account for variability in different rotor and stator windings. This permits the tool to be used with different winding sizes and patterns without adjustment.

Signal conditioning electronics at the handle end of the paddle accurately translate the inductance change in the sensor coil to distance — available in imperial or metric units - and wirelessly transmit to the operator's handheld device. The AGT is user friendly and accurate. Like the parallels, the AGT can be used in any orientation, horizontally or vertically depending on the design of the generator. The AGT is powered by a long-life rechargeable battery permitting up to eight hours of operation between charges.

The compression springs are located at the bottom and signal conditioning electronics at the top of the device, shown in figure 3. It is equipped with adjustable wedges in the middle to provide a consistent insertion depth if the rotor and stator design permit. They are easily user removed or adjusted depending on the depth required.

Figure 3. Kaman's AGT is designed to be just as user friendly as it is technically sound. Source: Kaman Measuring

A complete, connected solution

Measured distances are displayed and stored in a user-friendly app available for both iOS and Android devices. Instructions for download are included with purchase of the tool (mobile device not included).

During typical use, operator A positions the tool between the rotor and stator poles. Operator B then records data via the mobile app; this can be done either by voice command or touching the "Write Point" button on the mobile device shown in Figure 4. The app then sequentially numbers the data points and stores them, leaving no need for an operator to record manually. Data can be viewed in the app and downloaded to a PC for storage and analysis. This download feature is a major time saver for operators and eliminates possible manual data entry errors. More information on using the app is detailed below.

Using the mobile app

When the app is launched, it will automatically search for an AGT within Bluetooth range, which is typically 10 ft to 15 ft. An AGT within range will display on the screen and connect upon operator command. The intuitive user interface is easily set up prior to taking measurements. Main features include:

- Entry of the installation or generator number
- Entry of high and low display limits of acceptable gap measurements, shown in figure 4.

While the AGT is designed to wirelessly communicate with the app on the mobile device, some environments may have too much background interference for reliable communications. If a communication interruption occurs, recording of measurements resumes from the last data point when communication is restored.

For environments with higher interference or installations where wireless is not desired or permitted, the AGT and handheld device can be connected via a USB cable. In acoustically noisy environments a headset connected to the handheld device is recommended when using voice commands. The handheld device should be maintained within 6 ft of the AGT for the most reliable operation.

The AGT is supplied with factory calibration to NIST traceable standards for measurement ranges from 0.4 inch to 1.3 inches. With factory calibration, measurement accuracy is 0.001 inch over the entire measurement range. If an operator has a calibration lab to set the compression springs to specific distances, then a calibration check or recalibration can be done within the app.

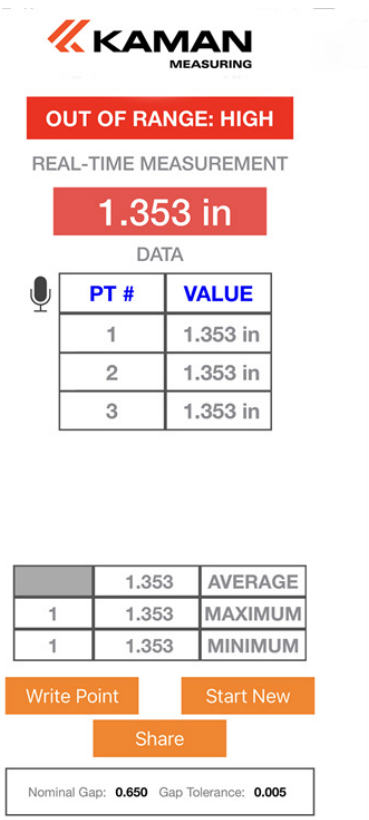

Figure 4. The mobile app intuitively stores measurements and notifies if out of range. Source: Kaman Measuring

Simplifying real-world complexities

Recent testing at a large-scale U.S. hydro-generating facility reported reduced measurement time over previously used parallels. Measurements with the parallels required two hours to check every third pole, whereas measurements with the AGT required only 30 minutes to take measurements of every pole. Since data was required for both above and below the rotor, the AGT was able to realize a time savings of three hours.

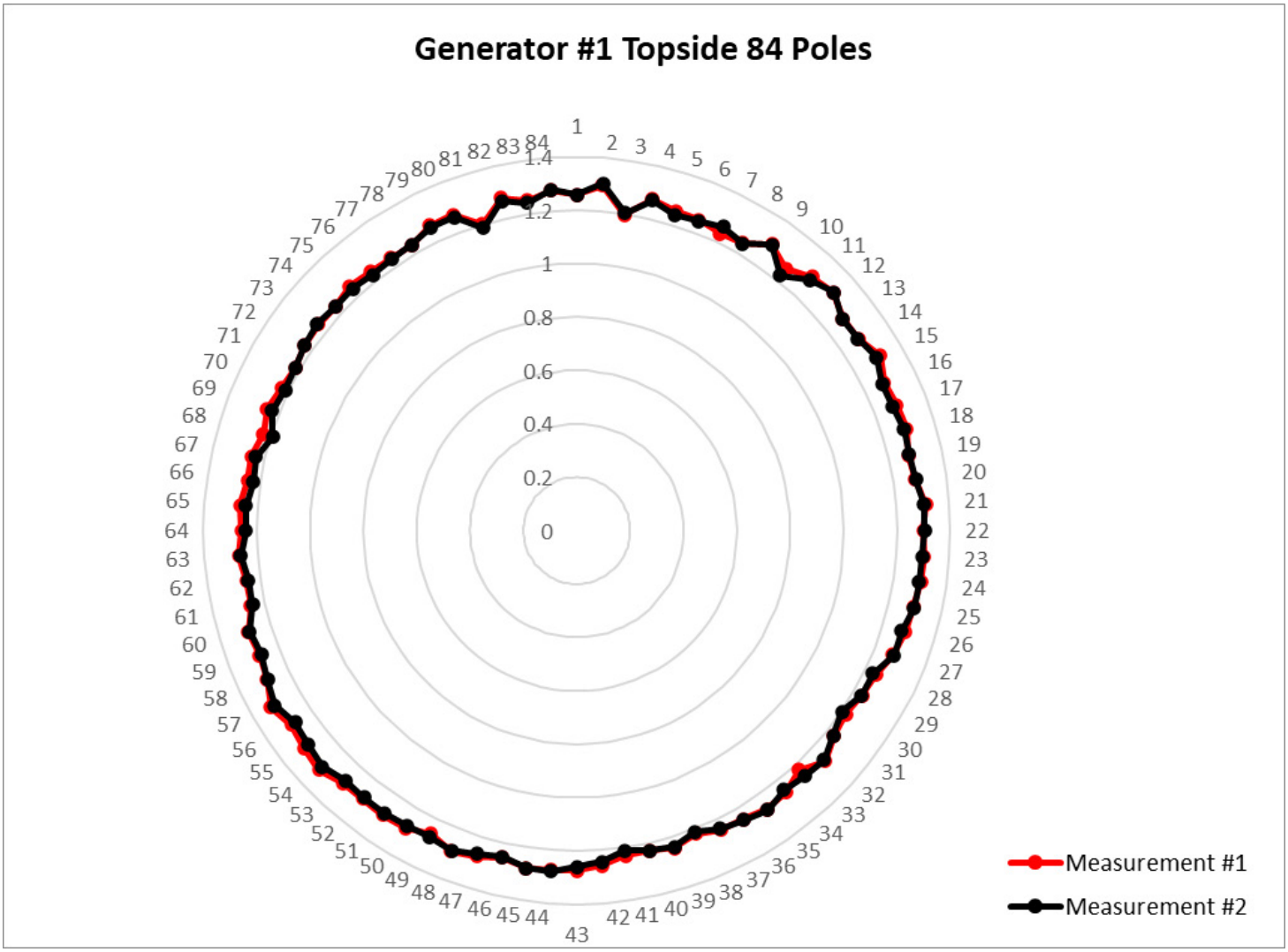

Figure 5. Measurement data easily and quickly reported for operator analysis. Source: Kaman Measuring

At this same facility, the operator quickly downloaded data from the app into an Excel spreadsheet and generated the radar plot shown in figure 5. The data is displayed with the actual pole number. Two sets of data were taken by two different operators to verify repeatability of the measurements. As can be readily seen, results are consistent. A quick review of the data can reveal inconsistencies or potential problem locations that should be verified.

Kaman Measuring

While other tools can measure hydroelectric rotor and stator alignment to an acceptable level, none can compete with the speed and precision of the Kaman static AGT.

With locations in Middletown, Connecticut, and Colorado Springs, Colorado, Kaman Measuring has been in the precision measurement business for many years as a trusted solutions provider. For more information or a quote on the AGT, contact Kaman Measuring.

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Kaman Precision Products — Measurement Division is a worldwide leader in the design and production of high-performance, precision non-contact position measuring systems using inductive, eddy current technology. Our solutions can be configured, custom engineered, and manufactured to meet the needs of any application. A staff of experienced applications engineers helps customers select the appropriate solution. Kaman Precision Products is part of Kaman Corporation, a diverse and highly creative company specializing in state-of-the-art technologies for government, industrial, and commercial markets. Founded by Charles Kaman in 1945, Kaman Corporation operates under the umbrella of Kaman Aerospace Corporation, a division of parent company Kaman Corporation. Kaman Precision Products is headquartered in Middletown, CT and has manufacturing locations in Orlando, FL, Colorado Springs, CO, and Tucson, AZ. Its three divisions, Memory, Measuring, and Fuzing, produce advanced devices, instruments, and systems for extreme environments and critical military and commercial applications.