Detecting Proximity Probe Cabling Errors Using Dynamic Calibration

THE MODAL SHOP
AN AMPHENOL COMPANY

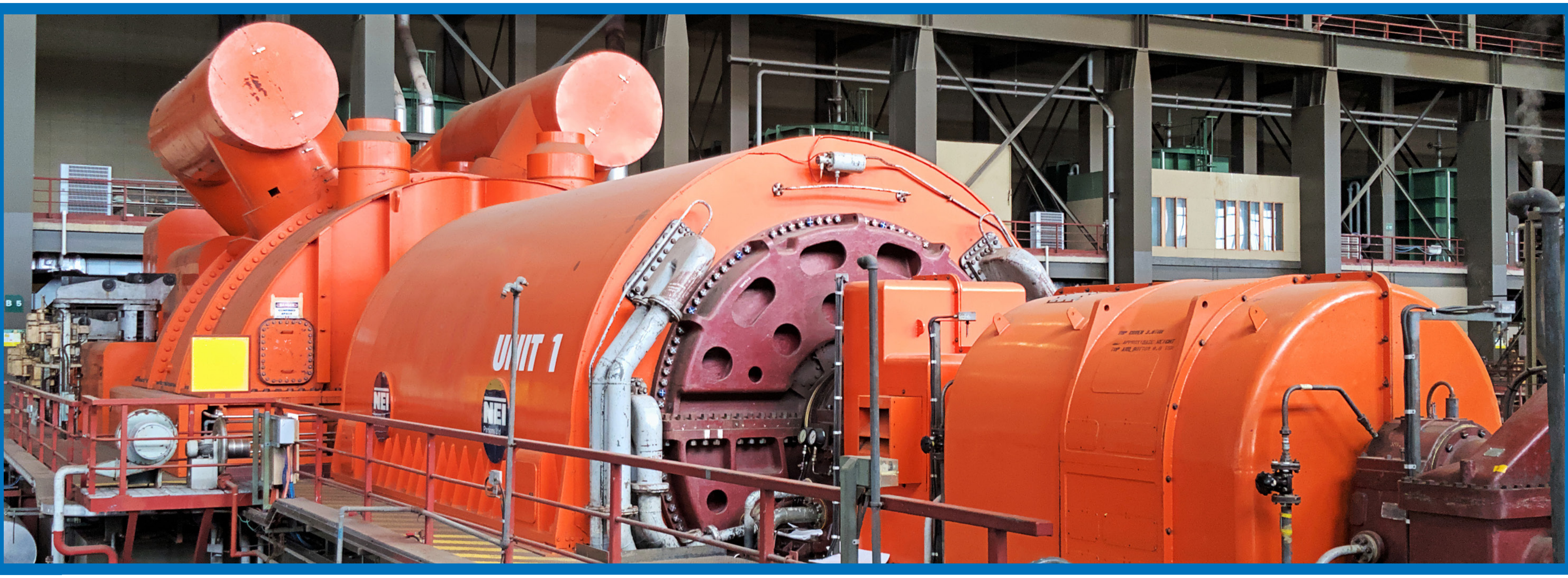

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Table of Contents

Proximity Probe System

Proximity probes play a critical role in protecting high-value rotating assets such as gas and steam turbines across power generation and offshore sectors. These machines often represent several hundred thousand pounds per day in production value, making reliable shaft vibration monitoring essential to avoid unplanned outages.

Non-contact displacement sensors (eddy current proximity probes) are commonly installed in pairs at 90° to one another to monitor shaft movement. By measuring relative shaft displacement and generating orbit plots, they allow engineers to identify imbalance, misalignment, rubs, and load-related vibration issues before they escalate. When these faults go undetected, they can lead to forced outages, secondary damage, and significant financial loss.

Proximity probe systems are typically verified in accordance with API 670 using static calibration. This involves checking probe output against a 4140 steel target at incremental gaps (for example, 10, 20, 30, 40, 50 mils) and confirming linearity and sensitivity.

However, static calibration alone may not reveal cabling faults, installation issues, or dynamic performance errors. Dynamic calibration provides an additional layer

of assurance by simulating real shaft vibration. This is commonly achieved using a wobble-plate system or portable dynamic calibrators, such as a Model 9100D Portable Shaker Table or Model 9110D Portable Vibration Calibrator fitted with a 4140 steel target. By replicating actual turbine vibration conditions, dynamic calibration can identify proximity probe cabling errors and performance deviations that would otherwise remain undetected.

For UK operators focused on reliability, lifecycle extension, and compliance with API 670 and OEM recommendations, incorporating dynamic verification can significantly reduce the risk of unexpected trips and improve confidence in machinery protection systems.

Proximity Probe
- "Eddy Current Probe"
- Coil of Wire
- No Moving Parts
- Impedance Changes Based Upon Magnetic Field

Includes
- Proximitor
- Proximity Probe
- Extension Cable

Proximity Probe System Components

A typical proximity probe system contains three main components: the proximitor, the extension cable, and the proximity probe itself. The proximitor acts as the signal conditioner or probe driver for the system. It provides the excitation signal to the probe and converts the returned signal into a usable output for the monitoring or protection system.

The proximity probe, also known as an eddy current probe, is a simple and reliable device with no moving parts. It primarily consists of a small coil of wire housed inside a protective casing. The tip of the probe includes a protective cap designed to prevent damage in the event of incidental contact with the shaft or target surface. Aside from this protective feature, the probe is essentially just a coil of wire contained within the housing.

The probe operates by generating a magnetic field at its tip. As the shaft or target—typically a ferrous material—moves relative to the probe, the impedance of the coil changes in response to fluctuations in the magnetic field. These changes are directly related to the distance between the probe tip and the shaft, allowing the system to measure relative displacement accurately.

Proximitor = Signal Conditioner

The proximitor is sometimes referred to as the probe driver. Those familiar with ICP® or IEPE accelerometers can think of the proximitor as a signal conditioner. Its role is to convert the probe's impedance into a linear voltage signal. Probe impedance itself is not linear; in fact, it is inherently non-linear. The proximitor converts this non-linear impedance into a linear output across the probe's operating range of approximately 10 mils to 90 mils.

For example, at a gap of around 10 mils, the probe output is typically about –1 VDC, while at 90 mils the output approaches –17 VDC. Over this range, the system produces a sensitivity of approximately 200 mV per mil, providing a very linear response between 10 and 90 mils.

Because the proximitor converts probe impedance into voltage, it is tuned to a specific cable length. Standard system lengths are typically 1 meter, 5 meters, and 9 meters. In the example shown earlier, the proximitor is configured for a five-meter system. If a technician connects a different cable length, the system output will no longer be linear, and the dynamic sensitivity will shift. The proximitor also includes terminals for power (VT), common (COM), and output (OUT).

> The proximitor converts probe impedance into a linear voltage signal.

- Designed for Specific Cable Length Systems
- 1 m, 5 m & 9 m are API 670 Standards
- -24 VDC Power Required
- Output, Common and Supply Voltage Connections
- Converts Probe Impedance to Voltage
- Linearizes the Signal

Proximity Probe & Cabling Part Numbers

It is important to understand the cabling and part numbering for proximity probe systems, as it is not always easy to distinguish between components. Bently Nevada is the market-leading manufacturer of proximity probe systems.

> Distinguishing cable length can be difficult.

On a typical proximity probe part number, the digits after the third dash indicate the length, in meters, of the integral cable attached to the probe. In this example, the proximity probe part number is 330171. The "10" indicates one meter of integral cable. This means the probe has one meter of integral cable and is intended for use in a five-meter system.

To achieve a five-meter system length, a four-meter extension cable is required. In an extension cable part number, the first number after the dash indicates the cable length in meters. For example, the "040" in part number 330130-040 represents a four-meter extension cable. When the one-meter integral cable is connected to the four-meter extension cable through a 10-32 microdot connector, and then to the proximitor, the result is a five-meter system matching the proximitor configuration.

Proximity Probe

- 330171-00-20-**10**-02-00
- **Number after 3rd dash = length in meters**
- 10 = 1 m

Extension Cable

- 330130-**040**-00-00
- **Number after 1st dash = length in meters**
- 040 = 4 m

Length of prox probe cable + extension cable must equal specified length on proximitor

- 5 m

Initial Set-Up

Before testing, the initial probe gap must be set correctly. A typical proximity probe operates linearly from approximately 10 mils to 90 mils, or about 0.25 mm to 2.5 mm. The probe tip is commonly positioned at an initial gap of 50 mils from the turbine shaft or target.

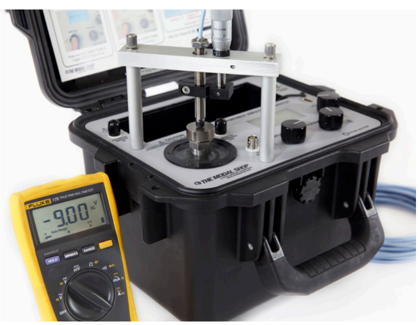
If the correct cable is installed, the exact initial gap is not critical for accuracy. Setting the gap at 50 mils is convenient because it is the center of the probe's dynamic range. This allows the shaft or target to move up to 40 mils in either direction while remaining within the linear measurement range.

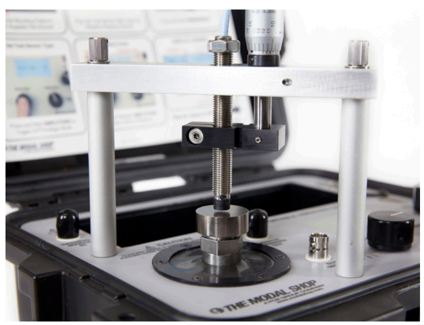
If the initial gap were set at 60 mils, no harm would occur, provided the correct cable lengths were used. The system would simply have a different available range.

For example, starting at 60 mils would allow the shaft to move 30 mils further away or up to 50 mils closer while remaining within the linear region.

In most applications, radial probes have alert and alarm settings well below 10 mils. Turbine shafts are typically well balanced, and vibration levels of 4 to 8 mils are often sufficient to trigger alerts. From a practical standpoint, as long as the correct cable is installed, an initial gap between roughly 40 and 60 mils is generally acceptable.

In this example, setting the gap at 40 mils produced a voltmeter reading of –8 VDC. This does not affect the dynamic output, but according to the probe datasheet, the DC output at 50 mils should be approximately –9 VDC.





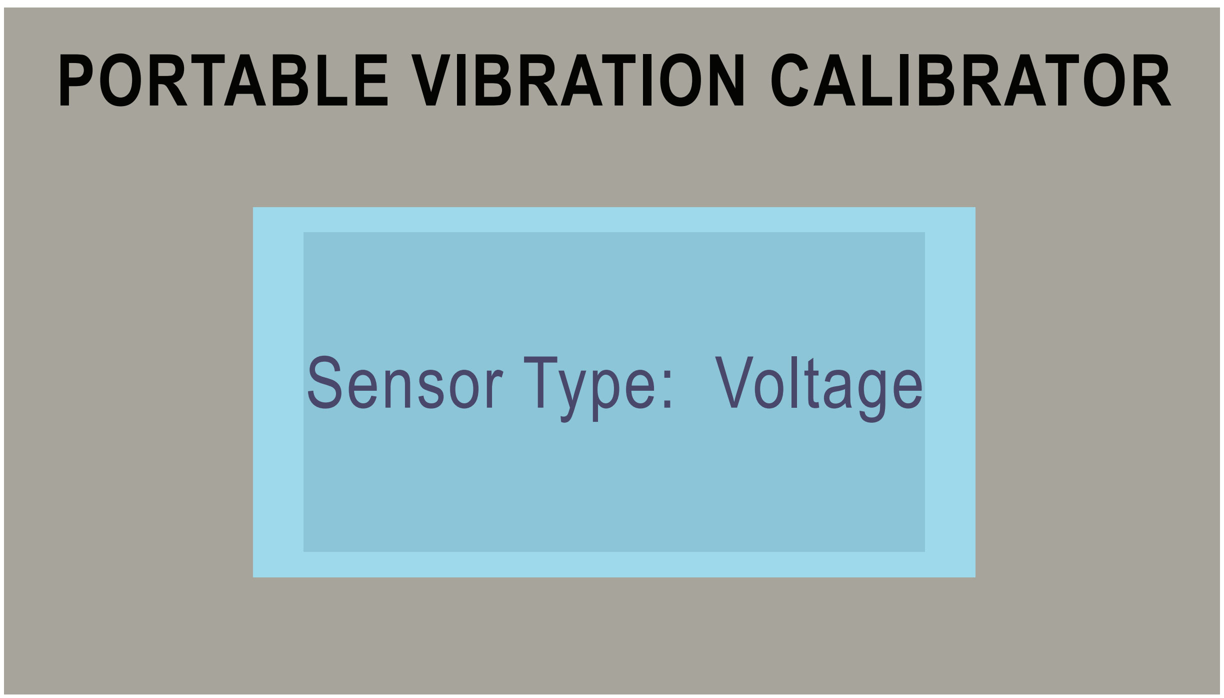
- Center of Dynamic Range is 50 mils (1.27 mm)
- DC Output = -9.00 V

Measuring Dynamic Output

To measure the dynamic output of the proximity probe, the portable vibration calibrator must be set to voltage mode. On The Modal Shop's 9110D, this is done by pressing the Amplitude button to toggle from ICP® mode to voltage mode.

ICP accelerometers are often permanently installed on bearing housings or used in route-based measurements with magnetic mounts. Portable calibrators can generate calibration certificates for these types of sensors, and in ICP mode, the calibrator supplies power to them.

In this example, the proximity probe is powered by the proximitor, and the AC voltage output from the proximitor represents the dynamic signal. To measure this, the calibrator is switched to voltage mode by holding the Amplitude button. The proximitor output is then connected to the test sensor input BNC on the calibrator.



Press and hold AMPLITUDE to toggle 9110D from ICP to Voltage Mode

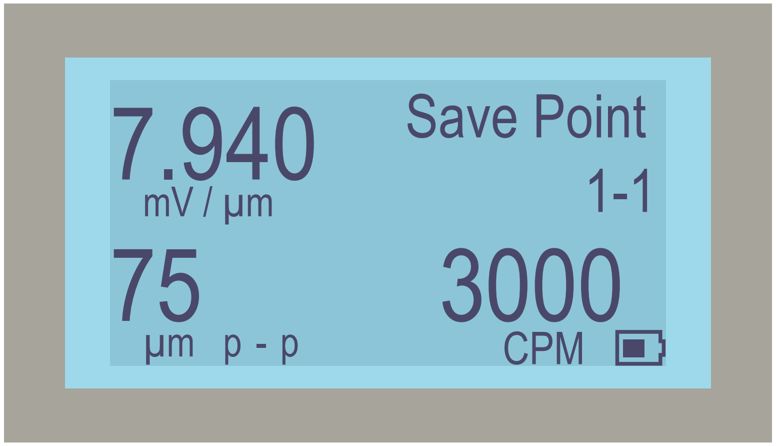
Connect output of proximitor to TEST SENSOR IN

Correct Dynamic Output

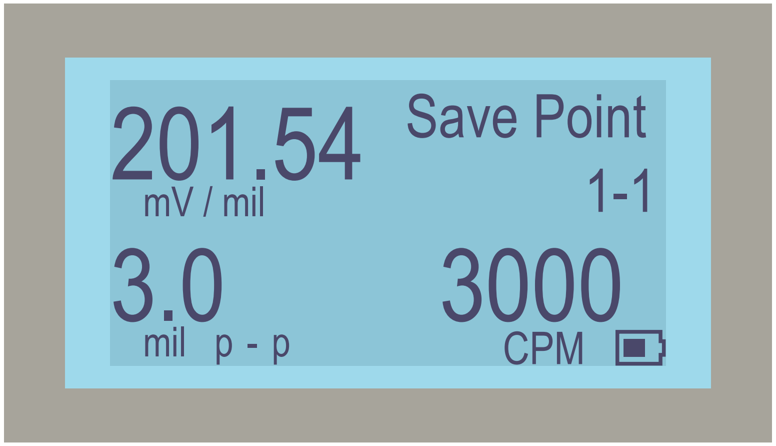
With the correct cable configuration—a one-meter integral probe cable and a four-meter extension cable—the system should produce approximately 200 mV per mil, or 7.90 mV per micrometer.

In this example, vibration is simulated at 3 mils peak-to-peak and 3000 CPM (60 Hz). The measured output is approximately 201 mV per mil. With a tolerance of ±5%, any reading between 190 and 210 mV per mil is acceptable for this test condition.

In metric terms, the simulation is 75 µm peak-to-peak at 3000 CPM, producing an output of about 7.94 mV/µm, which is very close to the expected 7.90 mV/µm.



Desired Dynamic Output
- ~200 mV/mil
- ~7.90 mV/µm



Desired Dynamic Output
- 5 m system
- Prox Probe = 1 m cable
- Extension cable = 4 m cable

Introducing Error

Cables look alike, have the same connectors, are the same color.
What if a 4.5-meter extension cable is used in our demo?

What happens if a cable error is introduced? The cables may appear very similar. They are often the same color, use the same connectors, and have nearly identical part numbers.

If the digits after the first dash are “040”, the cable length is 4 m. If they are “045”, the cable length is 4.5 m. A 4.5 m extension cable would be correct only if used with a probe that has 0.5 m of integral cable in a 5 m system.

In this example, a 4.5 m extension cable is mistakenly used with a probe that already has 1 m of integral cable, effectively creating a 5.5 m system connected to a proximitor configured for 5 m.

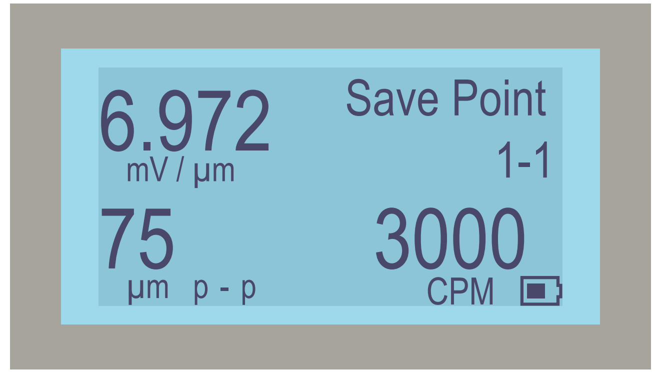
What happens if we introduce cable error?

Incorrect Dynamic Output

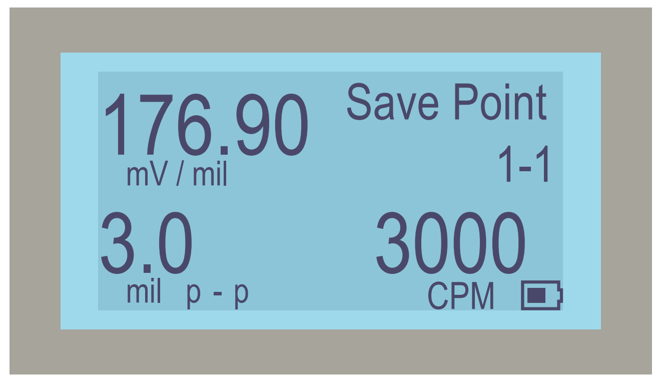
The data now reflects the use of an incorrect cable. The proximitor is configured for a 5 m system, but the actual cable length totals 5.5 m. This additional 0.5 m of cable results in an 11.5% reduction in dynamic output.

Instead of the expected 200 mV per mil, the system now produces approximately 177 mV per mil at 3 mils peak-to-peak and 3000 CPM. In metric terms, this corresponds to about 6.97 mV/µm at 75 µm peak-to-peak.

Because the vibration protection system expects a scale factor of 200 mV per mil, alert and alarm thresholds are effectively shifted. With only 177 mV per mil being produced, the alarms will trip approximately 11.5% later than intended, meaning more vibration is required before protection limits are reached.



Desired Dynamic Output
- ~200 mV/mil
- ~7.90 mV/µm
- % error = 11.5%

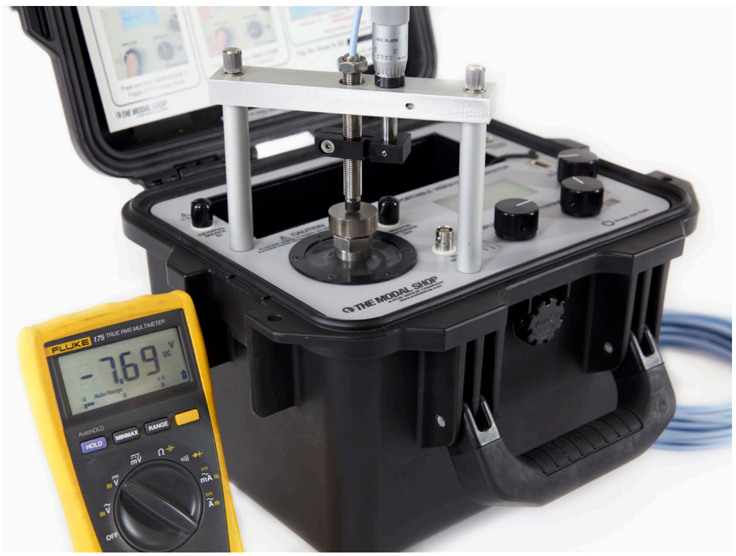


- 5 m system
- Prox Probe = 1 m Cable
- Extension Cable = **4.5 m Cable**

Adjusting Gap Voltage

The issue becomes more serious when an incorrect cable length is mistaken for an incorrect probe position. In many installations, the probe tip cannot be seen once installed, making it difficult to judge whether the gap is 40, 50, or 60 mils.

With the incorrect cable, the gap voltage will appear wrong. In this example, the reading is –7.69 VDC. A technician may assume the probe is not positioned correctly and adjust it to achieve the expected –9 VDC at 50 mils. However, the probe may already be correctly positioned, and the incorrect voltage is actually due to the cable error.



Incorrect cable length causes gap voltage to decrease

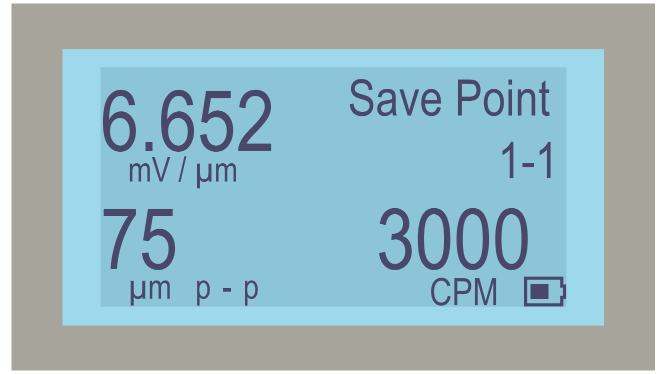
Technician adjusts position of proximity probe to correct for this error

Compounding Dynamic Error

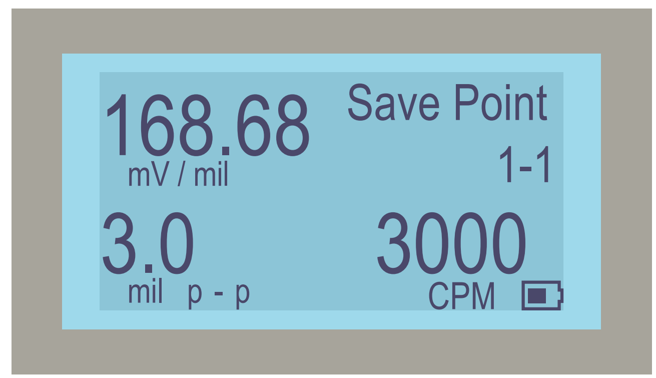
If the probe position is adjusted to correct the apparent gap voltage, the dynamic error becomes worse. Initially, the 5.5 m cable connected to a 5 m proximitor created an 11.5% error. After adjusting the probe position, the total dynamic error increases to about 16%.

Instead of the expected 200 mV per mil, the system now produces approximately 169 mV per mil. In metric terms, the expected 7.90 mV/µm is reduced to about 6.65 mV/µm.

As a result, vibration alarms set at 3 or 5 mils peak-to-peak will trip later than intended because the monitoring system is receiving a lower-than-expected voltage signal.



Desired Dynamic Output
- ~200 mV/mil
- ~7.90 mV/µm
- % Error = 16%



- 5 m system
- Prox Probe = 1 m Cable
- Extension Cable = **4.5 m Cable**
- **Gap Voltage Corrected**

Summary

Incorrect probe extension cable lengths are one of the most common causes of proximity probe errors in power generation applications. The cables can be easily confused, leading to installation mistakes. Technicians may then compound the error by adjusting the probe position to achieve the expected gap voltage.

Dynamic calibration provides a practical way to identify these issues before a gas or steam turbine is started, ensuring that proximity probes and alarm levels function as intended. In practice, the probe output does not need to be connected directly to the calibrator. It can remain connected to the monitoring system while the simulated displacement is increased to the alert and alarm thresholds, allowing the alarm response to be confirmed.

While static calibration can sometimes reveal cable length errors through a non-linear DC output curve, dynamic testing is the only method that verifies the entire measurement chain: probe, cable, probe driver, and monitoring system. It simulates real machine vibration at operating speed and confirms both system sensitivity and alarm setpoints.

Using a portable calibrator, calibration certificates can be generated for frequency response and proximity probe linearity, providing a documented record for quality assurance. The videos on the following page demonstrate how to mount the proximity probe into the adaptor kit for the Model 9110D and how to operate the system.

With a portable calibrator you can create calibration certificates for both frequency response and for proximity probes.

Thank You!

We appreciate your attention and thank you so much for working with The Modal Shop!

[Video: Proximity Probe and Eddy Current Probe Troubleshooting]

[Video: Using 9110D to Calibrate Proximity Probes & Create Certificates]

[Video: Installing the Proximity Probe Adaptor Kit & Mounting the Probe]

[Video: Loop Check and Calibrate Bently Nevada ProxPac®]

Contact Us

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