Shaft Eccentricity plays a very important role as part of a Turbine Supervisory Instrumentation (TSI) System on large steam turbines and should be included in retrofit plans when at all possible.

ROTOR ECCENTRICITY

Operators use eccentricity measurements to determine when a combination of slow roll and heating have reduced the rotor eccentricity to the point where the turbine can safely be brought up to speed without damage from excessive vibration or rotor to stator contact.

Eccentricity is the measurement of Rotor Bow at rotor slow roll, which may be caused by any, or a combination of

1. Fixed mechanical bow
2. Temporary thermal bow
3. Gravity bow.

In extreme cases of thermal/gravity bow, caused by a sudden trip of the unit and failure of the turning gear to engage, the rotor may be positioned and stopped 180° out of phase (bow up) to allow gravity to work entirely on the bow and substantially shorten the time required to reduce the bow.

Eccentricity is measured while the turbine is on slow roll (1 to 240 RPM below the speed at which the rotor becomes dynamic and rises in the bearing on the oil wedge) and requires special circuitry to detect the peak-to-peak motion of the shaft. This is accomplished using circuitry with long update times selectable between 20 seconds (> 3 RPM) and 2 minutes (< 3 RPM).

As the eccentricity measurement is not required after a turbine is brought to speed and under load provisions are made to lock the measurement to zero. This can be accomplished without external contacts through the use of a speed measurement channel with under speed or over speed alarms.

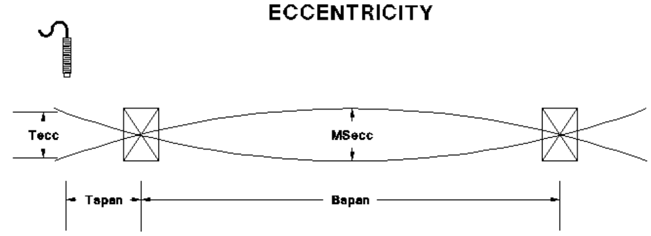
As it is impractical to mount Eddy Probe Transducers (Non-Contacting Pickups) midspan on the rotor where the bearing should be avoided as a mounting location because during slow roll operation the rotor is turning in the bottom of the journal bearing and is not dynamic while the eccentricity measurements are being made. This effect forces the bearings to become nodal points.
Assuming uniform stiffness and weight, the rotor mid-span eccentricity may be expressed as the ratio of the transducer span from the bearing over the transducer measured eccentricity to 1/2 the bearing span over the midspan eccentricity or calculated using the following formula,

$(T_{ecc} \times \frac{1}{2} B_{span})/T_{span} = MS_{ecc}$.

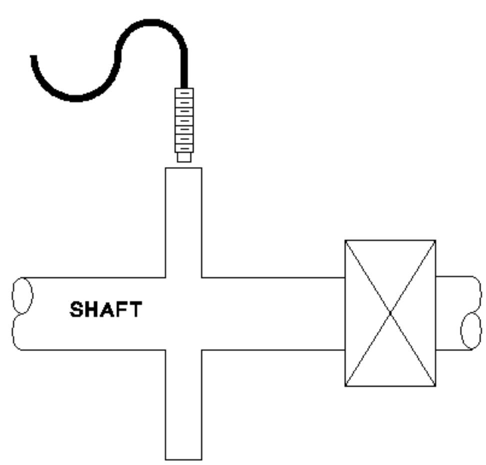
Where T_{ecc} = Transducer measured eccentricity
B_{span}= Bearing Span
T_{span}= Transducer span from bearing
MS_{ecc}= Midspan eccentricity

OEM's (Original Equipment Manufacturers) should be consulted for actual calculations.

MIDSPAN ECCENTRICITY

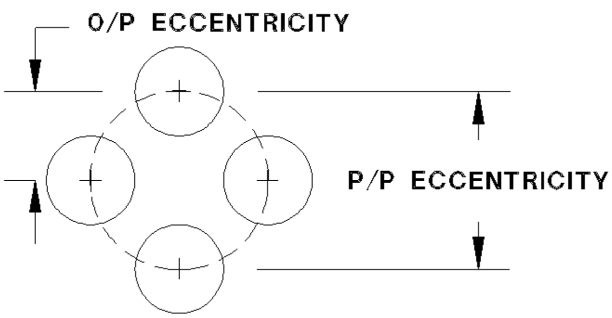


EXISTING ECCENTRICITY COLLAR



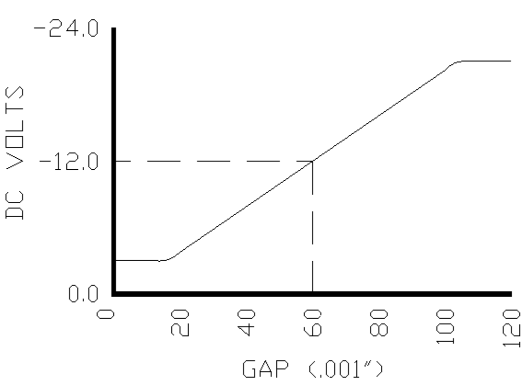
Turbine owners who are retrofitting existing eccentricity systems supplied by the OEM or others will mount the eccentricity transducer at the same location as the original installation. In many cases only minor modifications to the existing bracket are required. Using the same location has several advantages and simplifies installation.

1. OEM's original installation as a rule included an eccentricity collar or other good target for an Eddy Probe System.
2. Eddy Probe eccentricity measurements will agree closely with the original OEM supplied system, as the measurements will be taken at the same location.
3. Operators will need less training on how to interpret the new systems measurements, as they will be basically the same.
4. Eccentricity historical data will be valid.
5. Existing brackets may be modified.
6. Case or standard penetration for cable may be reused with minor modification.



Eccentricity is normally measured P/P (Peak to Peak) to agree with previously established conventions. The actual excursion from shaft centerline caused by bow would be one half that measurement or the 0/P (Zero to Peak) measurement. The Turbine Supervisory Instrumentation may be calibrated in either fashion to suite the users requirements.

Theory of Operation



Eddy Current Transducers work on the proximity theory of operation. A system consists of a matched component system: a Probe, an Extension Cable and an Oscillator / Demodulator (driver). A high frequency RF signal @2 MHz is generated by the Oscillator/Demodulator, sent through the extension cable and radiated from the Probe tip. Eddy currents are generated in the surface of the shaft. The driver demodulates the signal and provides a modulated DC Voltage where the DC portion is directly proportional to gap (distance) and the AC portion is directly proportional to vibration. In this way, an Eddy Current Transducer can be used for both Radial Vibration and distance measurements such as Thrust Position and Shaft Position.

Special Considerations

Mounting Orientation

All vibration transducers measure motion in their mounted plane. In other words, motion either directly away from or towards the mounted Eddy Probe will be measured as eccentricity.

For eccentricity measurements it is recommended that the transducer be mounted vertically. As most eccentricity sensors are internally mounted and are not visible from the outside of the machine whatever the angle of orientation is finally chosen it is very important that the mounting location be documented for future reference.

Linear Range

Several versions of Eddy Probe Transducers are available with a variety of Linear Ranges and body styles. In most cases, a sensor with a linear range of 90 mils (0.090") is more than adequate for Eccentricity measurements.

Model	Range	Output	Size
CMSS65	90 mils	200 mV/mil	1/4"x28 UNF 1" to 5" Length
CMSS68	90 mils	200 mV/mil	3/8"x24 UNF 1" to 9" Length

1010 East Main Street, League City, TX 77573 Phone: 281.334.0766 Fax: 281.334.4255
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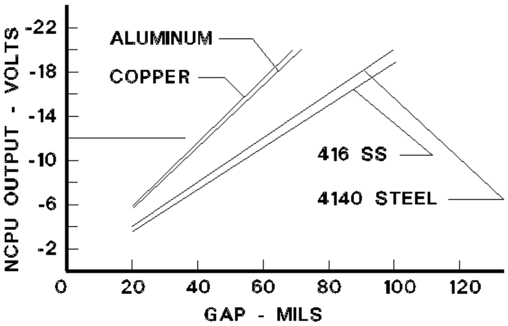
Target Material/Target Area

Target Material



Eddy Current transducers are calibrated at the factory for 4140 Steel unless specified otherwise. As Eddy Probes are sensitive to the permeability and resistively of the shaft material, any shaft material other than 4000 series steels must be specified at the time of order. In cases of exotic shaft material a sample may need to be supplied to the factory.

Mechanical Runout

Eddy Current transducers are also sensitive to the shaft smoothness for Eccentricity. A smooth (64 micro-inch) area approximately 3 times the diameter of the probe tip must be provided for a viewing area.

Electrical Runout

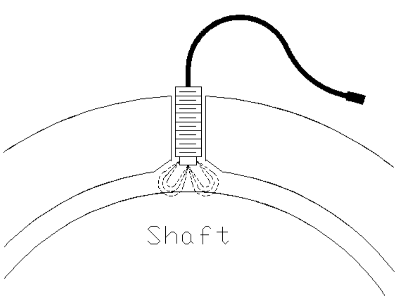
Since Eddy Probes are sensitive to the permeability and resistively of the target material and the field of the transducer extends into the surface area of the shaft by approximately 15 mils (0.015"), care must be taken to avoid non-homogenous viewing area materials such as Chrome.

Another form of electrical runout can be caused by small magnetic fields such as those left by Magna-fluxing without proper degaussing.

Perpendicular to shaft centerline

Care must be exercised in all installations to insure that the Eddy Probe is mounted perpendicular to the shaft centerline. Deviation by more than 1-2 degrees will effect the output sensitivity of the Probe.

Transducer (Probe) side clearances



The RF Field emitted from the probe tip of the transducer is approximately a 45° conical shape. Clearance must be provided on all sides of the Probe tip to prevent interference of the RF Field. Care must also be taken to avoid collars or shoulders on the shaft that may thermally "grow" out from under the Probe tip as the shaft expands.

Eddy Probe tip-to-tip clearances

Although Eddy Probe tip-to-tip clearances are not normally an issue on most machines, it should be noted that the probes radiate an RF Field larger than the probe tip itself. As an example, SKF-CM CMSS65 and 68 Eddy Probes should never be installed with less than one (1) inch of Probe tip-to-tip clearance. Larger probes require more clearance. Failure to follow this rule will allow the driver to create a "beat" frequency, which will be the sum and difference of the two driver RF frequencies.

System Cable Length and Junction Boxes

Eddy Probe Systems are a "tuned" length, and several system lengths are available. System length is measured from the probe tip to the Oscillator/Demodulator, and is measured electrically, which can be slightly different than the physical length. For example, the Model 403 is available in 9, 20, and 30-foot system lengths. Care must be taken to insure that the proper system length is ordered to reach the required Junction Box.

Grounding and Noise

Electrical noise is a very serious consideration when installing any vibration transducer, and special care needs to be taken to prevent unnecessary amounts of noise. As most plant electrical noise is at 60 HZ, and many machine-running speeds are also 60 HZ, it is difficult to separate noise from actual vibration signal. Therefore, noise must be kept to an absolute minimum.

Instrument Wire

A 3-wire twisted shielded instrument wire (i.e.; Belden #8770) is used to connect each Oscillator/Demodulator to the Signal Conditioner Card in the Monitor. Where possible, a single run of wire from the Oscillator/ Demodulator (Junction Box) to the Monitor location should be used. Splices should be avoided.

The gauge of the selected wire depends on the length of the instrument wire run, and should be as follows to prevent loss of high frequency signals:

Up to	200 feet	22 AWG
Up to	1000 feet	20 AWG
Up to	4000 feet	18 AWG

The following wiring connection convention should be followed:

Red -24 VDC Power
Black Common
White Signal

Common Point Grounding

To prevent Ground Loops from creating system noise, system common, ground and instrument wire shield must be connected to ground at one location only. In most cases, the recommendation is to connect commons, grounds and shields at the Monitor location. This means that all commons, grounds and shields must be floated (not connected) at the machine.

Occasionally due to installation methods instrument wire shields are connected to ground at the machine case and not at the monitor. In this case, all of the instrument wire shields must be floated (not connected) at the monitor.

Conduit

Dedicated conduit should be provided in all installations for both mechanical and noise protection. Flexible metal conduit should be used from the Eddy Probe to the Oscillator /Demodulator junction box, and rigid bonded metal conduit from the junction box to the monitor.

Calibration

All Eddy Probe systems (Probe, Cable and Oscillator Demodulator) should be calibrated prior to being installed. This can be done by using a SKF-CM P/N CMSS601 Static Calibrator, -24 VDC Power Supply and a Digital Volt Meter. The Eddy Probe is installed in the tester with the target set against the Eddy Probe tip. The spindle micrometer with target attached is then rotated away from the Eddy Probe in 0.005" or 5 mil increments. The voltage reading is recorded and graphed at each increment. The SKF-CM CMSS65 and 68 systems will produce a voltage change of 1.0 VDC ±0.05 VDC for each 5 mils of gap change while the target is within the NCPU's linear range.

Gap

When installed, Eddy Probes must be gapped properly. In most Eccentricity applications, gapping the transducer to the center of the linear range is adequate. For the Model 403 transducer gap should be set for -12.0 VDC using a Digital Volt Meter (DVM), this corresponds to an approximate mechanical gap of 0.060" or 60 mils. The voltage method of gapping the Eddy Probe is recommended over mechanical gapping because it is more accurate and easier to accomplish. In all cases, final Eddy Probe gap voltage should be documented and kept in a safe place.

Eccentricity Installation Checklist

1. Machine Slow Roll Speed
2. Transducer Orientation Documented
3. Target Material: 4140 or Other
4. Smooth Target Area
5. Size of Target Area
6. Junction Box Location(s)
7. Metal Conduit (Junction Box to Monitor)
8. Flexible Conduit (Junction Box to Probe)
9. Correct Instrument Wire
10. Shielding Convention: Monitor or Machine
11. Calibration
12. Gap Set