Glossary

ABBREVIATIONS:

CPM	= cycles per minute (frequency)	**um**	= 10^{-6} meter (displacement)	**mm/s**	= millimeters/second (velocity)
Hz	= Hertz; cycles/second (frequency)	**pk**	= peak (or zero-to-peak)	**g**	= gravitational effect (acceleration)
KHz	= Kilohertz; Hz x 1000	**pk-pk**	= peak-to-peak vibration (amplitude)	**HP**	= horsepower (power)
RPM	= revolutions/minute (rotative cpm)	**ips**	= in/sec=inches/second (velocity)	**kW**	= Kilowatts X 1000 (power)
mil	= .001 inch (displacement)	**RMS**	= root mean square (amplitude)		

ABSOLUTE VIBRATION: Vibration of an object relative to a fixed point in space. *Seismic sensors,* including *accelerometers* and *velocity sensors*, mounted externally on a machine case, measure absolute vibration.

ACCELEROMETER: A seismic *sensor* made from a piezoelectric material which produces a charge output proportional to acceleration (pC/g). When housed together with an electronic charge amplifier and charge-to-voltage converter (mV/g), it is referred to as an "internally amplified" accelerometer. If, due to temperature, only the *sensor* is machine mounted, the remote electronics are referred to as a "charge amplifier" (although it usually also contains a charge-to-voltage convertor).

ACCURACY: The ratio of the *error* to the full scale output, or the ratio of the *error* to the output expressed as a percent. It is sometimes confused with inaccuracy which is the departure from the true value into which all sources of *error* are combined, e.g. *hysteresis*, non-linearity, drift, temperature effects and random errors.

ALIGNMENT: Condition whereby the axes of machine components are colinear, parallel, or perpendicular, according to design requirements. A measurement of the relative position of a machine component with respect to another. Relative alignment measurements can be made from bearing to bearing, rotor to rotor, rotor to bearing, bearing to casing, casing to foundation, casing to piping, etc. Various techniques for cold and hot machine alignment measurement are used including optical, mechanical (dial indicators), and electronic *(proximity probes).*

AMPLITUDE: The magnitude of periodic *dynamic motion* (*vibration*). *Amplitude* is detected (i.e. electronically measured) in terms of *peak-to-peak, zero-to-peak, rms,* or *average.*

AXIAL: Along the shaft centerline.

AXIAL (THRUST) POSITION: Change in (or average) position of a rotor in the *axial* direction with respect to a thrust bearing support structure or nearby fixed point. *A proximity probe* observes the shaft, it's thrust collar or other nearby integral *axial* shaft surface. Measurement is made by a known probe gap distance (voltage) representing a known position of the thrust collar relative to the thrust bearing clearance.

BALANCING: A procedure for adjusting the *radial* mass distribution of a rotor so that the mass centerline (principal inertia axis) approaches the rotor rotational axis. This reduces the *radial vibration* of the rotor due to unbalanced inertia forces and the forces on the bearings at the once-per-revolution *frequency.*

BALANCE-OF-PLANT MACHINES: Machines not critical to the overall plant process. They often operate in tandem or spared installations.

CALIBRATION: Test where known values of the measured variable are applied to a *sensor, signal conditioner, monitor* or the entire *channel* output readings to verify or adjust as necessary.

CALIBRATION CURVE: Graph of a measured *sensor, signal conditioner, monitor* or entire *channel* output compared to a known input signal.

CHANNEL: A *sensor* with the associated *signal conditioner* and *monitor* hardware required to display its' output signal.

CONDITION MONITORING: Broad field of measurement and analysis of machine parameters to determine machinery health. Modern condition monitoring programs supplement real-time catastrophic vibration, temperature and process "protection monitoring" with more complex often computer based "predictive" maintenance analysis tools. Their aim is to predict the potential timing of machinery failures relative to scheduled production rather than potentially unnecessary time interval based "preventative" maintenance.
Supplemental tools may include performing *vibration analysis*, oil analysis, laser *alignments* and automated *balancing*. The use of thermography for undesirable heat transfer due to coupling misalignment, process or electrical connection problems, and the monitoring of acoustic changes in certain valves and rolling element bearings are also employed.

CRITICAL MACHINES: Machines required for a major part of the plant. When they go down, that part of the process cannot operate. They are usually unspared and monitored continuously.

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CROSS AXIS (TRANSVERSE) SENSITIVITY: Ratio of the change in signal output of a *seismic sensor* to an incremental change to a stimulus along any axis perpendicular to the sensitive axis.

CROSS TALK: Interference or *noise* in a *sensor* or *channel* which has its origin in another *sensor* or *channel.* It may occur when two (or more) *proximity probe* tips are too close together, resulting in the interaction of their electro-magnetic fields. The result is to have one signal component on each *sensor's* output signal. The *frequency* of the *noise* is the difference (beat *frequency)* of the two *probe driver* oscillation *frequencies.*

DISPLACEMENT: The change in distance, or position, of an object. It is usually a peak-to-peak measurement of vibration with units of *mils* or *microns*. In *proximity monitoring, eddy current proximity probes* measure shaft displacement directly. In *seismic monitoring*, *integration* of a *velocity sensor* signal is necessary to obtain displacement. An *acceleration* signal requires double (i.e. two stages of) *integration* to yield a displacement measurement.

DUAL PATH: *T*echnique used in *signal conditioners* and/or *monitors* whereby a single *sensor* input is processed through two separate paths; each has its' own measurement units (e.g., *velocity* and *displacement*), optional *filtering, setpoints* and readout displays.

DUAL VOTING: A concept requiring that two independent inputs agree before action is taken. This function may be incorporated in a *monitor,* whereby two (vs. only one) *sensor* input signals must both measure an *amplitude* value which exceeds a set point (usually the Danger set point only) before an alarm condition is indicated.

DYNAMIC MOTION: Vibration of a rotor system.

EDDY CURRENT: Electrical current generated (and dissipated) in a conductive material (usually a rotor shaft) when it intercepts the electro-magnetic field of a *proximity probe*.

ELECTRICAL RUNOUT: A source of signal error from a *proximity sensor system* which repeats with each shaft revolution; A *probe driver* output signal change not resulting from a probe gap change *(dynamic motion* or change in position); Often caused by varying conductivity of the shaft material or the presence of localized magnetic fields at a point(s) on a shaft surface. See also MECHANICAL RUNOUT.

ELECTRONIC VIBRATION SWITCH: Unitization of an *accelerometer*, *signal conditioner* and *monitor* (i.e. single *seismic monitoring channel*). Offers *setpoint time delay*(s) for false trip avoidance and more sensitive *velocity* (or *displ.)* measurement. Most have an optional second *setpoint.* See MECHANICAL VIBRATION SWITCH.

ERROR: The difference between the indicated and true values of the measured variable. Typically expressed as relative error which is a percentage of the output reading of the *sensor.*

ESSENTIAL MACHINERY: Machines critical to part of the plant. When down, the overall plant cannot operate to full capacity. They can be spared or unspared and are usually monitored continuously.

EXTENSION CABLE: A coaxial cable used to interconnect a *proximity probe's* cable to a *probe driver*. It serves to 1) extend the distance to a suitable location for a *probe driver* and 2) provide a disconnect point for easier installation and removal of standard mount style, threaded *proximity probes*. See also SYSTEM LENGTH.

FILTER: Circuitry which passes or rejects a specific *frequency* band usually to isolate a particular machinery mechanical condition(s). "High pass" filters allow only frequencies higher than their design *frequency* to pass (i.e. be detected). "Low pass" filters permit only lower ones. "Bandpass filters" are both low and high pass to narrow both ends of a standard frequency response range. At a filter's design *frequency*, *amplitude signal attenuation is* usually -3 dB and then slopes off (attenuates further) beyond at the design "roll off rate".

FORCED VIBRATION: The oscillation of a system under the action of a forcing function usually occurring at the *frequency* of the excitation force.

FREE VIBRATION: *Vibration* of a mechanical system following an initial *perturbation* (change of position or velocity). Depending on the kind of *perturbation,* the system responds by free *vibration* at one or more of its *natural frequencies.*

FREQUENCY: Repetition rate of a *periodic vibration* within a unit time. Normally expressed in units of cycles per minute (cpm), or cycles per second (cps or Hz). May be expressed relative to shaft RPM. For rotating machinery *vibrations,* there are two types of frequencies of interest: 1) the shaft rotational frequency (RPM) and 2) the various *vibration* frequencies as measured by *vibration sensors. Vibration* frequencies are usually expressed as a fraction or percentage of the shaft RPM: 1X means one times RPM, 2X means two times, 1/2X, means 50%, etc.

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FREQUENCY RESPONSE: Measured *amplitude* and *phase* characteristics of a mechanical or electronic system with respect to *frequency.*

G: The value of *acceleration* yielded by the force of gravity, which varies somewhat with the earth latitude and elevation of the point of observation. A value of 9.8 m/s^2 = 386 in/s^2 = 32.2 $ft./s^2$ is used for the *acceleration* due to gravity at sea level.

GEARMESH FREQUENCY: A potential *vibration frequency* on any machine employing gears. It is calculated by multiplying the number of gear teeth times that same gear shaft's RPM. For a given gear set, all contacting gears have the same gearmesh frequency for normal operation or else they would not mesh and soon fail!

HARMONIC: Sinusoidal quantity at a *frequency* which is an integer multiple of the fundamental *frequency.*

HERTZ (Hz): Unit of *frequency* in cycles/second. Divide shaft RPM by 60 for frequency in Hz.

HYSTERESIS(DEADBAND): Non-uniqueness between two variables as a parameter increases or decreases. In particular, the maximum difference in output at any given value of the measured variable within the specified range, when the value is first approached with an increasing signal and then a decreasing one. Also called deadband, or that portion of a system's response where a change in input does not produce a change in output.

INERTIALLY REFERENCED: Motion that is referenced to free space or to a fixed point in space; a *sensor* which measures such motion.

INTEGRATOR: Circuitry used in a *seismic signal conditioner* and/or *monitor* which performs mathematical integration. It converts a *veloc*
ity signal to *displacement* or an *acceleration* signal to *velocity*. A double integrator converts *an acceleration* signal to *displacement.*

LINEARITY: Closeness of a *calibration curve* to a specific straight line, expressed as the maximum deviation of any calibration point to that line during any one calibration increment.

MECHANICAL RUNOUT: A source of error on the output of signal of a *proximity sensor system*; a *probe* gap change not resulting from a shaft *center position* change or *dynamic motion.* Common sources include out-of-round shafts, scratches, chain marks, dents, rust, stencil marks, flat spots, and engravings.

MECHANICAL VIBRATION SWITCH: Resetable device which, after observance of a *forced vibration* greater than it's *setpoint*, *accelerates* a mass (e.g. a lever) to initiate closure or opening of a set of internal field contacts. See ELECTRONIC VIBRATION SWITCH.

MICRON (MICROMETER): Length or displacement equal to 10^{-6} meters. One micron = 0.04 mil.

MIL: Length or displacement = .001 inch = 25.4 um

MONITOR: A loosely used instrumentation term. For machinery, a "protection" monitor may accept inputs from a variety of sensors including temperature, vibration, RPM and 4- 20 mA output types. As a minimum, the monitor compares real-time measured values (after any signal conditioning) to an alarm setpoint(s), verifies input sensor/wiring integrity and provides for relay output for machinery ALERT and/or DANGER warning.

When the accepted monitor inputs include traditional vibration sensors with dynamic output that require the monitor to also have internal *signal conditioning*, it is referred to as a "vibration input" monitor. When a monitor accepts only 4-20 mA inputs from vibration transmitters (such as a PLC, DCS or certain Metrix products) it is often referred to as a "4-20 mA input" monitor.

NOISE: Any component of a *sensor* output signal which does not represent the variable intended to be measured.

PEAK-TO-PEAK VALUE: Difference between positive and negative extreme values of a signal or dynamic motion. See AMPLITUDE.

PERIODIC VIBRATION: Oscillatory motion whose *amplitude* pattern repeats in time.

PHASE: A measurement of the timing relationship between two signals, or between a specific *vibration* signal and a once-per-shaft revolution event (phase angle).

PHASE REFERENCE PROBE: A probe used for 1) determining the unbalance location (phase angle) relative to a measure once-per shaft revolution event location (e.g. a keyway or reflective tape); 2) for complex vibration vectorial addition or subtraction measurements. The *sensor* used in phase reference measurements with installed "protection" monitors is usually a *proximity sensor system* over a keyway. Unprotected machines, or those without a permanent phase reference probe, may have reflective tape temporarily added to be observed by an optical sensor.

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PIEZOELECTRIC: Any material which provides a conversion from mechanical to electrical energy. For a piezoelectric crystal, if mechanical *stresses* are applied on two opposite faces, electrical charges appear on another pair of faces.

PROBE: Loosely used term for any machine mounted instrument including a *vibration sensor.*

PROBE GAP: The physical distance in um or mils between a target (e.g. a machinery shaft or *proximity sensor calibrator* target) and a *proximity probe* tip. The measurement is made either mechanically with a "feeler" or thickness gauge or, more commonly due to machinery case access constraints, electrically by a DC output voltage signal reading from a powered *proximity sensor system.*

Setting the probe gap refers to static (i.e. machine off) positioning of the probe to a distance from the shaft in the center of the sensor system's linear range. This allows for linear electronic measurement of a movement (i.e. machine on) arising from dynamic *radial vibration* or changes in *axial position* about this static probe gap provided it does not exceed the sensor system's maximum linear range in either direction.

PROBE ORIENTATION: The angular location of a *proximity probe* with respect to a polar coordinate system when viewed from the driver end of a machine. Usually, zero degrees is at top dead center (vertical) or at the horizontal right (3 o'clock) position on the coordinate system.

PROXIMITY MONITORING: One or more *channels* of monitoring each consisting of: 1) *proximity sensor system*; 2) *signal conditioner*; 3) *monitor.* For a given application, these monitoring components may be partially combined (e.g. a *probe driver* and a *signal conditioner* to form a unitized *vibration transmitter*) or entirely into a proximity switch with relay output.

PROXIMITY PROBE: *A* non-contacting device which measures the *displacement* motion and position of an observed surface relative to the probe mounting location. Proximity probes used for rotating machinery measurements usually operate on the eddy current principle and measure shaft *displacement* motion and position relative to the machine bearing(s) or housing.

PROXIMITY PROBE DRIVER (OSCILLATOR-DEMODULATOR): A device which sends a radio frequency signal to an eddy current *proximity probe* usually through a *extension cable*, demodulates the *probe* output, and provides output signals proportional to both the average and dynamic *probe gap* distances.

PROXIMITY SENSOR CALIBRATOR: A mechanical device which generates *dynamic motion* of an observed surface at a known *amplitude* and *frequency.* The surface is observed by a *proximity probe* for the purpose of calibrating only the *proximity sensor system* or, with it's *monitor,* an entire proximity *channel.*

PROXIMITY SENSOR SYSTEM: An electrically matched (tuned) sensor system comprised of a *proximity probe*, usually an *extension cable* and a *probe driver*.

RADIAL: A direction of a machine which *is* perpendicular to the shaft centerline; in the XY plane; usually refers to direction of shaft or casing motion or measurement.

RADIAL (CENTERLINE) POSITION: The average position of the shaft centerline within the bearing. This can be measured by noting the change in VDC output of two XY probes from a known position with the shaft at rest. The XY probes should be attached to the bearing or its' housing to eliminate thermal growth errors.

RADIAL (LATERAL) VIBRATION: Shaft *dynamic motion* or casing *vibration* which is measured at 90° to the shaft centerline.

RELATIVE MOTION: *Vibration* measured relative to a chosen reference. *Proximity probes* measure shaft *dynamic motion* and position relative to the probe mounting, usually the bearing or bearing housing.

RELATIVE PROBE: A *proximity probe* observing shaft motion relative to a stationary reference such as a bearing housing.

REPEATABILITY: The ability of a *sensor* or *monitor* to reproduce output readings when the same value is applied to it repeatedly, under the same conditions, and in the same direction. Also the maximum deviation from the mean of corresponding data points taken from repeated tests under identical conditions.

RESOLUTION: The smallest change in applied stimulus that will produce a detectable change in the instrument output. Resolution differs from precision in that it is a psycho-physical term referring to the smallest increment of humanly perceptible output (rated in terms of the corresponding increment of input).

RESONANCE: The condition where a forcing frequency coincides with a natural frequency of the system. A resonant condition usually causes a substantial *amplitude* increase.

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RMS (ROOT MEAN SQUARE): Square root of the arithmetic average of a set of squared instantaneous values. In *rolling element bearings,* certain bearing problems may be indicated by increased RMS vibration levels of the *outer race* motion. See AMPLITUDE.

ROLLING ELEMENT (ANTI-FRICTION) BEARING: A bearing which uses *rolling elements* (rollers or balls) to support the load of a rotating shaft with minimum friction.

RTD: An acronym for a Resistance Temperature Detector; a sensor which measures temperature or temperature change as a function of resistance.

RYTON: A highly chemical and abrasion resistant material (polyphenylene sulfide resin) made by Phillips Petroleum Company used to fabricate proximity probe tips.

SEISMIC MONITORING: One or more channels of monitoring each consisting of: 1) seismic (casing) *accelerometer* or *velocity sensor*; 2) *signal conditioner*; 3) *monitor.*

For a given application, these monitoring components may be partially combined (e.g. an *accelerometer* and a *signal conditioner* to form a unitized *vibration transmitter*) or entirely into an *electronic vibration switch* with relay output.

SENSOR: A device for translating the magnitude of one quantity to another. The second quantity often has different units of measure and serves to provide a more useful signal. *Vibration sensors* convert mechanical motion into an electronic (typically a voltage proportional) signal.

SETPOINT: An adjustable threshold above which a measured value will initiate relay output indicating a machine or process Alert and/or Danger warning condition.

SET POINT (TRIP) MULTIPLIER: A function provided in a monitor system to temporarily increase the alarm (Alert and Danger) setpoint values by a specific multiple (usually two or three). This function may be applied by manual or control relay action during start-up to allow a machine to pass through high *vibration* speed ranges without excessive monitor alarm indications. Such speed ranges may include system resonances and other normal transient *vibrations.*

SIGNAL ATTENUATION: The reduction in magnitude of a signal without changing the basic characteristics of the signal. Also, the amount of voltage reduction utilized to reduce large electronic signals down to full scale deviation on instruments such as tape recorders. This non-dimensional number is usually in even steps of 0.5, 0.2 and 0.1 Signal attenuation may also result from reduced mechanical transmission of vibration from one machine part to another (e.g., shaft to bearing housing) and also from *signal conditioner* circuits in some applications.

SIGNAL CONDITIONER: A device placed between a signal source (*sensor)* and a *monitor* to change the signal. Examples: attenuators, amplifiers, signal converters (for changing one electrical quantity into another such as volts to amps, analog to digital, integrators) and filters.

SIGNAL GAIN: The increase in magnitude of a signal. Also, the voltage amplification utilized to enlarge small electronic signals up to full scale deviation on instruments. Often expressed in steps of 2, 5, and 10.

SKI-SLOPE: An elevated noise floor that decreases with increasing frequency, often overwhelming the peaks at discrete frequencies that are present in normal measurements.

SPALL: A flake or chip of metal removed from one of the races from a *rolling element* of a bearing. Spalling is evidence of serious bearing degradation and may be detected by relatively small increases in signal amplitude at the bearing frequencies during operation.

SYSTEM LENGTH: A feature of *proximity sensor systems* equal in magnitude to the combined electrical lengths of a *proximity probe* and (usually) an *extension cable* are matched (tuned) to the *proximity probe driver* electronics for proper function (linearity).

Newer *proximity sensor systems* generally have 5 or 9 m system lengths that are normally within +/-5% of their dimensional length. Some older systems have 15 or 20 feet system lengths and, for small diameter probes, have up to -15% shorter dimensional lengths.

THERMISTOR: An electrical device used for temperature measurement. Their coefficients of resistance are either positive or negative (i.e., with increasing temperature, the resistance may increase or decrease for a given type).

THERMOCOUPLE: A temperature sensing device comprised of two dissimilar metal wires which when thermally affected (heated or cooled) produce a proportional change in electrical potential at the point where they join.

THRESHOLD: The smallest change in the measured variable that will result in a measurable change in an output signal.

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THRUST POSITION: See AXIAL POSITION.

TIME DELAY: Electronic vibration protection systems usually offer two types to avoid false alarms for transient conditions: 1) machine start up time delay (or *setpoint multiplication*) ; 2) monitor (running) time delay. They may be of fixed or adjustable time duration.

TOTAL RUNOUT: Equal in magnitude to the electrical plus the mechanical runout.

TRANSDUCER: See SENSOR

TRANSIENT VIBRATION: Temporary vibration of a mechanical system. It may consist of forced or free vibration or both. Typically associated with changes in machine operating condition such as speed, load, etc.

TSI (TURBINE SUPERVISORY INSTRUMENTATION): A TSI system is a continuous monitoring system generally used on turbogenerator sets. It can include such measurements as shaft radial vibration, shaft absolute vibration, axial thrust position, differential expansion case expansion, valve position, eccentricity peak-to-peak, zero speed, and shaft RPM. Metrix does not currently offer this type of instrumentation.

UNBALANCE (IMBALANCE): Unequal *radial* weight distribution on a rotor system; a shaft condition where the mass centerline (principal inertial axis) does not coincide with the geometric centerline. Also, the amount of mass causing the *unbalance.*

VELOCITY: Time rate of change of displacement. *Velocity* leads *displacement* by 90 degrees in time. Units for velocity are inches/second or millimeters/second, *zero-to-peak* or *RMS.* Velocity measurements are obtained 1) by electronic integration of an acceleration signal from an accelerometer or 2) directly from a *velocity sensor.* Velocity is a widely used measurement for evaluating machine casing and other structural response characteristics.

VELOCITY SENSOR: A seismic *sensor* which converts *velocity* motion into a proportional electrical signal.

VIBRATION: Dynamic motion resulting from an applied stimulus. Out-of-tolerance measurements for excessive vibration are useful to protect from 1) personnel injury; 2) costly machinery downtime; 3) avoidable extensive repairs; 4) higher insurance rates.

VIBRATION ANALYSIS (and DATA COLLECTION): Process involving the collection, manipulation, display and more specifically the interpretation of machine casing and/or shaft *vibration waveform* as it relates to machine condition.

Except for the very largest machines, data collection is commonly done by walk around operators who are properly trained in collecting scheduled measurement points. Permanently mounted proximity or seismic *sensors* that are of part of an excessive *vibration* “protection” *monitor* are accessed when possible, or an accelerometer is temporarily attached for casing measurements.

Depending on the data collector, the data may be displayed by an on board screen or downloaded, stored and later retrieved for manipulation on a PC prior to analysis.

Root cause of high or increasing *vibration* is performed by analyzing both time *waveforms*, *frequency* spectrums (i.e. amplitudes at discrete frequencies) for a given instance in time and *phase* information.

VIBRATION METER: A portable one or two part (remote sensor) instrument used to measure seismic (casing) vibration *amplitude*.

VIBRATION TRANSMITTER: An instrument combining a *seismic accelerometer* or a proximity *probe driver* vibration sensor together with a voltage-to-current *signal conditioner* to provide proportional 4-20 mA output. This output represents the zero to full scale nameplate vibration and provides an input to a user’s PLC or DCS wherein a *setpoint*(s), *time delay*(s) and input integrity check(s) may be programmed as part of the *monitor* function.

XY: Perpendicular axes in a Cartesian coordinate system. Usually used as a reference for orthogonal mutually perpendicular dual *vibration sensors.*

WAVEFORM: A presentation or display of the instantaneous *amplitude* of a signal as a function of time. A *vibration waveform* can be viewed on an oscilloscope in the *time base* mode.

ZERO-TO-PEAK VALUE (PEAK): One half of the *peak-to-peak value.*

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