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M

Machine monitoring, global

Monitoring systems were consulted up to now in the conventional sense for the evaluation of the so-called global machine condition. One understands herein the adherence of one or several scalar sizes to within certain limits, for instance peak or rms values of vibration, which stand usually in no connection to each other or to operating regimes, modes of operation and operating conditions. In the foreground it is essential to recognize rapidly arising and unexpected changes of the machine condition in order to prevent damage. Such a violation of given limit values leads to a notification of emergency and/or to the fast shutdown of the plant. Subsequently, one searches for the fault.

The monitoring refers with global systems to the observance of determined limit values of the primary measured variables; one sometimes calls these systems protective or safety systems (level monitoring of scalar quantities).

Machine, stationary

The machine, whose axis of rotation is valid as a reference for the set which is to be aligned. With laser alignment systems the laser-detector is attached to this machine.

Machine, to be aligned

That aggregate of a machine set, which is to be moved relative to the stationary machine (horizontal/vertically). One also usually accomplishes a tilting foot investigation at this machine.

Magnetically-forced vibration

Vibration, excited by (electro-) magnetism

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Maintenance

Measures for maintaining and re-establishing a specified condition, as well as for the statement and evaluation of the actual condition of technical means of a system. These contain the measures of

- Maintenance
- Inspection and
- Repair.

They include

- Agreement of the maintenance goals with the company targets
- Definition of appropriate maintenance strategies.

Note: The four fundamental ideas of maintenance, service, inspection and repair cover in each case the totality of all measures, which are necessary for the maintenance of the technical means of a system (plant and/or components) within an undertaking (in-plant). For maintenance, inspection and repair the specified individual measures are specified in the order of their temporal and logical sequence. The type and range of the individual measures orient themselves in each case to the maintenance strategy of the undertaking. If individual maintenance measures, like execution by protective measures or the execution of defined repair measures outside of the enterprise, e.g. by the product manufacturer or a third party of its own direction and responsibility, then these can orient themselves in principle only at the product and to operating and site conditions which can usually be subordinated. The consideration of operational-specific special conditions and of maintenance measures which result from the maintenance goals and the maintenance strategy of the undertaking, requires special agreements.

Maintenance strategies

Maintenance, damage-oriented; maintenance, time-oriented; maintenance, preventive; maintenance, condition-dependent.

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Maintenance, condition-based

The condition-oriented maintenance concept is based on the regular collection of measurements of authoritative quantities to indicate the machine condition <machine condition monitoring>. With this concept machines are stopped only if their condition requires it; parts are changed only if a damage criterion has been reached.

Maintenance, corrective

Corrective M. (unscheduled M.) is necessary in partial or total breakdown cases for the re-establishment of the specified condition. It does not consider the provisional stages before the loss of systems or building groups.

Maintenance, damage-based

Damage-oriented M. corresponds in principle to corrective maintenance. Drastically expressed, this means operating the machine until breakdown. Thereby no expenditure for maintenance and inspection up to the breakdown is set aside.

Maintenance, preventive

If maintenance is aligned to prevent damage and losses of production one speaks of preventive M. This is also sometimes designated as planned maintenance.

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Maintenance, time-based

Time-oriented M. prescribes the examination and/or inspection of the plant after given time intervals (revision default). The machines go in coordination with the production plan into revision. They are stopped, must be dismantled, individual parts are to be examined, parts are replaced according to their damage and wear condition or only after their specific operating interval has expired. The method is expensive from a time and cost point of view.

Malfunction

Emergence of a disruption during approved deployment of a unit (application) because of a cause inherent in itself.

Note 1: In a system, all of its elements including the human ones are considered potential causes.

Note 2: In contrast to considerations of reliability are cases of failure, but not disturbances for other reasons.

Note 3: Failure exists if an error of the unit occurs during its approved deployment.

Mass

- A characteristic of bodies, by which is shown their inertia and weight, unit for the M. is the kilogram.
- Reference electrode in an electronic circuit, usually with earth potential.

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Master-Slave system

Central bus access procedure by which a central station (master) queries the sub-stations and so makes possible the transmission of information about the common bus.

It is simpler (lower-priced) than a decentralized bus access procedure. In case of failure of the central Master the communications network is however no longer ready for use.

Maximum excursion of shaft vibrations

With the measurement of shaft vibrations, the characteristic quantity “maximum excursion S_{max}“ is defined as the largest value of the kinetic shaft excursion $s_k(t)$.

Note: This characteristic quantity corresponds to the assessment quantity according to VDI 2059, sheet 1 and the assessment standards according to VDI 2059, sheets 2 to 5.

Between the kinetic shaft excursion $s_k(t)$ in the measurement plane and the vibration displacements $s_1(t)$ and $s_2(t)$ in the two measurement directions 1 and 2 at right-angles to one another, there is the relationship:

$$s_k(t) = \sqrt{s_1^2(t) + s_2^2(t)}$$

Maximum peak value

Peak value, positive or negative in polarity, measured against zero.

Maximum RMS value

Maximum effective value

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M

MB

Abbr. for **M**ega**b**yte
Unit for memory size. 1 MB = 1,024 x 1,024 = 1,048,576 Byte.

Mbit

Abbr. for **M**ega**bit**

MByte

Abbr. for **M**ega**byte**

Measure; Measurement

The experimental procedure by which a special value of a physical dimension (measured variable), the measured value as a multiple of a unit or a reference value is determined. The measured value is already in the simplest case the result of the measurement, which is generally faulty. One differentiates between direct and indirect M. With direct M. the measured variable being searched for is attributed to different physical dimension and determined from these, e.g. the resistance can be measured from the current and tension. Since with M. the measured variable must affect the measuring instrument, energy is drawn from the item under test, whereby the result of the measurement can be falsified. For precise measurements in particular potentiometer methods are suitable, because thereby the item under test is not loaded.

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Measured object loading

Every measurement object is loaded when a vibration sensor is attached, i.e. the total vibrating mass is increased. According to the rule of thumb, this influence is permissible when the sensor mass is lower than 1/10 the mass of the vibrating object.

Measured signal processing

See Measured data processing

Measured value

A value which belongs to the measured variable and which is clearly assigned to the output of a measuring instrument or measuring equipment.

By measurement of the measured variable – independent of the fact whether this measured variable is constant or not – the determined actual value is called the M.

Measured value acquisition

The collection and preparation of the signal from a measurement sensor located at a measurement point.

Measured value output

The totality of all procedures by which the measured value of a variable is made perceptible for the measurement (or a mechanism for the subsequent treatment of this value). Most important forms of the M. are the display and recording with recording instruments.

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M

Measurement (Measurement of a measurement variable)

Execution of planned activities for the quantitative comparison of the measured variable with a unit.

See also Measure

Measurement accuracy

An inexact term frequently used for measurement inaccuracy or for margins of error. This term should be avoided, at least for quantitative data.

Measurement amplifier

In the broader sense a converter (measurement converter), which strengthens weak signals in such a way that they are suitable for the display, registration, transmission or other subsequent treatment. A M. needs an auxiliary energy to function. One differentiates according to the type of the channels between single amplifiers for only one channel and central amplifiers for several channels. M. are used preferentially in the operating measurement technique. They are implemented as independent devices or as building groups of measuring equipment. M. must have defined transfer functions with a high long-term constant, low errors, a constant phase lag and usually high input impedances. For achieving the desired parameters, inverse feedback circuits and special feedbacks are used. M. strictly speaking are DC voltage amplifiers for measuring purposes, whereby one usually uses operation amplifiers.

Measurement axis

Measurement axis, of a vibration sensor

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M

Measurement converter

See Converter

Measurement converter; Transmitter

An electronic circuit, which converts measured signals into standardized unit signals. Components of a M. can e.g. be: instrumentation amplifiers, analogue-digital converters; filters; correction circuits.

Measurement data processing; Measurement signal processing

The acquisition, processing (in particular the compression by summary, computational processing, short-term storage and evaluation) and output of measured values according to a task and derived results of measurements, or other conclusions, with the help of the data processing. The M. can take place analogously or digitally. Since the measuring signals of the material world are usually similar, a transformation is necessary by means of an encoder with digital M. Afterwards the processes and methods of digital signal processing are valid e.g. by means of microcomputers or digital signal processors.

Measurement device, digital

Measurement equipment, with which the measured value statement takes place in number form, contrary to analogue measuring instruments, whereby the indicator excursion is given over an analogue scales among other things.

Measurement direction

See Vibration sensor, measurement direction

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Measurement error, absolute

Deviation of measurements acquired and the measurement variable of an assigned value from the true value.

Measurement point selector

A change-over switch, which selectively switches measured signals from several sensors to a signal processor in the measuring equipment As a M. e.g. an automatically operating multiplexer can be used.

Measurement principle, inductive

A sensor constructed according to the M. consists of an inductive half-bridge, which is fed by a generator with an alternating voltage within the kHz range. Both coils of the half-bridge are laid out as transformers with an air gap. Now if the air gap of a coil is changed, then the change of inductance causes a bridge unbalance. The second coil is laid out with a constant air gap. Downstream electronics converts the air gap proportional change of inductance into a linear signal voltage. Caused by the fact that both inductances are hooked up in a housing and commonly connected in a bridge, the temperature influence is compensated.

Measurement procedure; measurement technique

Practical application of a measurement principle and a measurement method.

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M

Measurement resistor

1) A high-precision resistor with low temperature dependence for measurement purposes, e.g. in measurement bridges.

2) A resistance transducer, which is used directly as sensor. A strain gauge or resistance thermometer can e.g. be called a resistance transducer.

Measurement result

An estimated value, acquired from measurements, for the true value of a measured variable.

Note: In the simplest case this deals with a measured value acquired by measurement, often however M. is also the result of a computation from several measured values of homogenous, or different measured variables, according to a given relationship.

Measurement sensor

See measurement value sensor

Measurement sensor; Measurement probe

A sensor, which the measured variable affects and which emits an output signal representing the measured variable.

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M

Measurement signal

Quantity in a measuring instrument or measuring equipment, which is clearly assigned to the measured variable.

Measurement technique

The technique of acquiring, transferring and processing of characteristics which can be characterised by measured variables (measure). Acquiring the measured variables and their quantitative evaluation according to the measured values are the center of attention, since the transmission and processing of the acquired measuring information also take place in the information transfer procedures used for other information. According to the employment area of the M. one differentiates e.g. the industrial M. (operational measuring technique), which includes the laboratory measuring technique, and analytical measuring techniques which are likewise frequently regarded as part the operating measuring technique, the biomedical measuring technique and, if the acquired measuring information will be transferred over larger distances, the telemetering technique. According to the type of measuring signals one further differentiates the analogue measuring technique (analogue technique) and the digital measuring technique (digital technique). A special area of M. is the correlation measuring technique.

Measurement types for shaft vibrations

Measured variables in the measuring directions 1 and 2 (these directions stand right-angled to each other) are the displacement amplitudes dependent on time (instantaneous amplitudes between the sensors and the shaft surface)

$$x_1(t)\overline{x}_1 + s_1(t) \; and \; x_2(t)\overline{x}_2 + s_2(t)$$

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Measurement uncertainty

Characteristic value which is acquired from measurements and, together with the measurement result for the characterisation of a range of values, serves for the true value of the measured variable.

Measurement uncertainty, relative

Measurement uncertainty, related to the amount of a measurement result.

Measurement value under operational conditions, static

Describes → static variables (e.g. radial shaft position) which are measured under relatively constant operational conditions.

See also Measurement values under operational conditions, dynamic

Measurement values in transient operation, static

Describes → static variables which are measured during the run-up or coast-down (at variable rotational speed) of a machine.

See also Measurement values in speed-variable operation, dynamic

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Measurement values, static

Describes → static measured variables. Their output is quantitatively carried out either with or without measurement conditions.

In connection with predictive (condition-oriented) maintenance, static measured values (amplitude, phase angle, frequency, shaft position situation, rotational speed, time, date, announcement of an emergency, equipment readiness etc.) are represented as trend graphics or in a list format. The converse is the dynamic measured values.

Measurement, dynamic

Measurement whereby the measured variable is either temporally variable, or its value is substantially derived from temporal changes of other variables and is dependent upon the selected measurement principle.

Measurement, static

Measurement, whereby a temporally constant variable is measured after a measurement principle which is not based on the temporal change of other variables.

Measuring bridge

A bridge circuit for the measurement of resistance (resistance-measuring bridge) and/or impedances (impedance-measuring bridge, alternating current measuring bridge).

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Measuring chain

Consequence of elements of a measuring instrument or measuring equipment, which forms the displacement of the measuring signal from the acquisition of the measured variable up to the preparation of the output.

Measuring equipment

The totality of items necessary for the execution of a measurement and adjustment. M. are e.g. cables and auxiliary power sources. If the latter, or other elements, involved in the measurement process are not particularly and directly characterised, then one speaks of measuring aids.

Measuring generator; test generator; signal generator

A generator, which produces temporally variable voltages with certain requirements concerning the curve shape, the frequency, the amplitude and the indicated performance. While the frequency generator is able to produce only one frequency, the tunable M. is tunable to arbitrary frequencies within a range. According to the type of delivered signal a distinction is made between noise generators, sinus-wave generators and square wave generators. Sinus-wave generators produce a voltage which approximates the sine function as closely as possible. Square-wave generators, sometimes also known as impulse generators, deliver an output voltage, whereby the amplitude, period duration and pulse time are adjustable. Square-wave generators serve, e.g. for the high-speed examination of filters, amplifiers, regulators, and cables amongst other things concerning transfer function and frequency response.

Measuring head

See Probe

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Measuring instrument drift

Slow temporal change in the value of the instrumentation characteristic of a measuring instrument.

Measuring instrument; Measuring device

Equipment, which is intended alone, or in connection with other mechanisms, for the measurement of a measured variable.

Measuring method

Special type of procedure for the measurement, independent of the measurement principle.

Note: The applied M. is not identical to the basis of measurement principle and the concrete measuring procedure.

Measuring microphone

A microphone with high precision, which is used in acoustic measuring techniques. M. are condenser microphones, which can often be equipped with different microphone capsules, in order to be able to adapt them to the respective measuring task, or piezoelectric microphones, which are used e.g. in portable sound level measurement. Often one sets a tubular probe in front of the microphone capsule, in order to lead the sound from the acoustic source better to the M.

Measuring plane

In balancing: A plane perpendicular to the shaft axis, in which the amount and angle of the unbalance is to be determined.

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Measuring principle

Physical basis of the measurement.

Note: The M. is in general independent of the applied measuring method, but is conditionally usually a certain measuring procedure.

Measuring range (specified); operating range

Range of the values of a measured variable, within which it is required that the measurement deviation of a measuring instrument remain within fixed limits.
If partial measuring ranges can be selected with a changeover switch, the whole of all partial measuring ranges is called the total measuring range.

Measuring range extension

In the broader sense the extension of the measuring range of a measuring instrument by certain circuit measures.

Measuring system; measuring equipment

The totality of all measuring instruments and additional mechanisms for the achievement of a result of a measurement.
A M. consists of a measuring instrument or several connected measuring instruments – possible with additional mechanisms, which form a whole. Additional mechanisms are above all auxiliary devices, which do not serve directly for the acceptance, conversion or output (e.g. a mechanism for auxiliary energy, thermostat), as well as signal and measurement cables. The substantial task of a M. is the acquisition of a physical variable, its conversion into a measuring signal that represents the measurement value and the output of that measurement value.

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M

Mechanical (signal-) system

System (Signal-system), mechanical

Mechanical resonance

Resonance

Mechanical run-out

Physical run-out of a machined surface, the deviation from a true circle.

Megabit

Abbr.: MBit

Unit for memory size: $1\ Megabyte = 1{,}024x1{,}024 = 1{,}048{,}576\ Bit$

Megabyte

Abbr.: MByte; MB

Unit for memory size: $1\ Megabyte = 1{,}024x1{,}024 = 1{,}048{,}576\ Byte$

Megahertz

Abbr.: MHz

Unit for frequency: $1\ Megahertz = 1{,}000{,}000\ Hertz\ (Hz)$

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M

Mhz

Abbr. for **M**ega**h**ert**z**

Micrometre; Micron

Abbr.: μm
A unit of length, resp. Unit for vibration displacement: $1\mu m = 1 * 10^{-6} m = 1 * 10^{-3} mm = 0.04\, mil$.

mil

A unit of length, resp. unit for vibration displacement: $1\ mil * 10^{-3} inch\ =\ 25{,}4\ \mu m$.

Minimum achievable specific residual unbalance

Residual unbalance, minimum specific achievable

MIPS

Abbr. for **m**illion **i**nstructions **p**er **s**econd
A million computer operations per second. Unit for the working speed of a computer.

Modulate

Change one or several characteristic variables of a vibration or wave in agreement with the process of a signal or another vibration or wave.

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Modal unbalance tolerance

The equivalent unbalance of a mode shape below which the unbalance condition is assumed to be acceptable for this mode shape.

Modulated signal

See Signal, modulating

Modulating signal

See Signal, modulating

Modulating sinusoidal phenomenon

See Sinusoidal event, modulated

Modulation

A procedure, by which a variable characterises a vibration or a wave, follows the progress of a signal or another vibration or wave.

Multiplication of vibrations (i.e. the instantaneous values of the vibrations) with one another as opposed to the overlay of an addition. During the reverse procedure - demodulation - the original, low-frequency signal (the message) is recovered from the carrier oscillation.

- With amplitude modulation (Abbr. AM) the amplitude of the high frequency wave (HF) is influenced by the low-frequency oscillations (LF) of the message. The positive half-waves of the LF increase the amplitude of the HF, the negative half waves decrease them, both all the more the larger the amplitude of the LF. The relationship of the LF-amplitude to the HF-amplitude is called the modulation factor. One can think of replacement of the carrier frequency amplitude-modulated by the LF frequency, by an un-modulated carrier frequency and two sideband frequencies located on either side of the carrier frequency with a distance of the LF frequency. Several LF frequencies correspond to multiple sideband frequencies each of which forms one sideband.

- With frequency modulation (Abbr. FM) the frequency of the carrier oscillation, instead of the amplitude, is changed to the frequency of the LF. Thereby the influenced frequency deviation is called frequency departure. The relationship of the frequency departure to the highest modulating frequency is called modulation index. A frequency discriminator serves for the demodulation.

- Phase modulation is identical to frequency modulation for only one low frequency. Both types of modulation are summarized also under the term angle modulation.

Modulation degree

A measure for the modulation depth with amplitude modulation. The M. is defined as the relationship of the low frequency amplitude to the high frequency amplitude.

Modulation index

The phase fluctuation, which arises in the case of frequency modulation of a carrier frequency as a result of a frequency band B for the upper critical frequency f_g.

Modulation stage

See Modulator

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M

Modulation, linear

A modulation with which one of the characteristic variables of the carrier is a linear function of the instantaneous values of the modulating signal.

Modulator; Modulation stage

Non-linear circuit, to influence a characteristic variable of a vibration or a wave to follow the changes of a signal or another vibration or wave.

An arrangement for the realization of modulation. A M. has inputs for a carrier value and for the modulating variable as well as an output for the signal resulting from the modulation.

Module value

See Mean value

Moment unbalance

This condition is present, if the central principal axis of inertia dissects the shaft rotational axis of the rotating body at the centre of gravity.

Monitoring

It is the task of pure monitoring to recognize whether an error has occurred and in automatic systems, to trigger a reaction (alarm, shutdown) automatically, should an error occur.

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M

Motion, dynamic

The time-variable, actual (physical) motion of an object; synonymous with vibration.

mrad

The angular unit in alignment. $1\ mrad$ corresponds to an opening of $1\ mm$ at a distance of $1\ m$.

MSB

Abbr. for <**m**ost **s**ignificant **b**it>

The highest value Bit in a Byte.

MTBF

Abbr. for <**m**ean **t**ime **b**etween **f**ailures>

Mean length of time between two errors, e.g. the loss of a computer, equipment or a machine. The MTBF is thus a yardstick for the quality of equipment.

Multimeter

A measuring instrument for different electrical variables, e.g. current, voltage, resistance in different measuring ranges.

Multiplane balancing

Every balancing procedure on flexible rotors that requires more than two balancing levels for unbalance compensation.

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Multiplex operation

A mode of operation of a functional unit, with which several orders alternating in time intervals can be completed.

Note: The time intervals can be of different length. Frequently this mode of operation is selected in order to use the functional unit more economically.

Multi-tasking

Working on multiple tasks and programs all at the same time. In only one computer several programs can be loaded at the same time and worked on simultaneously in different windows.

MUX

Abbr. for **Mu**ltiple**x**er