Tips and Techniques for Successful Condition Monitoring - Page 1

Plant ConditionMonitoring - Why?

Maintenance procedures on industrial plant have traditionally taken the two pronged approach - A periodic shutdown and overhaul schedule coinciding with summer holidays or week ends. Off-linemachinery can be accessed safely, inspected for obvious faults due to wear or neglect and wear-prone components like bearings on pumps, fans and motors replaced, irrespective of their potential to operate for a longer time. In addition to this cyclical program, remedial work on unpredicted plant breakdowns is effected on a reactive basis by engineers on 24 hour call out. They in turn need immediate access to replacement parts from an expensive stock list intended to cover all contingencies. It is an expensive exercise and works on the assumption that breaks in production with their obvious repercussions on product cost and wastage can be absorbed. In today's competitive world - a risky assumption!
Fortunately in today's competitive world, there is technology which can minimise this risk and make for a safer working environment.
It is called Plant **PredictiveMaintenance.**

By definition - ***The business of anticipating machine failure with sufficient accuracy to enable corrective action to be taken before breakdown***

One thing is certain: If you run industrial plant, you can benefit from implementing a condition monitoring strategy. The key to success is to select the most appropriate technique for you.

The benefits - the choices

Condition Monitoring offers the following benefits
1/ Increased plant availability
2/ Reduced maintenance costs
3/ Improved product quality
4/ Increased plant safety

Techniques
There are several ways to monitor the condition of machinery during operation.
A/ Vibration
B/ Temperature
C/ Oil debris analysis
D/ Acoustic

Each technology has a particular benefit but Vibration Monitoring has the following advantages in combination:-
Vibration levels are proportional to the magnitude of the problem
Can be measured non invasively
Virtually all faults display vibration early in the deterioration sequence
Can be measured instantaneously
Can indicate:-
i severity and deterioration rate of fault
ii the location of the fault
iii the likely cause of the fault

Overall, then, it is the above combination of features which has made plant vibration monitoring a powerful tool within the maintenance regime.

How is it applied?
By means of a vibration sensor or accelerometer.
Operating machinery produces a degree of vibration due to its rotational or linear action. Small levels of ambient vibration are acceptable. However, increasing trends towards a higher level signal impending problems and are a symptom of some abnormality. Usually, with rotating machinery, the problem arises through misalignment of drive train components, worn or damaged bearings, load assymetry due to debris adhesion on rotary parts (particle build-up on fans etc) or even incorrect assembly.
This vibration is the unwanted small, high speed repetitive to and fro movement, generally with itsmajor component perpendicular to the rotational axis of the load transmission shaft. Since the movement is constrained by the stiffness and geometry of the machine's structure and the way it is clamped to its base; the vibrating elements oscillate between two end limits, governed by the above and the speed of rotation of the shaft concerned. It is often possible to see or feel the vibration, but the best method is by contact on the offending part with a sensor.
How do we read the vibration? With a device which mimics the vibration and translates it into engineering units which can be processed. Any device which converts a physical state into an electrical signal is called a transducer or sensor.
In vibration terms, this transducer is either:
i an eddy current probe (proximity detector)
ii a velocity transducer
iii an accelerometer

Transducer types

Eddy Current Probe
Measures the gap between the tip of the probe and the surface of the target.
Good for low speed (50 rpm down to steady state) and is primarily used for axial movement, phase reference angle, reverse rotation, tapered shaft axial position speed measurement and reciprocating compressor rod drop monitoring. It works only with conductive targets, is relatively difficult to mount and vulnerable, particularly during installation or removal.

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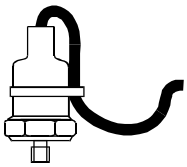
Velocity transducer
Again, has a low frequency response but, unlike the eddy current probe, is a self generating device. It is, however, relative to an accelerometer, mechanically much more complex, much heavier and with a smaller frequency range. It does, however, have a niche market within the power generation industry to which its attributes lend themselves.

Accelerometer
Piezoelectric accelerometers are the most widely used transducer for condition monitoring. They have no moving parts; are robust, easy to fit, have the widest frequency response and the benefit of low cost.
Their output which is directly porportional to acceleration (an industry standard 100mv/g) can be integrated to provide velocity or displacement units of measurement.

The Accelerometer - How does it work?

If an accelerometer is shaken back and forth in its sensitive plane, it generates an electrical output which is proportional to the severity of the shaking.
The harder it shakes - themoreitgenerates!

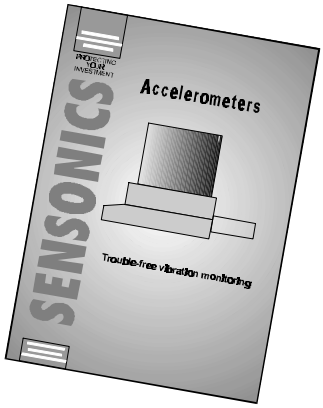
The heart of a piezoelectric accelerometer is a small piezo crystal which is bonded to a seismic mass. If the accelerometer is vibrated, the crystal is alternately compressed and decompressed between its outer case (attached to the machine) and the seismic mass whose inertia provides a resistance tomotion.
The crystal generates an electrical signal proportional to vibration severity (acceleration measured in picocoulombs per "g") This extremely low energy signal is converted by internal electronic circuitry into a useable voltage output, proportional to acceleration (100mv/g) which can then be read by a data collector or on line system.



A Sensonics 100mv/g PZA1 Accelerometer

By attaching the accelerometer securely to themachine (pump, gearbox, fan, motor, etc) it will generate an electrical output proportional to the distress level in the machine. Industrial accelerometers are available which have been designed specifically for use in the maintenance field. Their intrinsic design is such that, under extremes of temperature or harsh environmental conditions, they can be permanently installed on plant machinery for many years, requiring no maintenance. A wide choice of models is offered including high temperature, submersible, intrinsically safe, radiation resistant etc; Various output configurations (acceleration, velocity, 4-20mA) are available to match most proprietary monitoring systems.

Hz?
As well as operating to these calibrated sensitivities, piezoelectric accelerometers are also dynamic devices operating within a specified frequency range eg: 2 Hz (2 cycles per second) to 11kHz (11000 cycles per second) To relate these frequencies to rotational speed (rpm) multiply by 60.



For more detailed information on construction, choice of accelerometer or the complete Sensonics range, please contact Sensonics on 01442 876833.

Implementing a Strategy - Hired help? - Regular patrols? - Permanent monitoring?

Hired help
There are companies ranging in size from one man to those with regional offices all over the country who will provide a predictive monitoring schedule by way of regular visits around assigned patrol routes. The main benefit of this type of service is the elimination of any outlay on capital investment and additional personnel.

Regular patrol
For many applications, the regular use of even a simple but accurate hand-held vibration meter will pay dividends within a short space of time. It is virtually impossible to accurately predict bearing failure from one snap-shot reading but as a general guide the chart overleaf will give some guidance until a trending pattern has been established. The more sophisticated data collector/analysers will gather data from multiple points and then download the information into PC based analysis software. The key to success is regularity and consistency,

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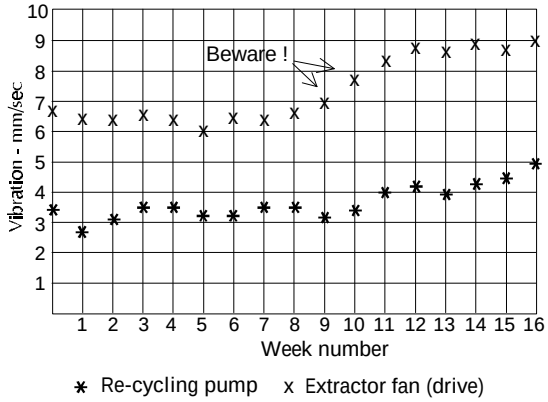
Mark your patrol points clearly, try to monitor each time under as near similar running conditions as possible, and don't be tempted to "give it a miss, just this once."

Permanentmonitoring

If the continuous operation of plant is paramount, permanently installed vibration monitoring from fixed sensors is advisable. This system offers the most complete protection but has high initial cost of installation and hardware.

Trending in vibrationmeasurement

A condition monitoring program is not dependent on high accuracy measurement of absolute levels from day one of the program. Instead, a pattern is developed by vibration monitoring at regular intervals **on the same pre-determined points and under similar operating conditions (ie: load, speed etc.,)** Again, even with a fairly basic vibration meter, it is possible to build up a data history on machinery which, when plotted graphically, can warn of potential bearing failure or increasing unbalance. The accuracy of prediction increases in direct proportionproportion to the pre-history of the monitoring program.



It should be noted that very rarely do bearings fail without giving sufficient warning for remedial action to be taken. Thismay,inthefirstinstance,simplybeaspur to increasing the frequency of the patrol inspections at the suspect points. But it will enable the scheduling of machine strip-down and repair to coincide with a planned production break.

Getting started

As to the actual means of measurement, there is a wide choice. Some vibration meters simply display the basic measurement in mm/sec rms which is entered into a notebook for later insertion into a spreadsheet and subsequent graphing (simple, but for trending applications, it works very well) Others will store the readings, date them and then either analyse at the point ofmeasurement or download into dedicated software at a central computer point for more sophisticated analysis.

Which ever system is used, as long as it is done regularly, the cost savings will not be long in coming. It is worth remembering that even a very basic meter can provide instant comparisons where the same type of machinery is duplicated across a plant. Rogue machines can be spotted after only one pass and measurement becomes a quantitive procedure rather than an approximation based on sight, sound or touch.

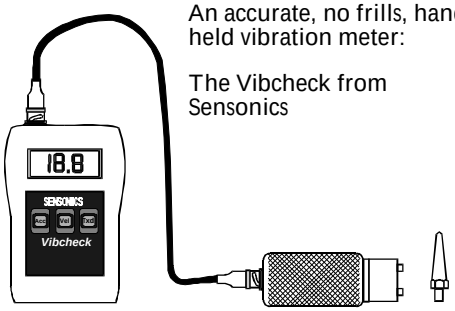
The actual meter kit will usually include a magnetic mount and a spike for attachment or contact with the machine under investigation.

ISO GUIDELINES ON MECHANICAL VIBRATION SEVERITY IN ROTATING MACHINERY

MACHINE SIZE CLASSIFICATION							
1 (SMALL) 15 kW		2 (MEDIUM) 15 - 75kW		3 (LARGE)		4 (TURBO)	
VELOCITY mm/sec		VELOCITY mm/sec		VELOCITY mm/sec		VELOCITY mm/sec	
0.28		0.28		0.28		0.28	
0.45	A	0.45		0.45		0.45	
0.71		0.71	A	0.71		0.71	
1.12	B	1.12		1.12	A	1.12	
1.80		1.80	B	1.80		1.80	A
2.80	C	2.80		2.80	B	2.80	
4.50		4.50	C	4.50		4.50	B
7.10	D	7.10		7.10	C	7.10	
11.20		11.20	D	11.20		11.20	C
18.00		18.00		18.00	D	18.00	
28.00		28.00		28.00		28.00	D
45.00		45.00		45.00		45.00	

Class 3 includes large prime movers withrotatingmassesmounted onrigid&heavyfoundations,relatively inthedirectionofrotation.
Class4relativelysoftin thedirectionofrotation(eg-turbo-generatorsets)

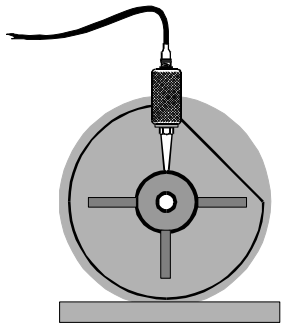
NB: Spot readings are only snap-shots of vibration levels and should be supplemented by regular monitc



An accurate, no frills, hand-held vibration meter:

The Vibcheck from Sensonics

The accelerometer connection - how andwhere?



As close to the bearing as possible and at right angles to the axis of rotation.

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Permanentmonitoring

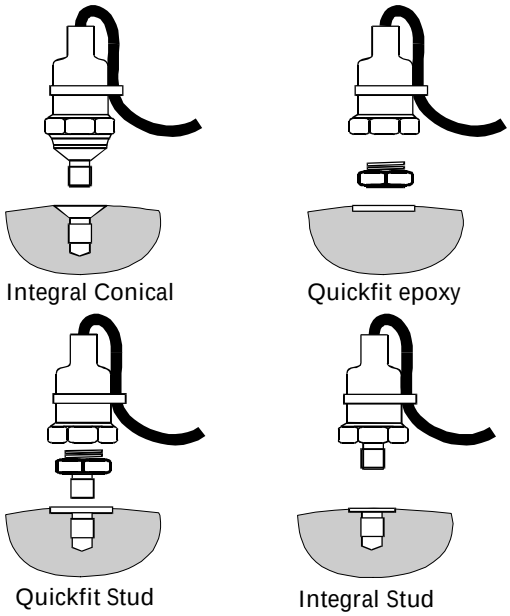
In many industries, because of the nature of the end product, breakdown during production can be catastrophic. Many processes have to be run on a continuous basis. Paper and steel mills, newspaper printing presses. Extractor fans in hazardous areas, for health and safety reasons. There are many more examples where downtime is measured in thousands of pounds per hour. In these areas of maximised production, even a weekly patrol with a data collector could not guarantee continuous running.

In some industries, predictive maintenance has vibration monitoring at the top of the priority list. Likewise in chemical plants the savings, thanks to avoiding unpredictable breakdowns, can run into millions of pounds over a few years.

More companies build vibration sensors into their end product. It is not a concession to reliability, merely a realistic acceptance of the fact that nothing can run for ever!

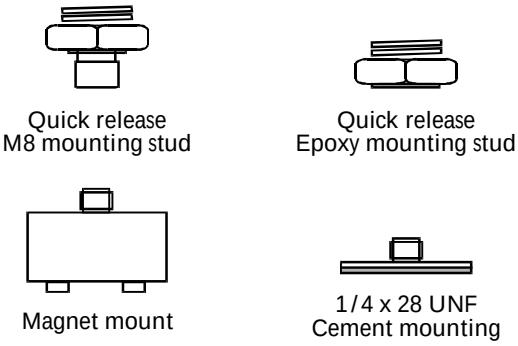
So, instead of applying a portable accelerometer to individual machines and taking a spot reading it is advisable to fix permanent accelerometers at the same points.

Accelerometer mounting methods



NB: Check with machine supplier re; warranty conflicts before drilling and tapping holes on machinery. If in doubt attach bymagnet or epoxy.

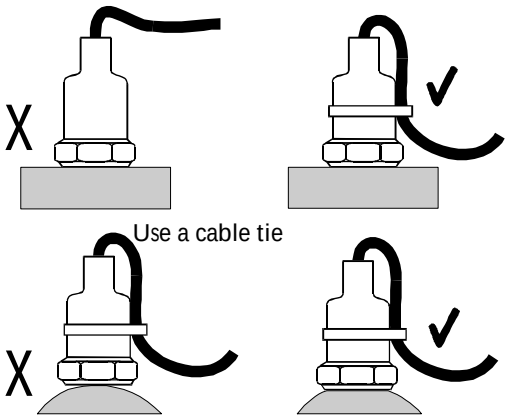
Because of the hostile environment in which accelerometers are oftenmounted, the accelerometer's pvc cabling is usually encased in a stainless steel armoured outer cover. This gives the best protection, but because of the unwieldy nature of armoured cable it is very difficult to screw mount the accelerometer in conjunction with a long length of relatively inflexible cable. The solution is to use a quick release adaptor as shown below. These adaptors are screwed or glued on to the machine and then the accelerometer can be secured by the quick release thread with less than one turn of a spanner.



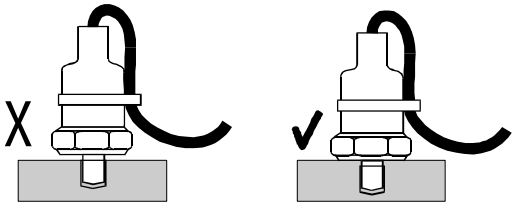
Mounting Tips

To reproduce precisely the vibration generated by the machine under surveillance, the accelerometer's mounting face must, in effect, becomes part of the structure. It should mate with a flat surface at the machine attachment point. An irregular surface would distort the true pattern of the vibration signal.

Shown following are three pitfalls to avoid.



Ensure mating surface is flat and clean



Tapped hole too shallow.

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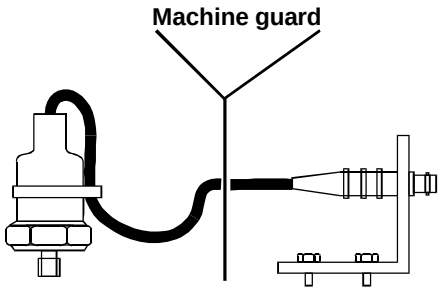
Machine safety

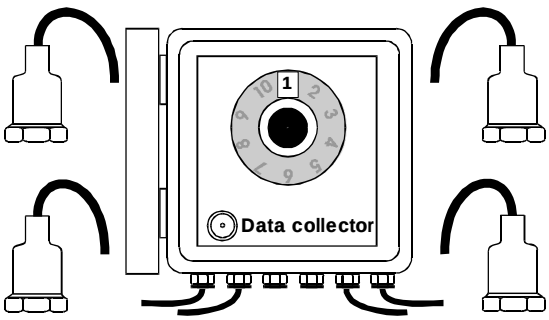
It is mandatory for machines to have guards fitted wherever there is a potential danger to an operator. This can make it difficult, if not impossible, to gain access to the running machine in order to undertake the vibration monitoring.
A neat solution is to fit a permanent, remote vibration sensor, hard wired back to a jack socket.
Most types of data collector have an auxiliary output socket which not only provides the power to energise the remote accelerometer but also reads the signal back into the data collector's software. There is sufficient drive available to enable distances of tens of metres to be bridged in this way.



PZA 1 Vibration sensor

Additionally, if there are a number of accelerometers mounted on a machine, it makes for a convenient solution to wire them all back to one switchbox. This single point can then be addressed by the data collector.
The same technique can be applied if the environment is uncomfortable (behind furnaces, up ladders to roof mounted fans or through a maze of associated machinery)
The job becomes easier and time is saved accordingly.
Switchboxes are available in polycarbonate, painted steel (or stainless steel if located where food or certain chemicals are being processed)

The switchbox short-cut

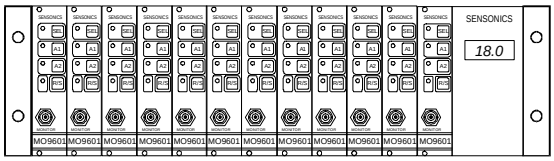


A Sensonics IP66 switch box connected to 4 PZA1 piezoelectric accelerometers.

A machine assembly with a number of points to monitor, if fitted with multi-point switchbox saves time, money and contributes towards safety on plant. The accelerometers are mounted in their respective locations and wired back to a convenient access point for centralised data collection. The data collector is connected to a common output socket on the switchbox after which, the rotary channel selector switch routes each accelerometer through the data collector for storage and analysis.

Plant protection systems

If we drive the accelerometer with a constant current source and condition its output, we have the basis of our vibration monitoring protection system. The individual amplifiers which fulfil the above functions can be supplied in a "plug-in" format and so be tailored economically to the number of monitoring points. Specialisedmodular systems, aimed at themaintenance environment, are usually housed in a robust wall mounted cabinet or built into a control panel. Controls are kept to a minimum but auxiliary outputs (analogue and relay) are available for control, data information transfer or alarm functions. These units can drive accelerometers over a distance ofmorethan500metres and provide two levels of alarm. From the back panel, various outputs are accessible for each channel, including 0-10vdc, 4-20mA and relay changeover contacts. Built in delays ignore startup transients and individual LED displays allow quick identification of out of limit channels. The decision as to when to use this scheme instead of routine data collector patrol will be decided by the need for continuous surveillance or, perhaps, long term economics.
If the intending user already has a data collector, he can access the unprocessed signal from the accelerometer via the output socket on the front of each amplifier channel. All options are available - on-line monitoring, retransmission, alarm alerts and detailed analysis.



A Sensonics "Aegis" modular Machine Condition Monitoring System

Specialised applications

In addition to the more multi-purpose type of signal conditioning monitoring unit previously described, there are systems and sensors of a more specialised nature to be used where a specific need is identified.
Industrial fans, for example, can cause major damage if allowed to operate in an increasingly unstable condition due to inbalance caused by an accumulation of debris on fan blades.

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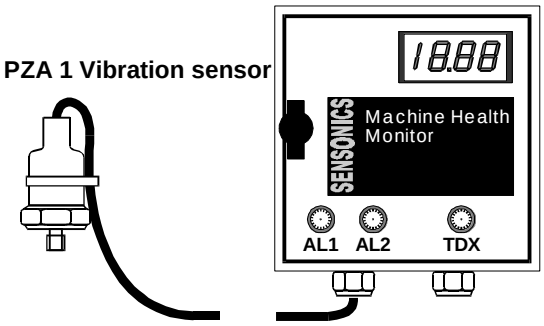
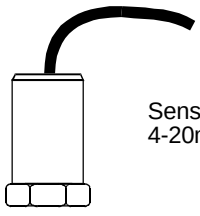
There are systems available, easily installed with a minimum of technical knowledge which can monitor a fan's overall vibration performance and raise a warning when a set level is exceeded. Normally supplied as an accelerometer connected to a weatherproof cabinet containing a digital display of vibration, two alarm levels and analogue outputs.
Channel capacity can be increased by using a simple scanner or multiplexer to interrogate each channel in turn over a period of no more than a few minutes.



The Sensonics MC9601 Machine Health Monitor
(A low cost solution to specialised condition monitoring problems)

The 4-20mA solution

Most industrial accelerometers are energised by connection to signal conditioning amplifiers, but there are devices which can be wired straight into a 4-20mA process loop. Where there is spare capacity within a plant DCS system or maybe just an accessible PLC close to the intended vibration monitoring point, a 4-20mA accelerometer, chosen with the appropriate velocity range can supply a low cost solution.
It is essential to know the vibration range over which the accelerometer is working in order to provide the optimum working range for the current output. Corresponding velocity values for the full 4-20mA range can be set at 5, 10, 20, 50mm/sec, depending on the type of machine under investigation.



Sensonics PZDC
4-20mA accelerometer

SUMMARY

There are various solutions to the application of condition monitoring on Industrial Plant. The basics, however, are indisputable. To first of all detect vibration requires a sensor which can, in effect, copy the vibration pattern and convert it into a processable signal. (The accelerometer)

The signal is then further processed by a conditioning unit which can provide all the information required to keep plant running uninterruptedly at optimum speed.
When these conditions are met, everyone benefits.
But, if you're still contemplating the why's and maybe's of condition monitoring on your plant - remember ...

The more it shakes - the sooner it breaks!

SENSONICS THE COMPANY

Since 1978, Sensonics has offered a wide range of predictive maintenance products and bespoke systems design, configuration, supply and installation - from a single vibration transducer to a large-scale turnkey site monitoring contract. This is supported by a comprehensive range of high quality customer services.
The Sensonics range of industry proven, high quality transducers for monitoring vibration and displacement includes:
Velocity Transducers
Accelerometers
Eddy Current Probes
LVDTs & RVDTs
Sensonics offer a wide range of advanced single and multi-channel analogue and digital equipments for all machine monitoring applications.

Our aim, quite simply, is to maximise our customers' profitability and to give them a competitive advantage by providing them with technically superior and cost-effective solutions tailored to each specific need. And to support these with services of the highest quality.

Tips and Techniques for successful Condition Monitoring

A practical introduction to Predictive Maintenance
By Roger Dunn

1st Edition - 2000

With acknowledgements to :-
The International Standards Organisation (ISO Std 2372 - Machine Vibration Severity Chart)

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