An Introduction
to
Vibration Analysis

Theory and
Practice

An overview of…

Various Maintenance Methods

- Breakdown
- Preventive
- Predictive
- Reliability centered (Proactive)

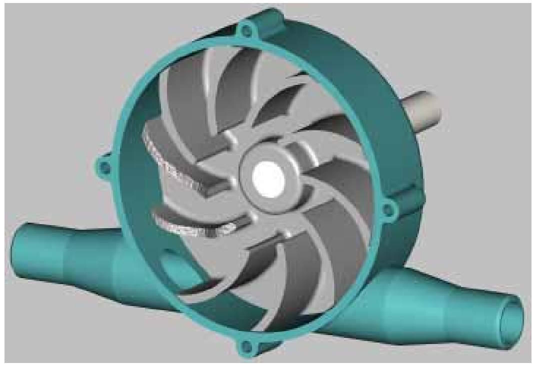
Vibration analysis

- What is machine vibration
- Measuring and analyzing vibration
- The BIG 4

Why do machines stop running?

Component failures:

- Failed bearings
- Broken fan blades
- Seized couplings
- And the list goes on…



Why Question Existing Maintenance Practices?

Minimize failures:

- Balance and align machines
- Improved maintenance practices
- Clean lubricants

Reduce the impact:

- Avoid unscheduled repairs
- Stop “secondary damage”
- Save $$$$$

Breakdown Maintenance

Just let it fail

- Also known as “run to failure”
- Remains common practice in many places
- Budgeted and accepted cost of operation

Disadvantages:

- Secondary costs of failure (10X$)
- High downtime
- Large spare parts inventory
- Worker safety issues

Preventive Maintenance

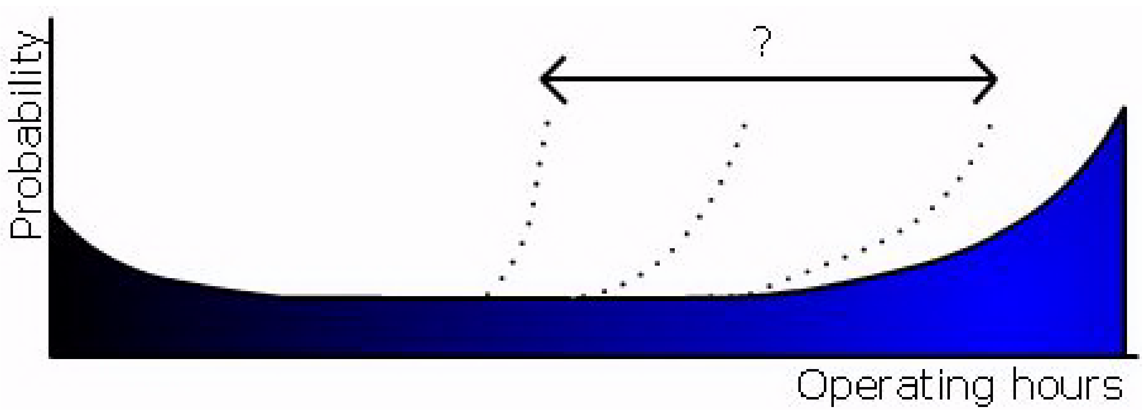
Fix it before it breaks

- Also known as “planned maintenance”,
  - Historical maintenance
  - Periodic Maintenance
  - Calendar-based maintenance
- Most common maintenance practice today
- Assumes that all machines will fail in time
- You perform maintenance before it fails
  - But **WHEN** will it fail?
  - **WHY** will it fail?

Preventive Maintenance

Disadvantages

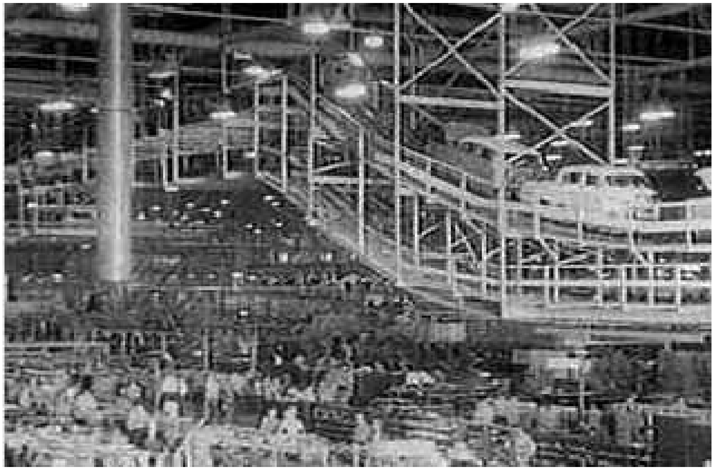
- Machines fail before planned shutdown
- Perfectly good machines are “over-repaired”
- Overhauls often introduce problems due to defects
- Unnecessary costly downtime
- Excessive spare parts Inventory



Predictive Maintenance

"*If it ain't broke, don't fix it!*"

- Also known as "condition based maintenance"
- Predict when a machine will fail
- Repair it when most convenient
- Repair/replace ONLY the components that are required
- Intelligently assess the "risk"



Predictive Maintenance

- Perform “condition monitoring”
- Determine health status
- Predict failure mode
- Act accordingly

Advantages:

  - No surprise downtime
  - No unexpected failures
  - No secondary damage
  - All maintenance is planned
  - Sounds great!

Proactive Maintenance

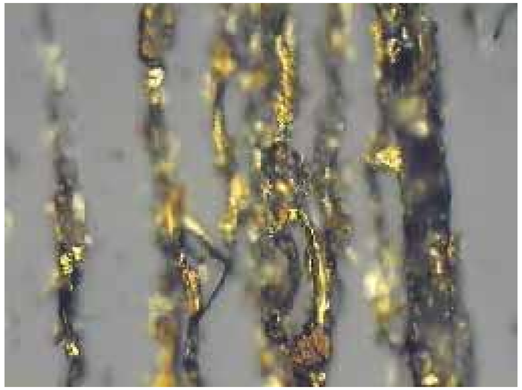
"*Fix it once, fix it right!*"

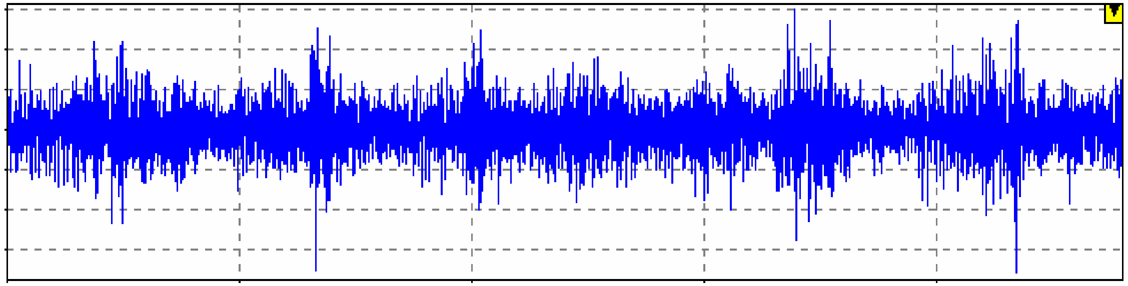
- Also known as "reliability centered maintenance" and "precision maintenance"
- Change machine design, purchasing and maintenance procedures to reduce failures and increase machine reliability
- Precision balancing, laser alignment, etc.

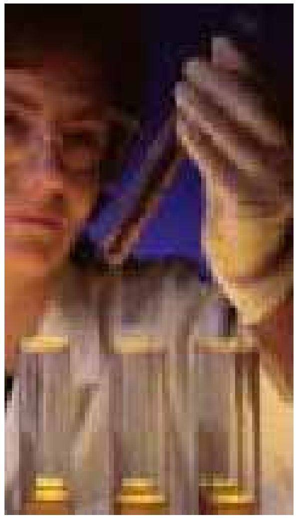
What technology is available

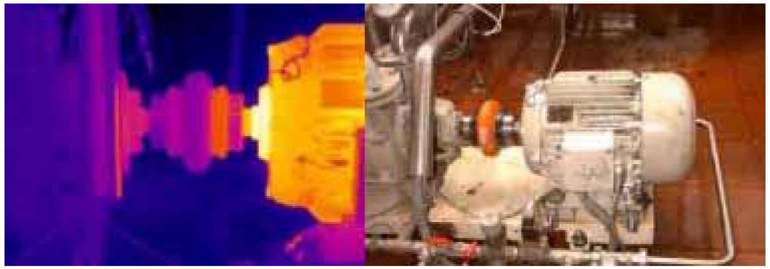
Condition monitoring:

- Vibration analysis
- Oil analysis
- Wear particle analysis
- Thermography
- Ultrasound
- Steam Trap

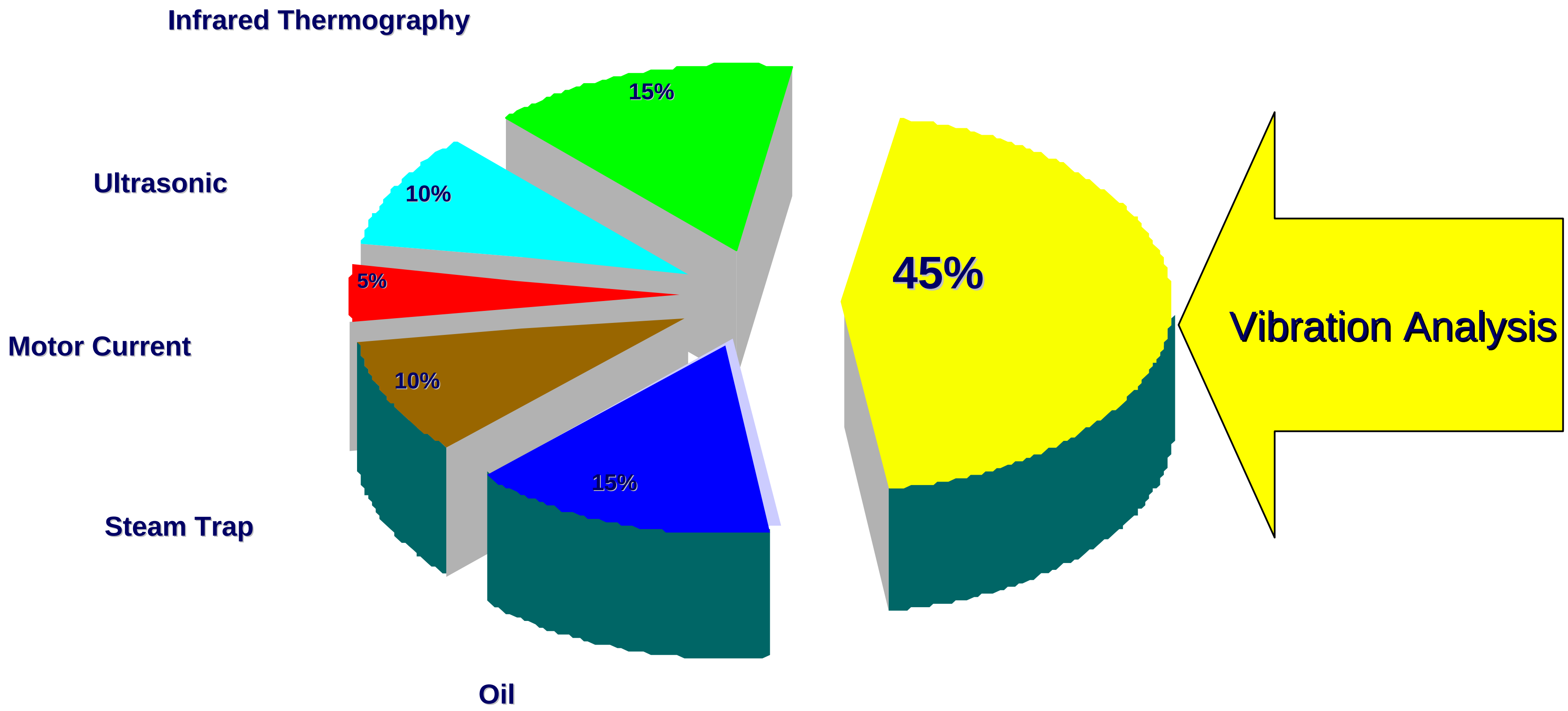








Which Technology to use?



Percent of total PAYBACK when adopting a predictive maintenance program plant wide

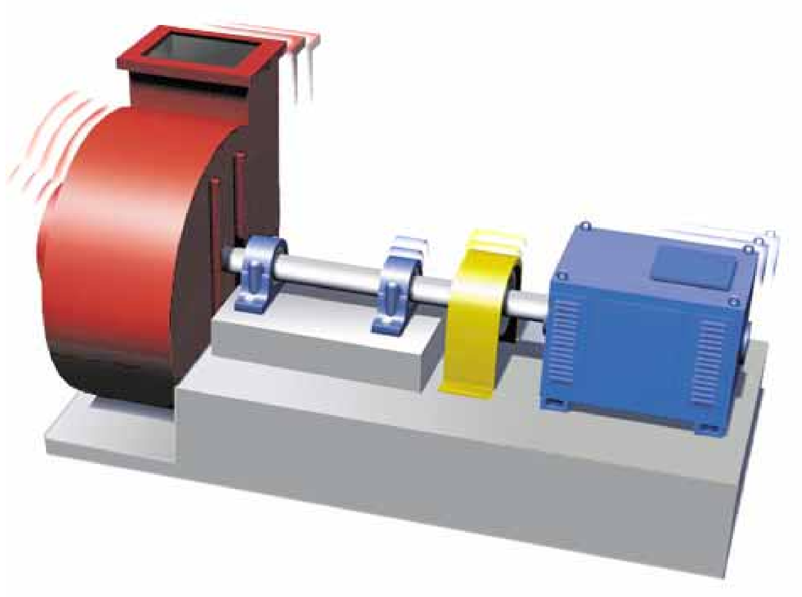
Vibration Analysis

- All machines vibrate

- The vibration 'signature' changes as the condition changes.

- What you can hear is only part of the story.

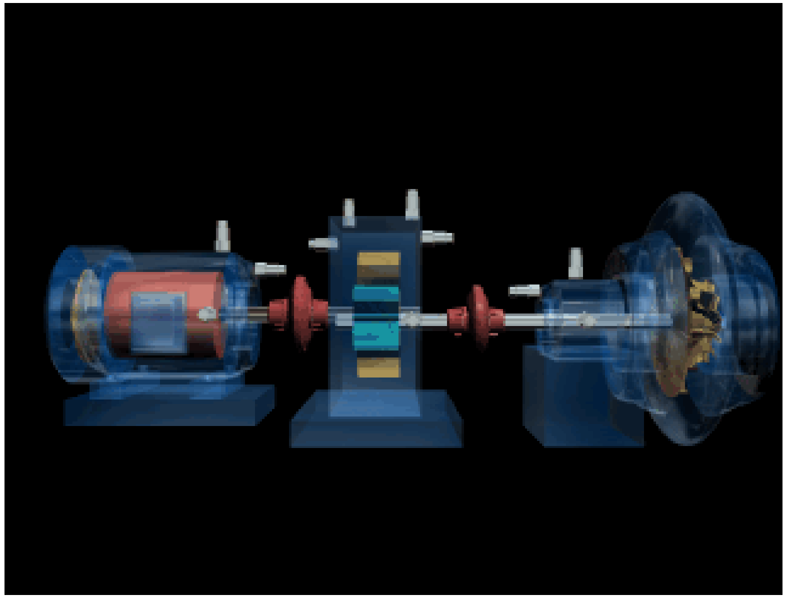
- Vibration analysis can help you detect a wide variety of fault conditions.



What Causes Vibration?

As the shaft turns, there are frictional and rotational forces.

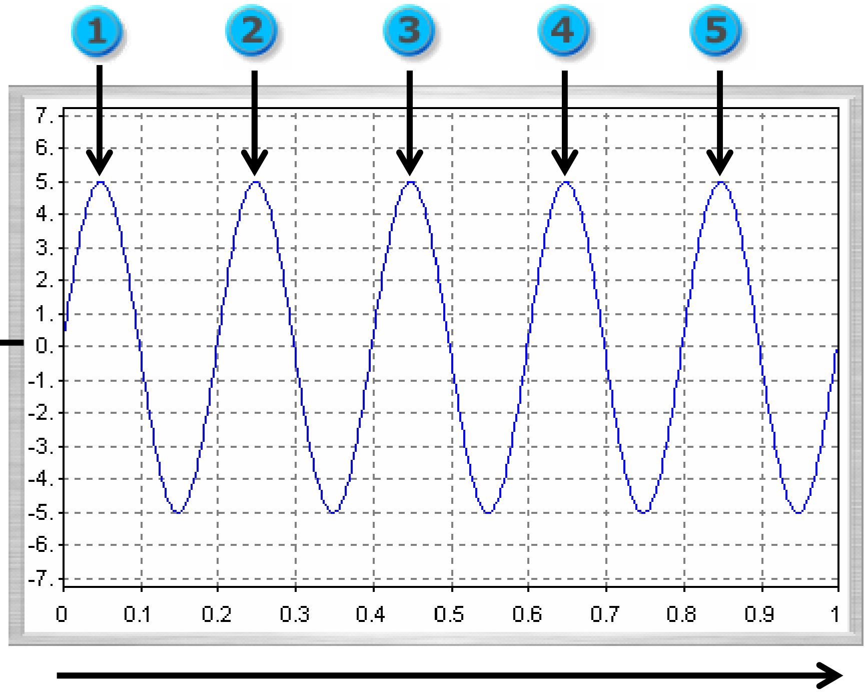
That vibration created by those forces is transferred via the bearings to the machine housing.



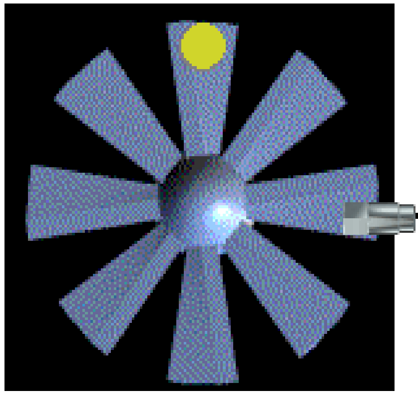
The BASIC Vibration Signal

- The fan rotates five times every second.

- Add weight which creates an unbalance force.



One second of time

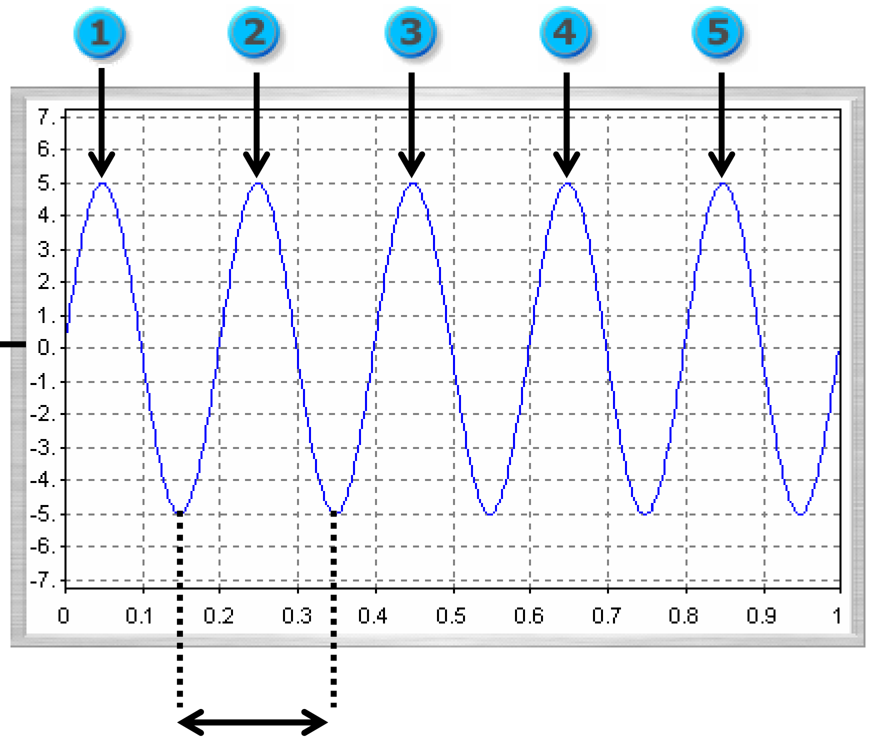


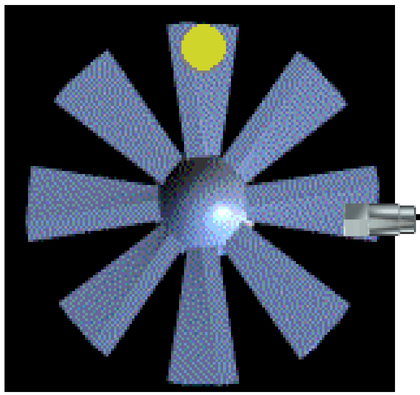
The 'Frequency?'

- Hertz = Hz = Cycles per second

RPM = Revolutions per minute
CPM = Cycles per minute
CPM = RPM = Hz x 60

- Fan speed = 5 Hz or 300 RPM



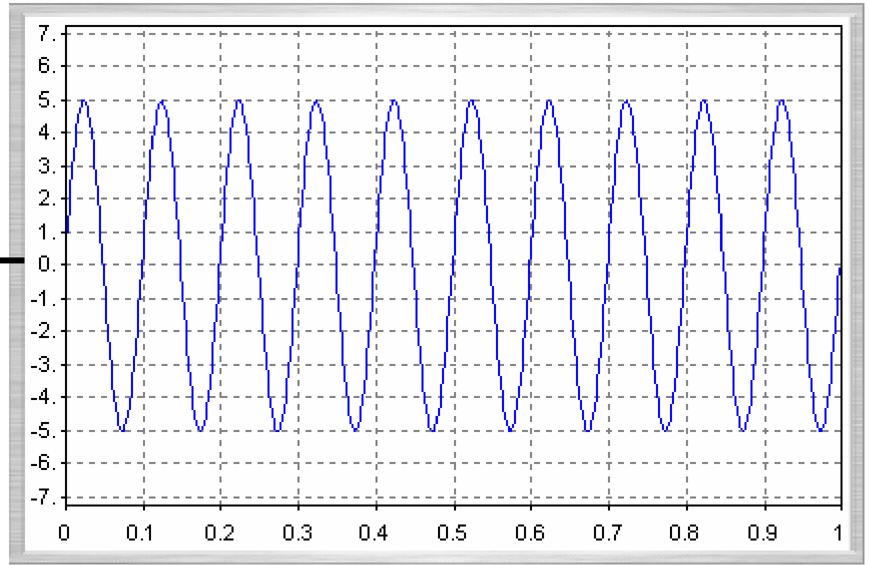


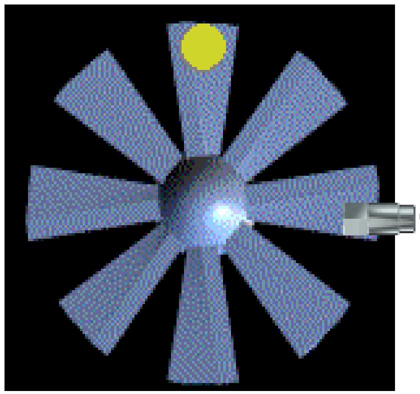
Period = 1/Frequency

Fan speed = 5 Hz or 300 RPM

Increase the Frequency

- The fan is now going twice as fast.
- Cycles of the waveform are closer together.
- Fan speed = 10 Hz or 600 RPM

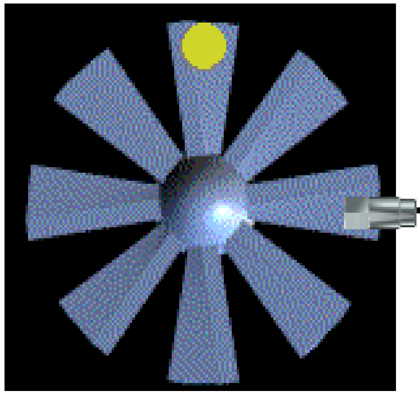


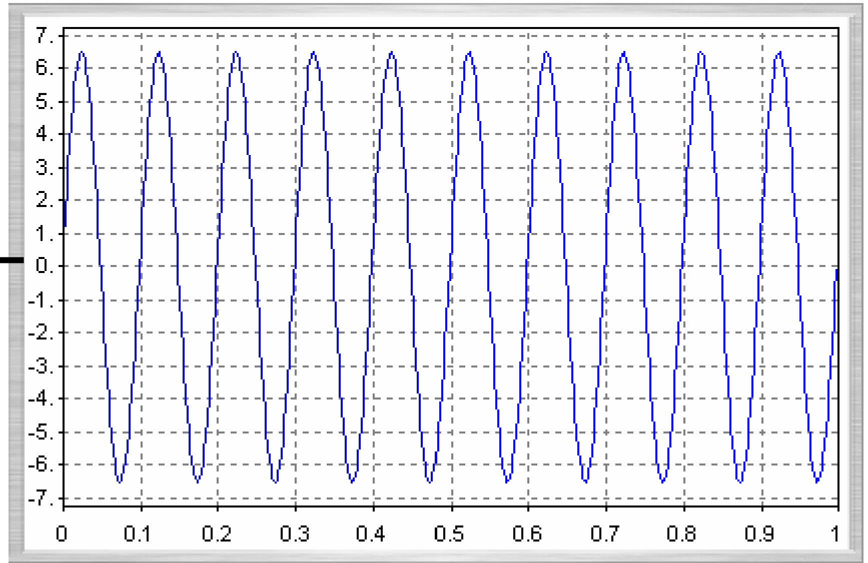


The 'Amplitude'

- ➢ The height of the wave is the "amplitude".

- ➢ Because of the weight on one blade, the vibration level increases as the fan speeds up.





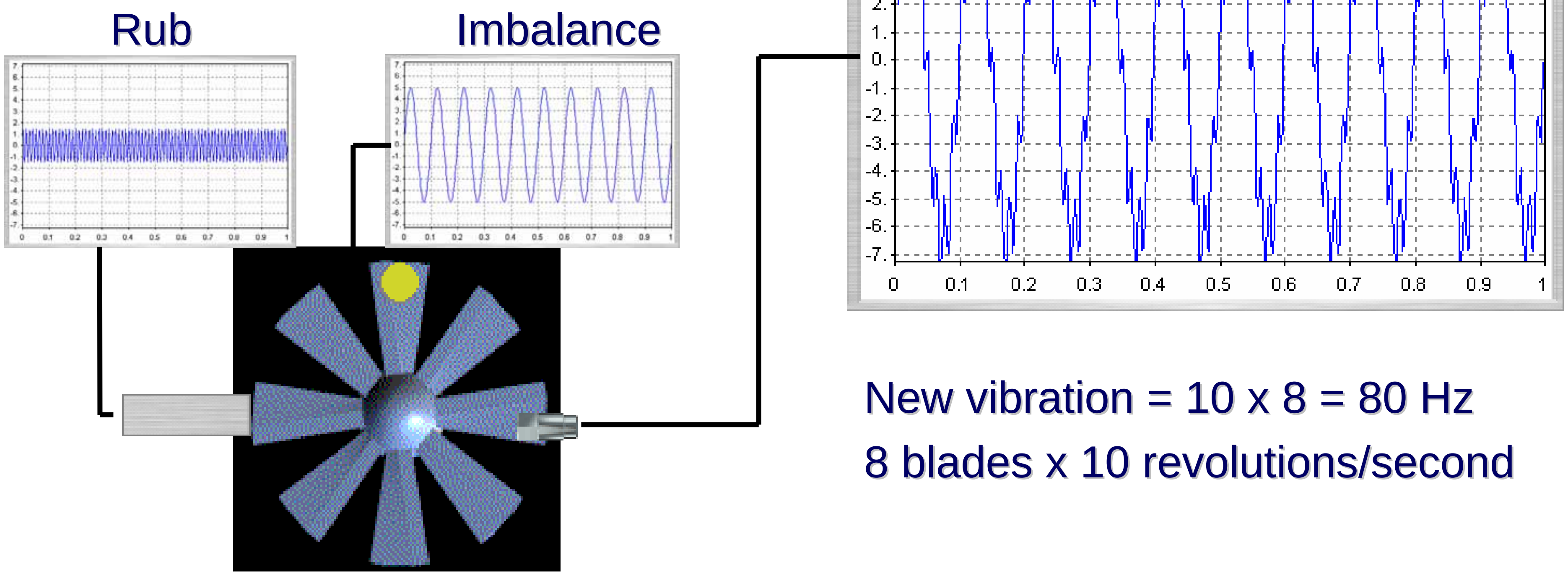
Displacement: mils or microns

Velocity: in/sec or mm/sec

Acceleration: g

Add a second source of vibration

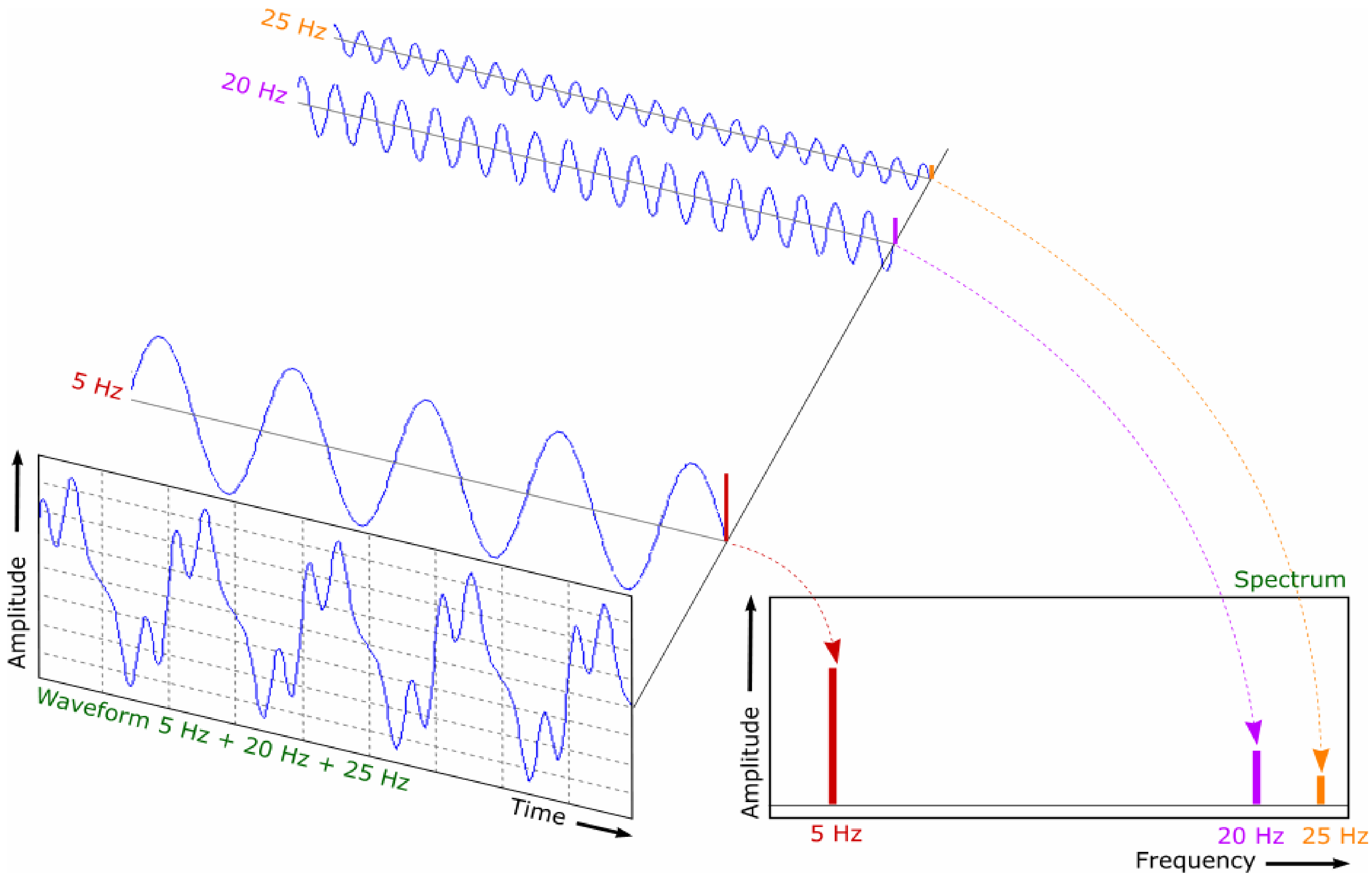
- The rub introduces a new source of vibration.



New vibration = 10 x 8 = 80 Hz

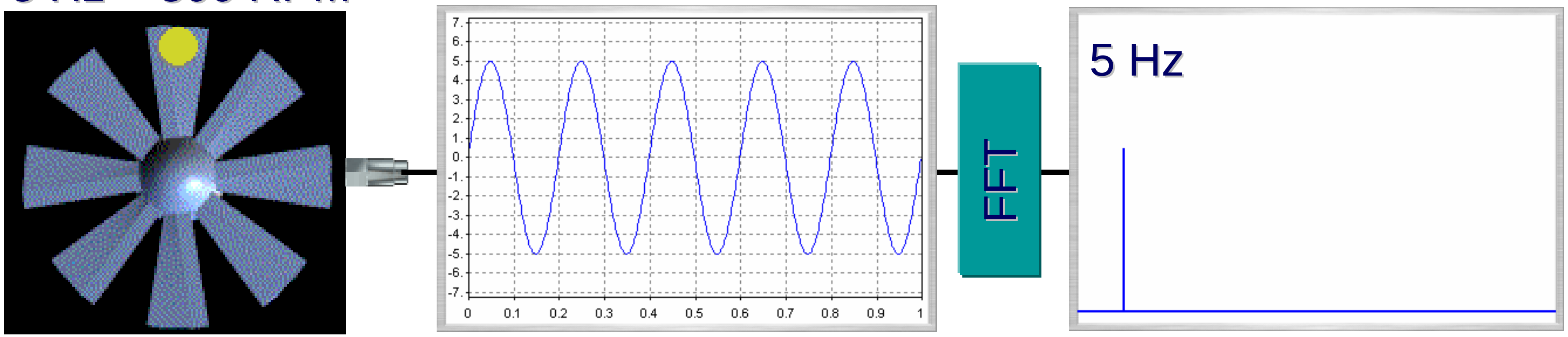
8 blades x 10 revolutions/second

The ‘Spectrum’

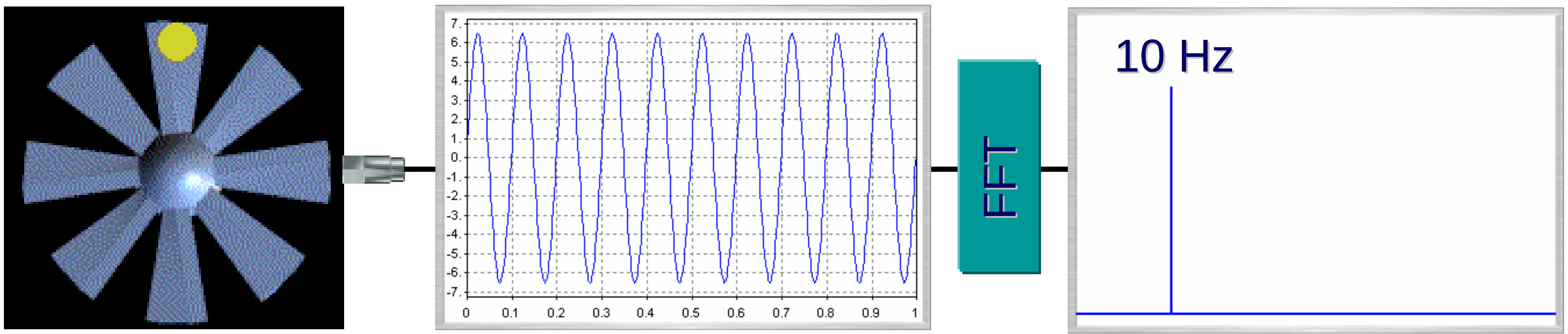


Spectrum - Examples

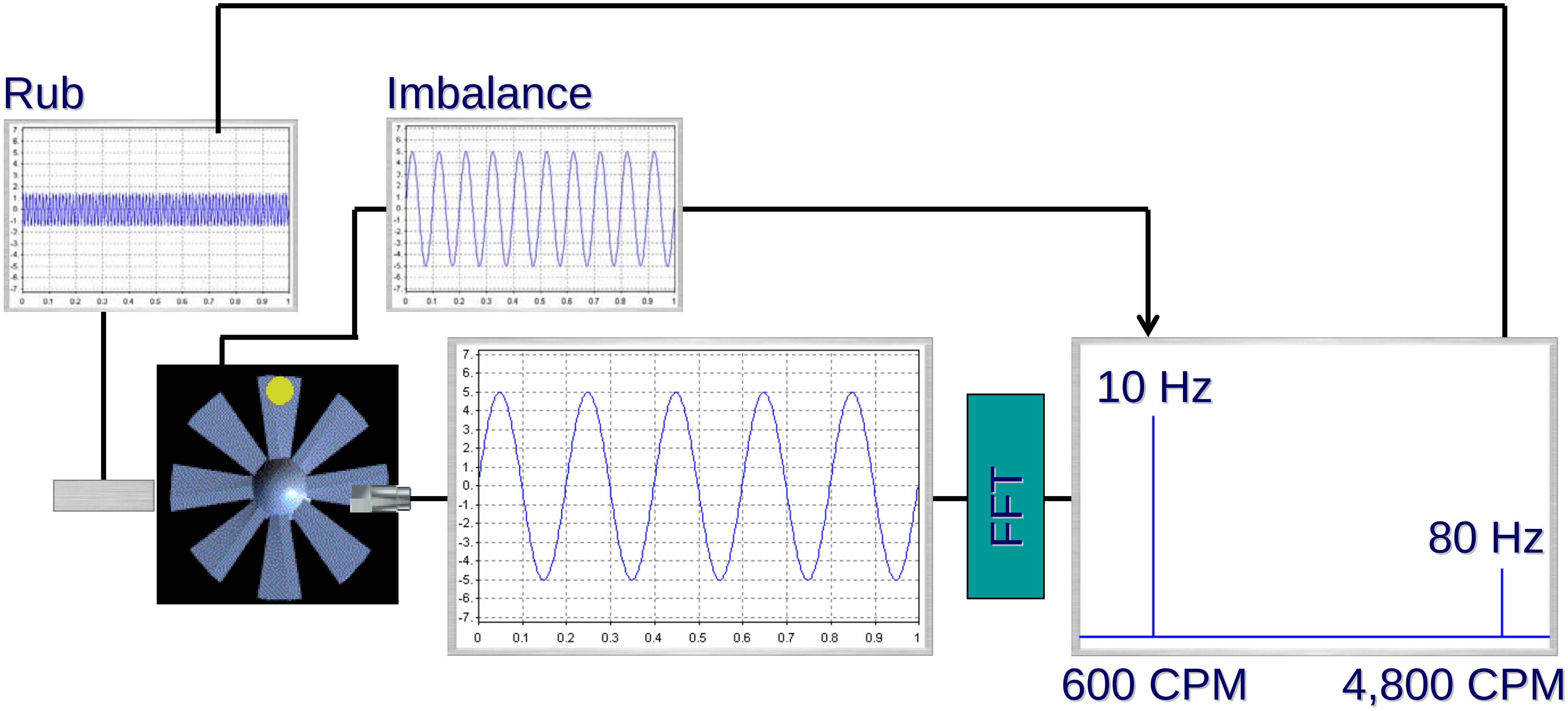
5 Hz = 300 RPM



10 Hz = 600 RPM



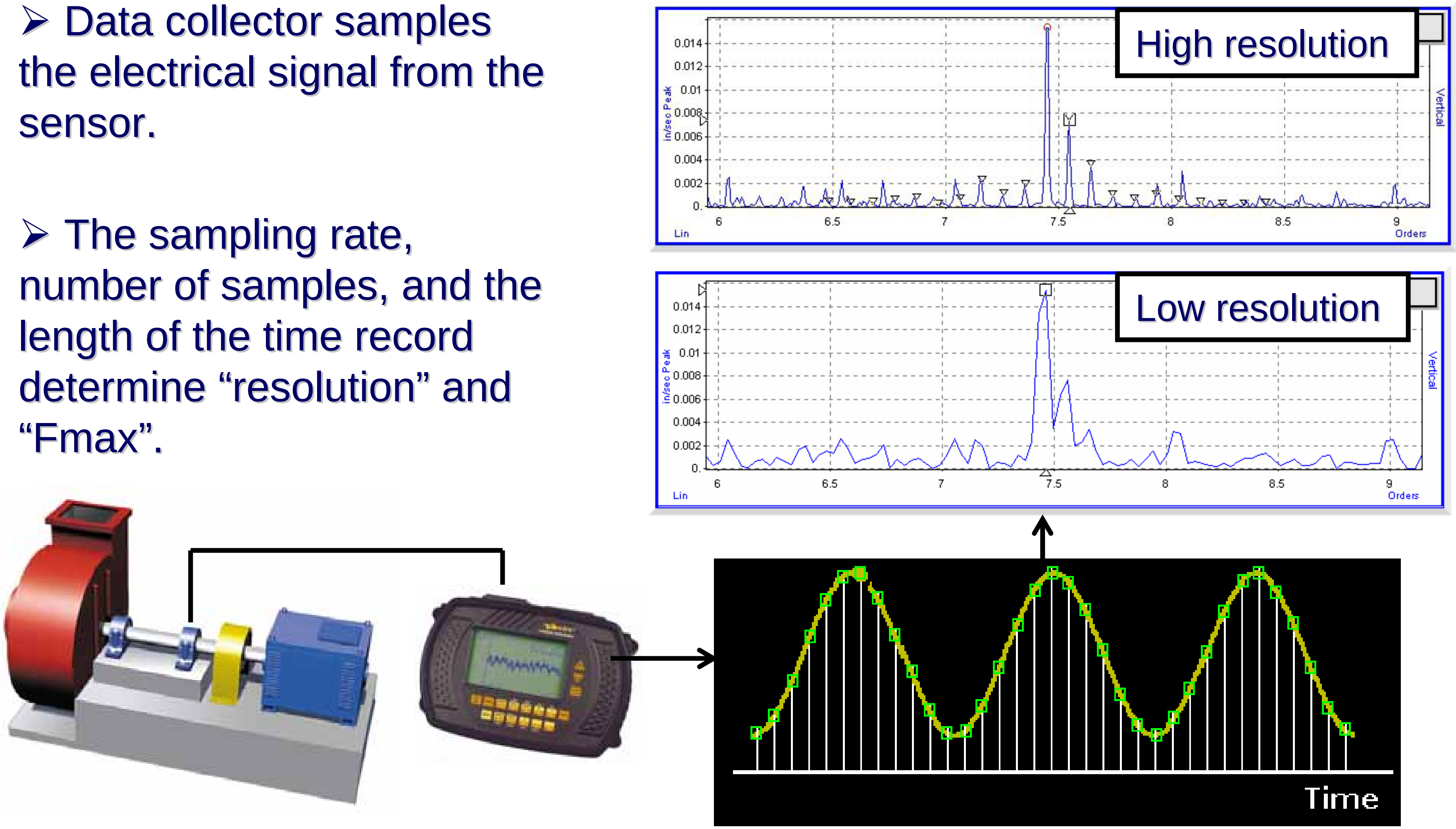
A More Complex Spectrum



Resolution

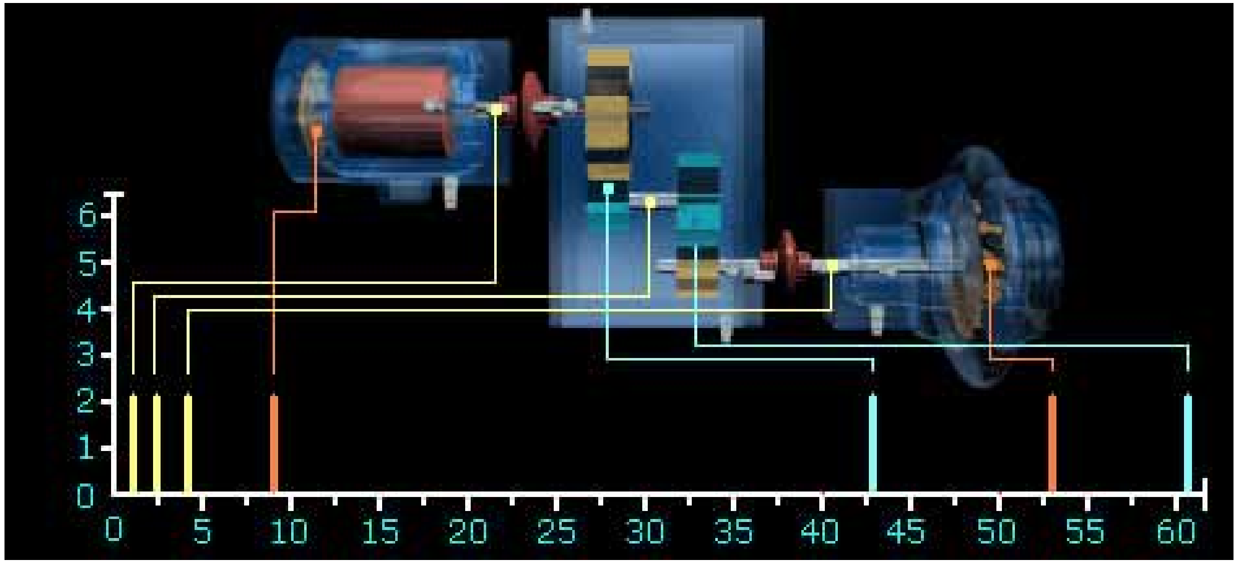
- Data collector samples the electrical signal from the sensor.

- The sampling rate, number of samples, and the length of the time record determine “resolution” and “Fmax”.



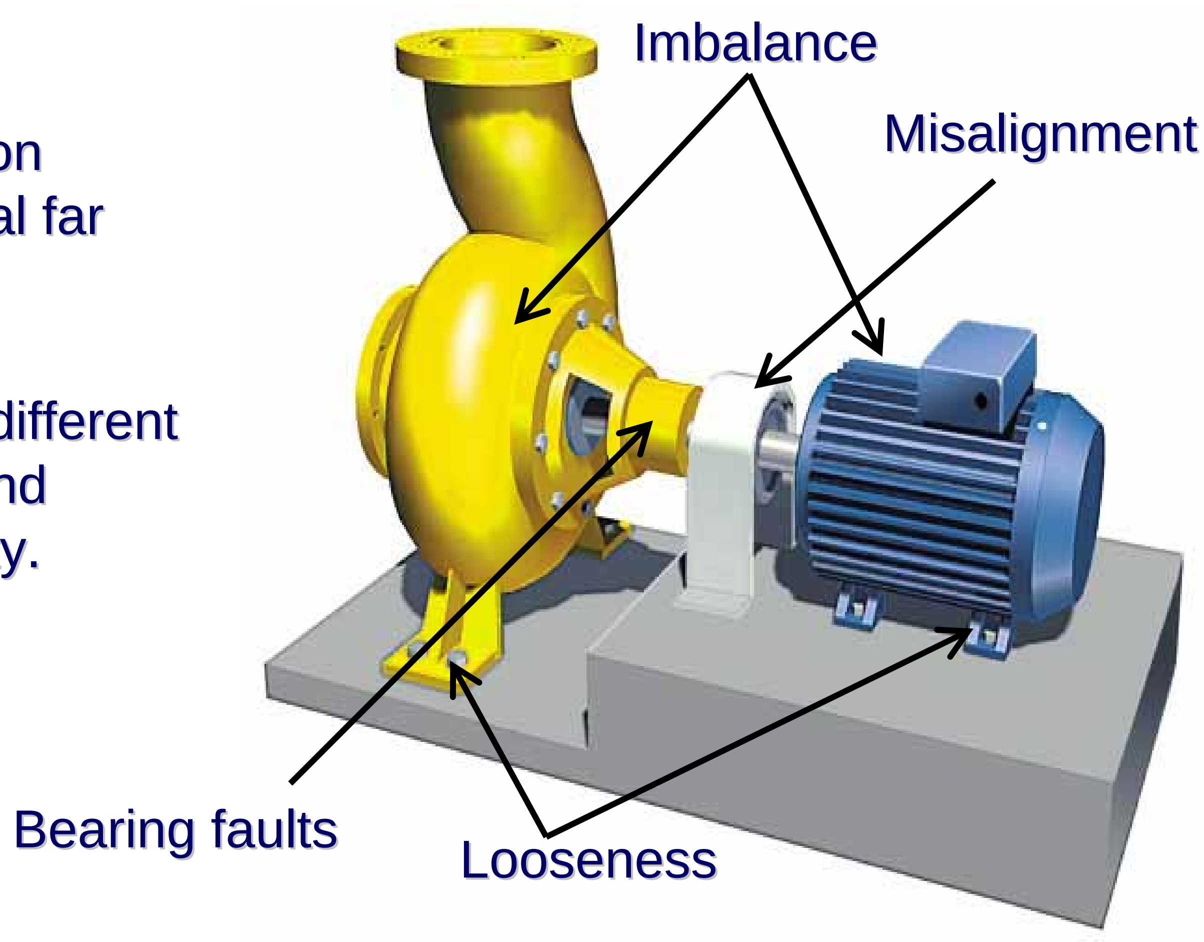
Forcing Frequencies

Special calculations are used to indicate where to look in the spectrum – called “forcing frequencies”



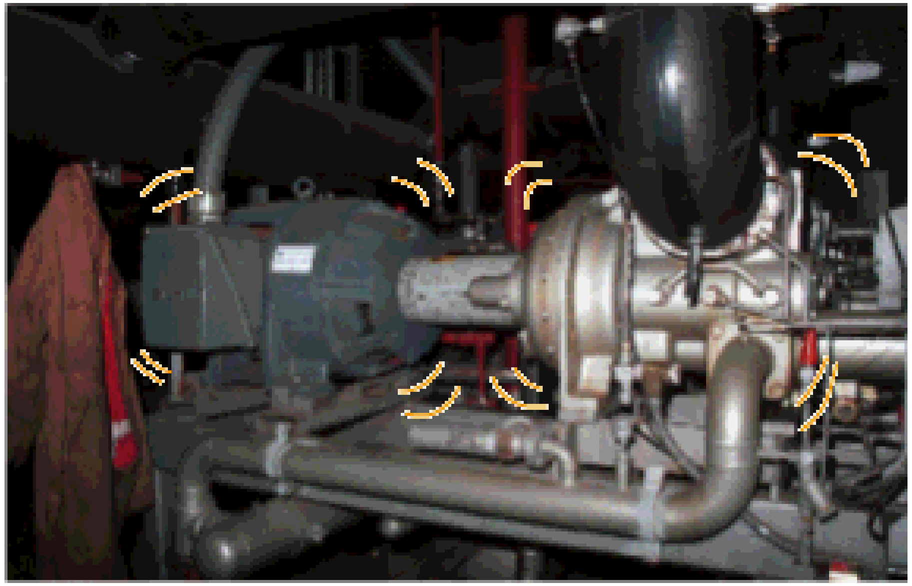
Vibration tells an interesting story

- Detailed vibration analysis can reveal far more information.
- We can detect different fault conditions, and assess the severity.



The Big 4

- Imbalance
- Misalignment
- Looseness
- Faulty Bearings



Imbalance

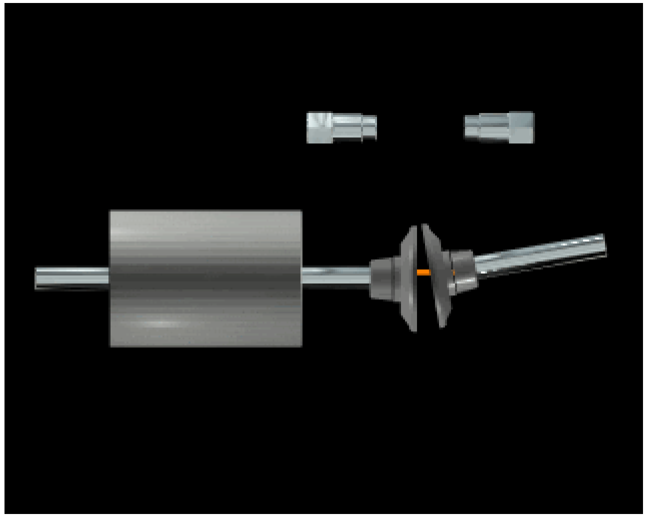
What causes “Imbalance”?

- A heavy spot along the shaft
- Causes high vibration and premature bearing failure
- Your vbSeries data collector can correct imbalance

Misalignment

What is "Misalignment"?

- Definition: "The shaft center-lines are not collinear"
- Can be detected in vibration signature
- Corrected with dial indicators and lasers
- Also cause of high vibration, and thus bearing damage



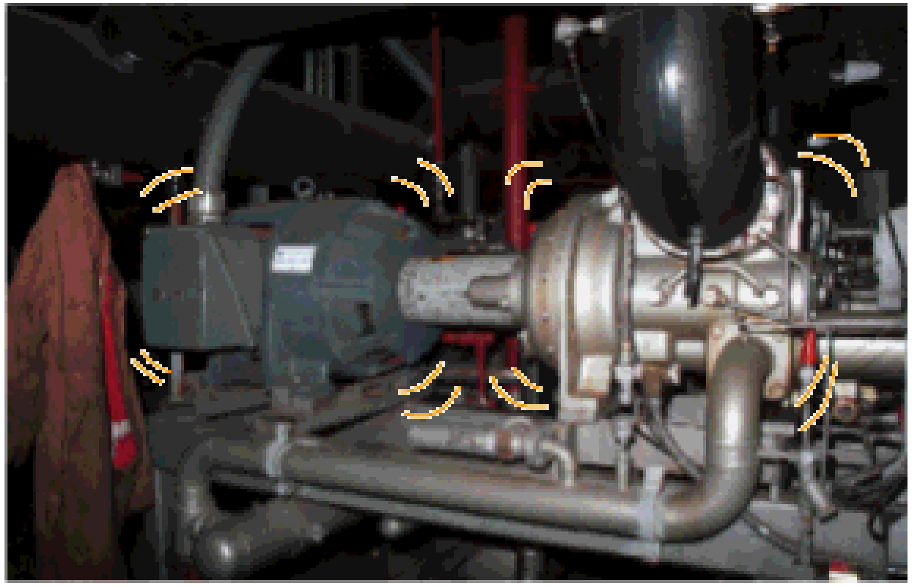
Looseness

- Rotating looseness

- excessive clearance between rotation & stationary parts

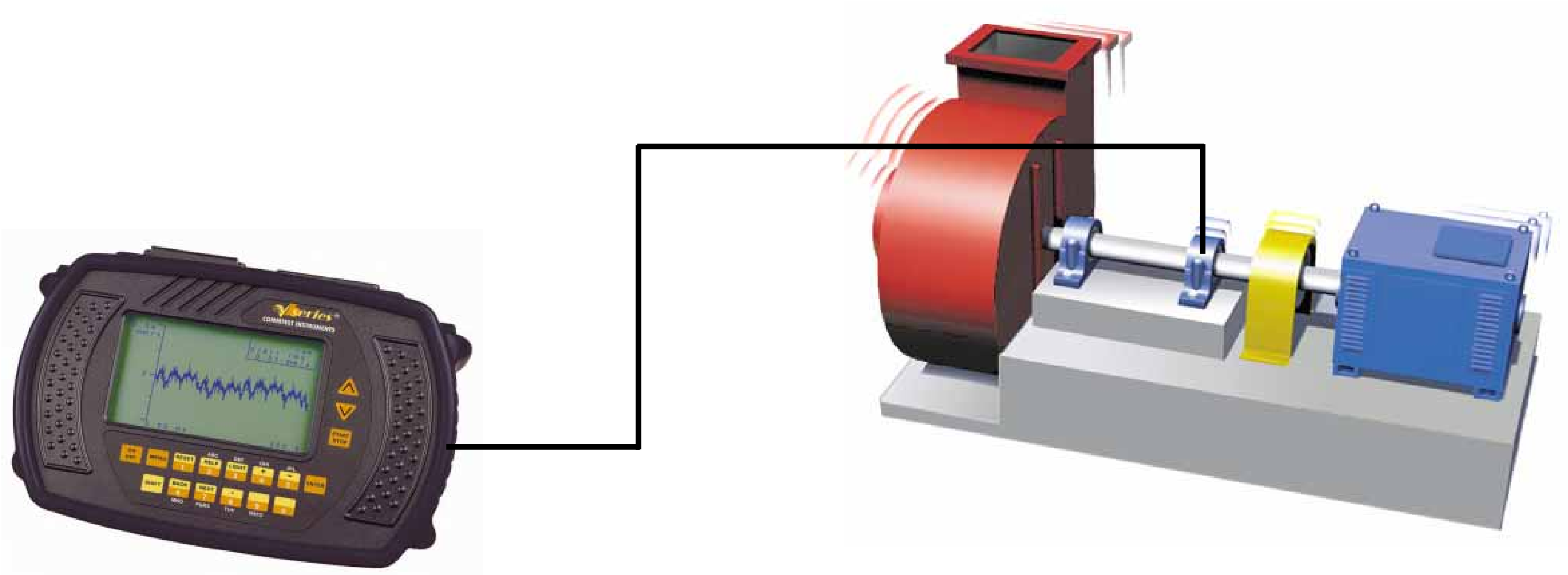
- Non Rotating looseness

- between two normally stationary parts. ie between foot & foundation



Bearing Faults

- Monitor the vibration at the bearings
- Amplitude levels indicate *severity* of the problem
- Frequency patterns indicate *nature* of the problem
- Many different ways to analyze the data

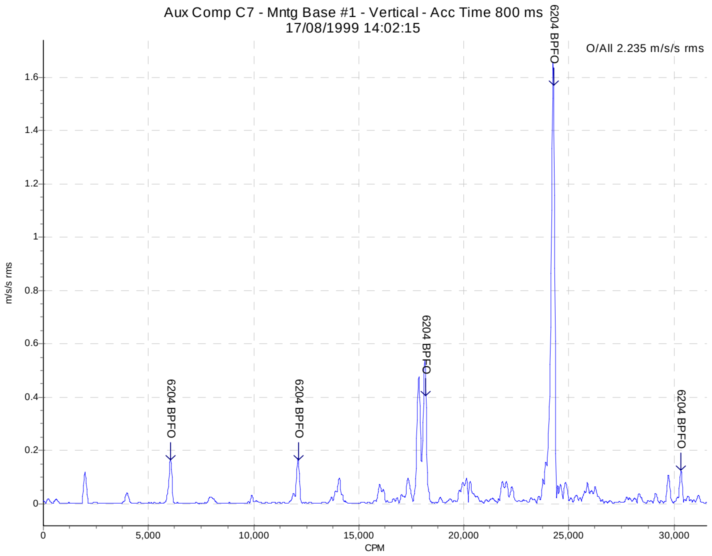


Demodulation

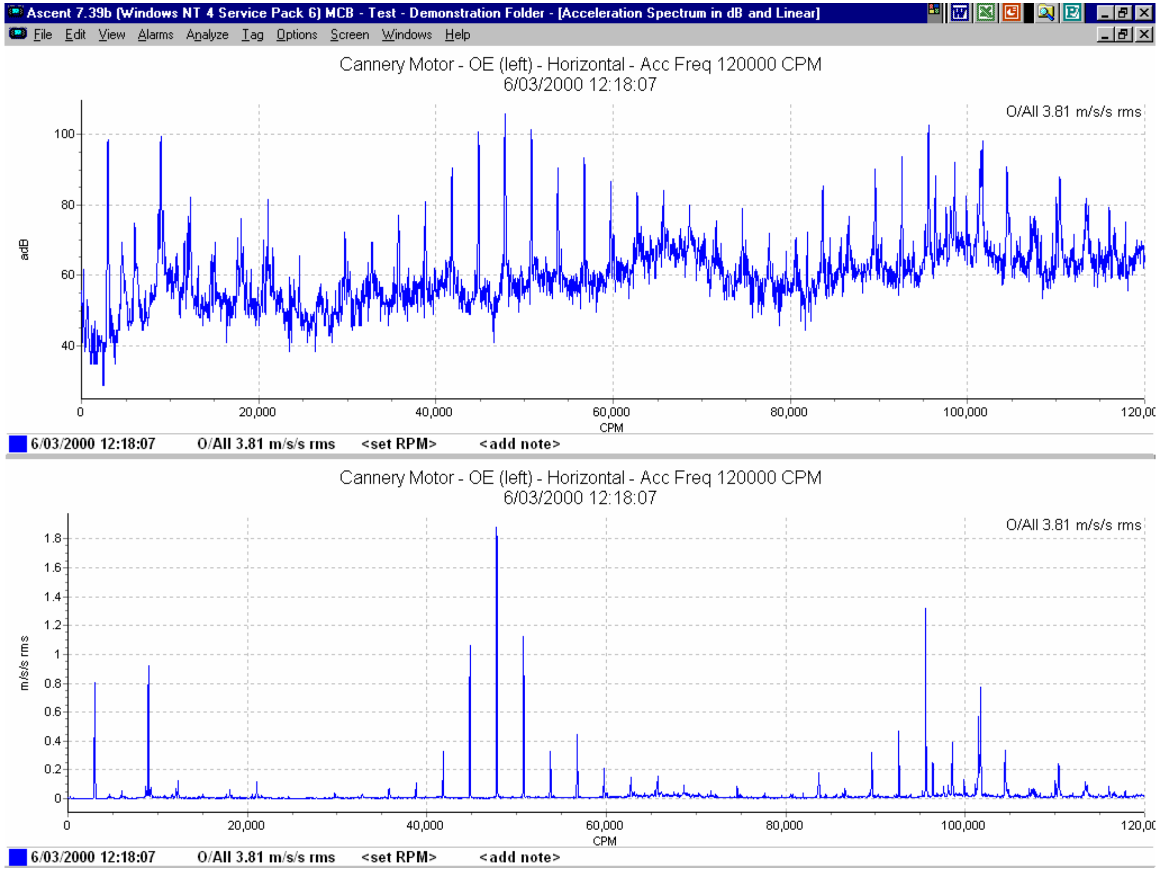
- Ball/roller strikes defect and creates a “shock wave”.

- Bearing then “rings like a bell” or resonates.

Demodulated spectrum

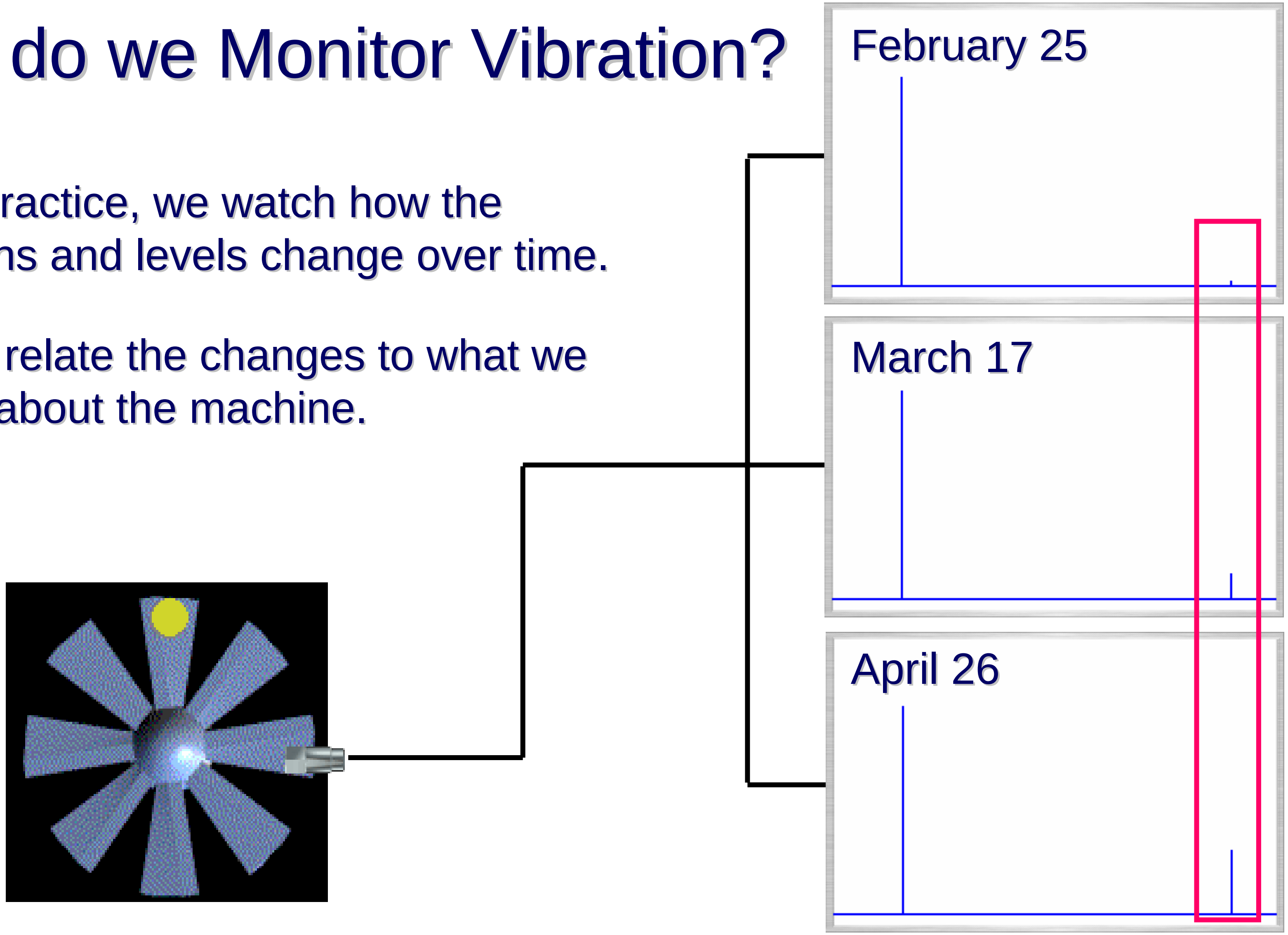


BASIC Vibration Analysis



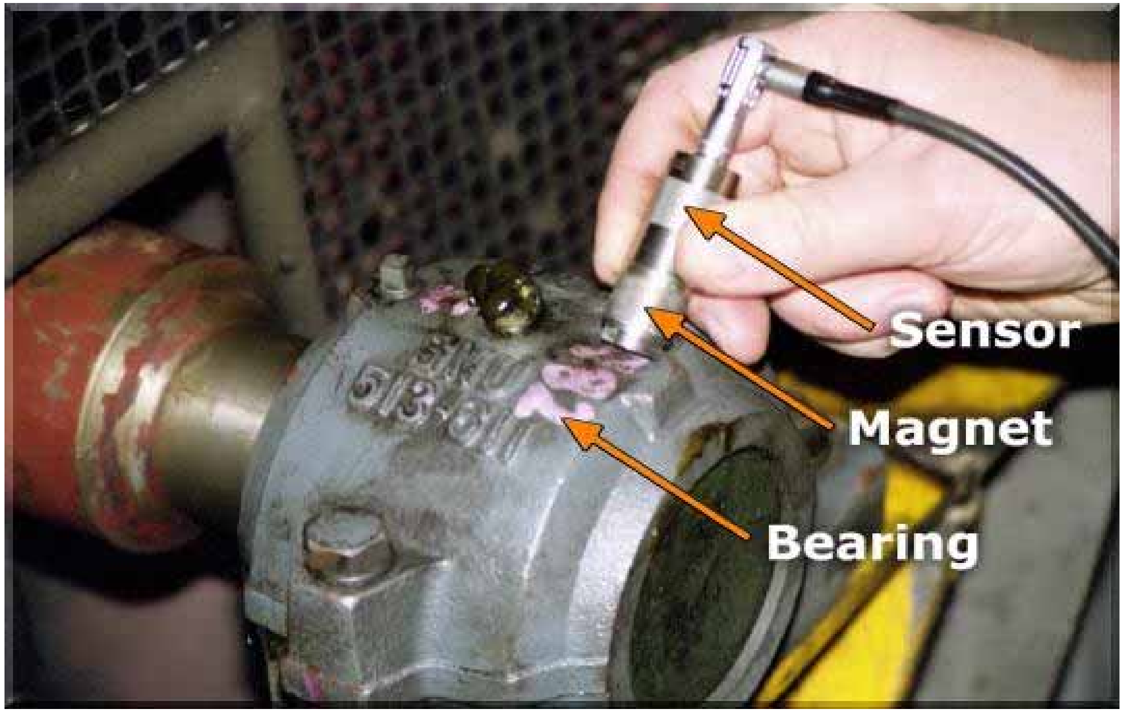
How do we Monitor Vibration?

- In practice, we watch how the patterns and levels change over time.
- We relate the changes to what we know about the machine.



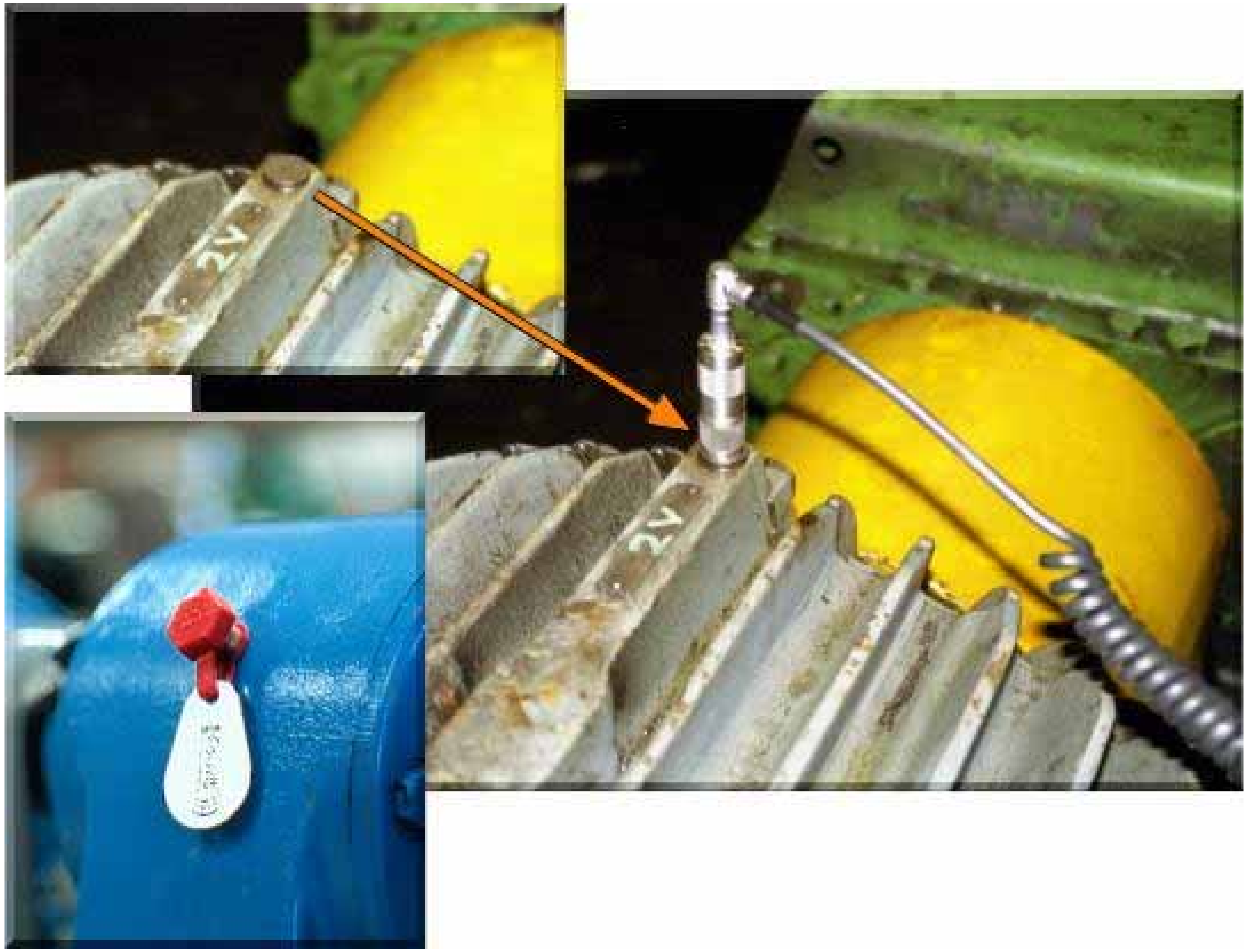
Where do I mount the Sensor?

- The sensor converts the vibration into an electronic signal.
- The most common sensor is an accelerometer.
- The sensor is commonly attached using a magnet.



Mounting the sensor

- Proper mounting is very important.
- “Repeatability” is essential.
- Good “mechanical transmission path” from the bearing.

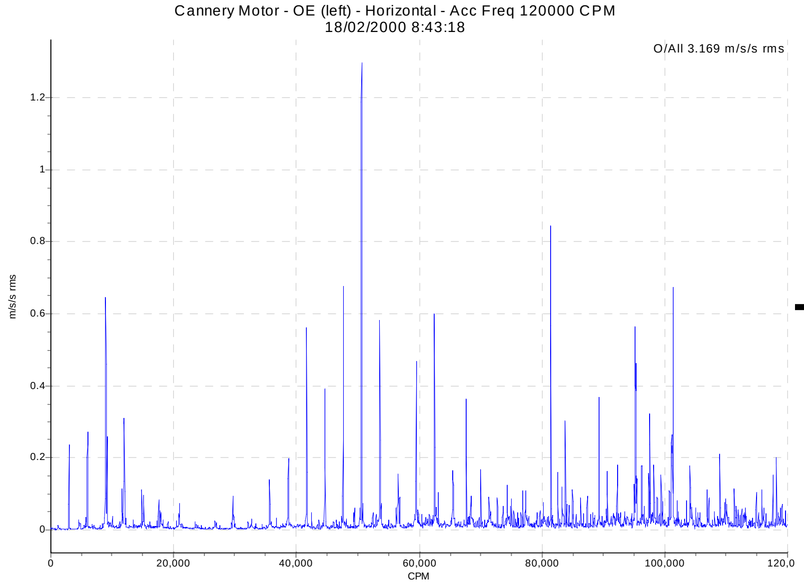


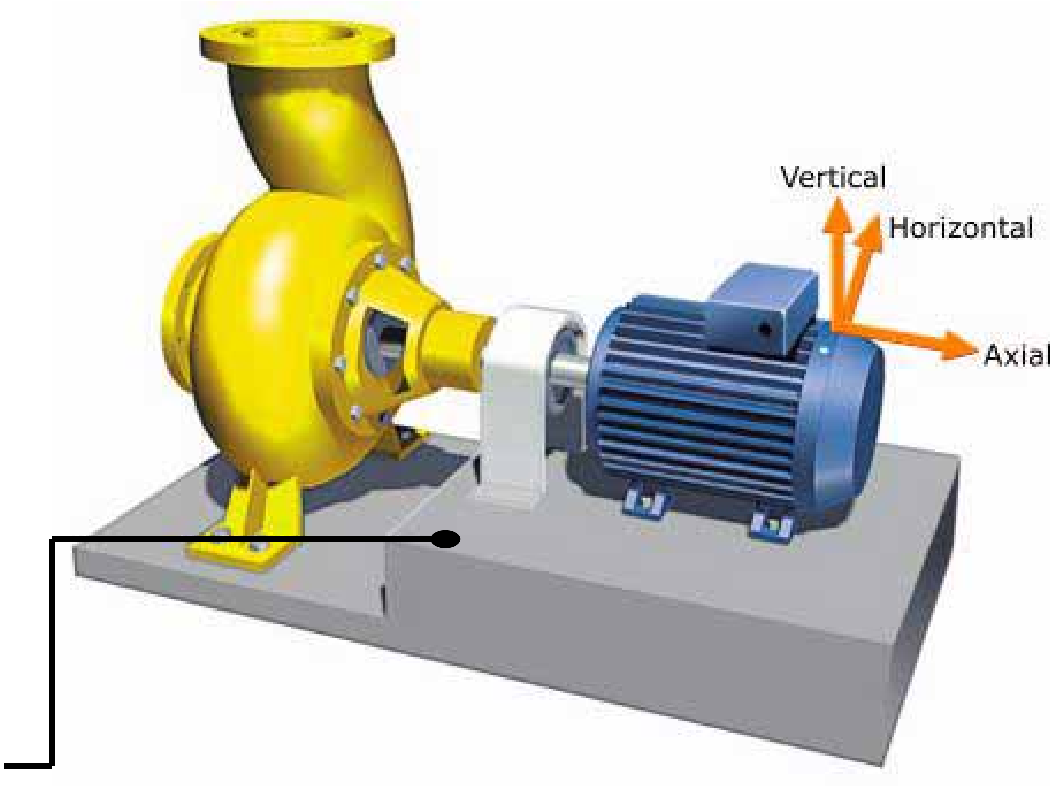
Repeatability

- ➢ Vibration changes when the speed and load change.
- ➢ The machine must operate in the same state during every test.
- ➢ Check the speed and load with each measurement.

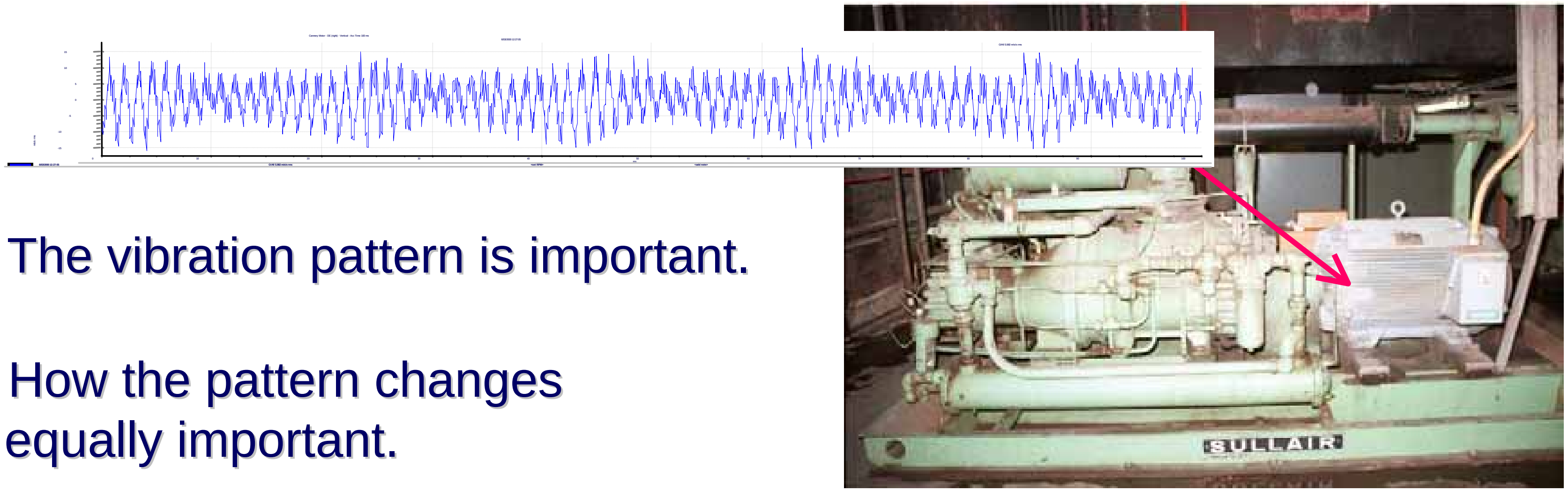
Repeatability

- Tests are typically performed every 30 days.
- Test a machine at 2 or 3 bearings.
- Collect vertical, horizontal and axial data.





Look for patterns and changes

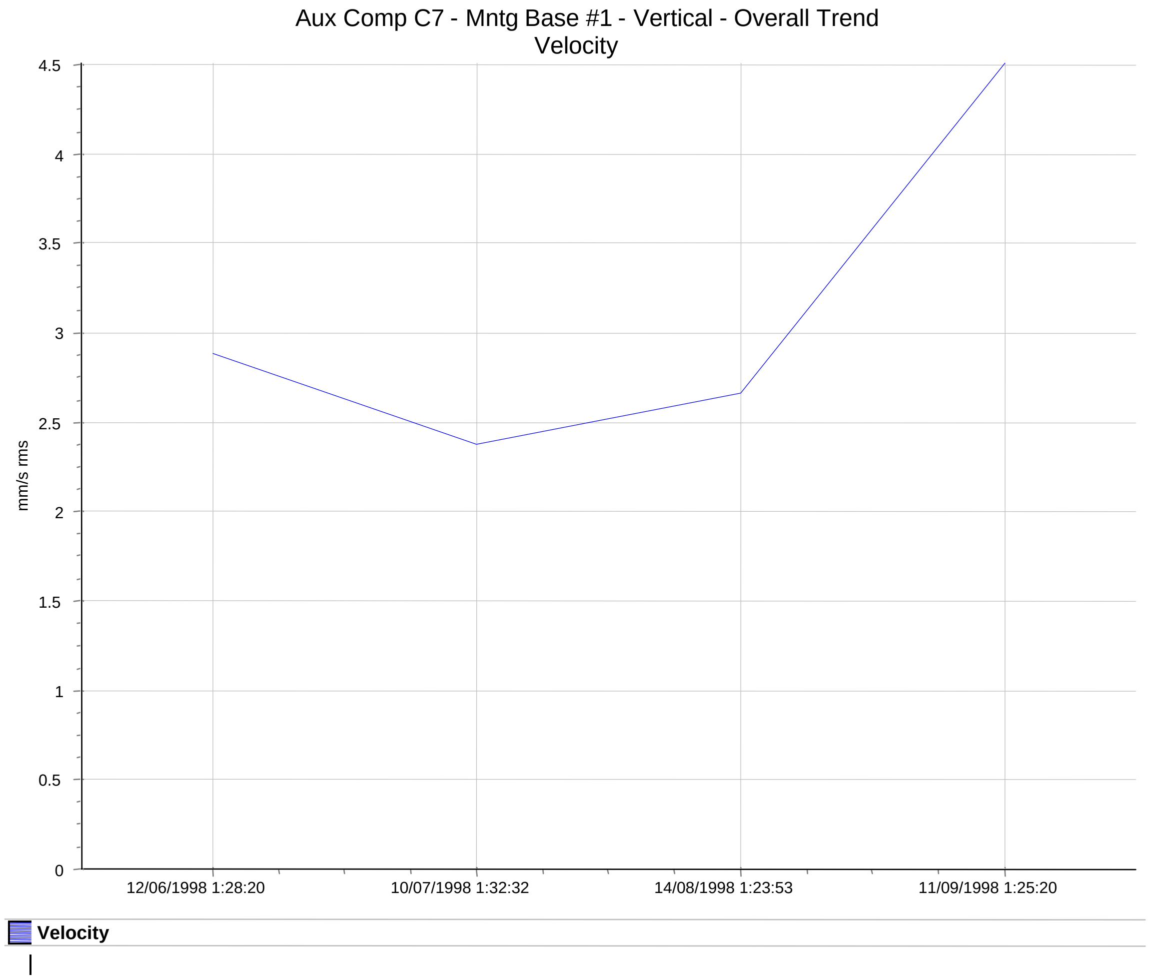


- The vibration pattern is important.

- How the pattern changes is equally important.

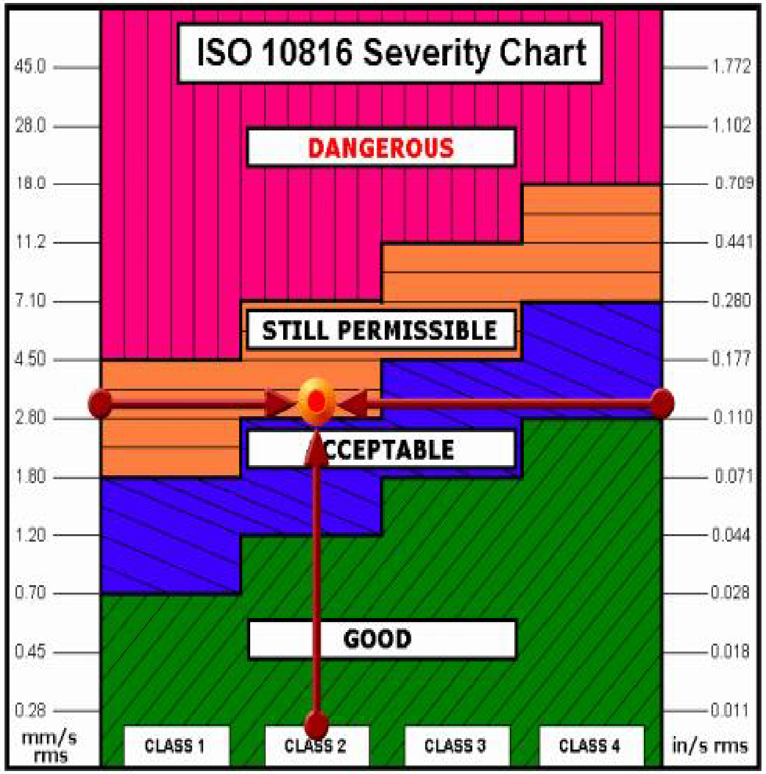
Trend vibration levels

An Overall RMS trend can provide useful information



What does it mean…..?

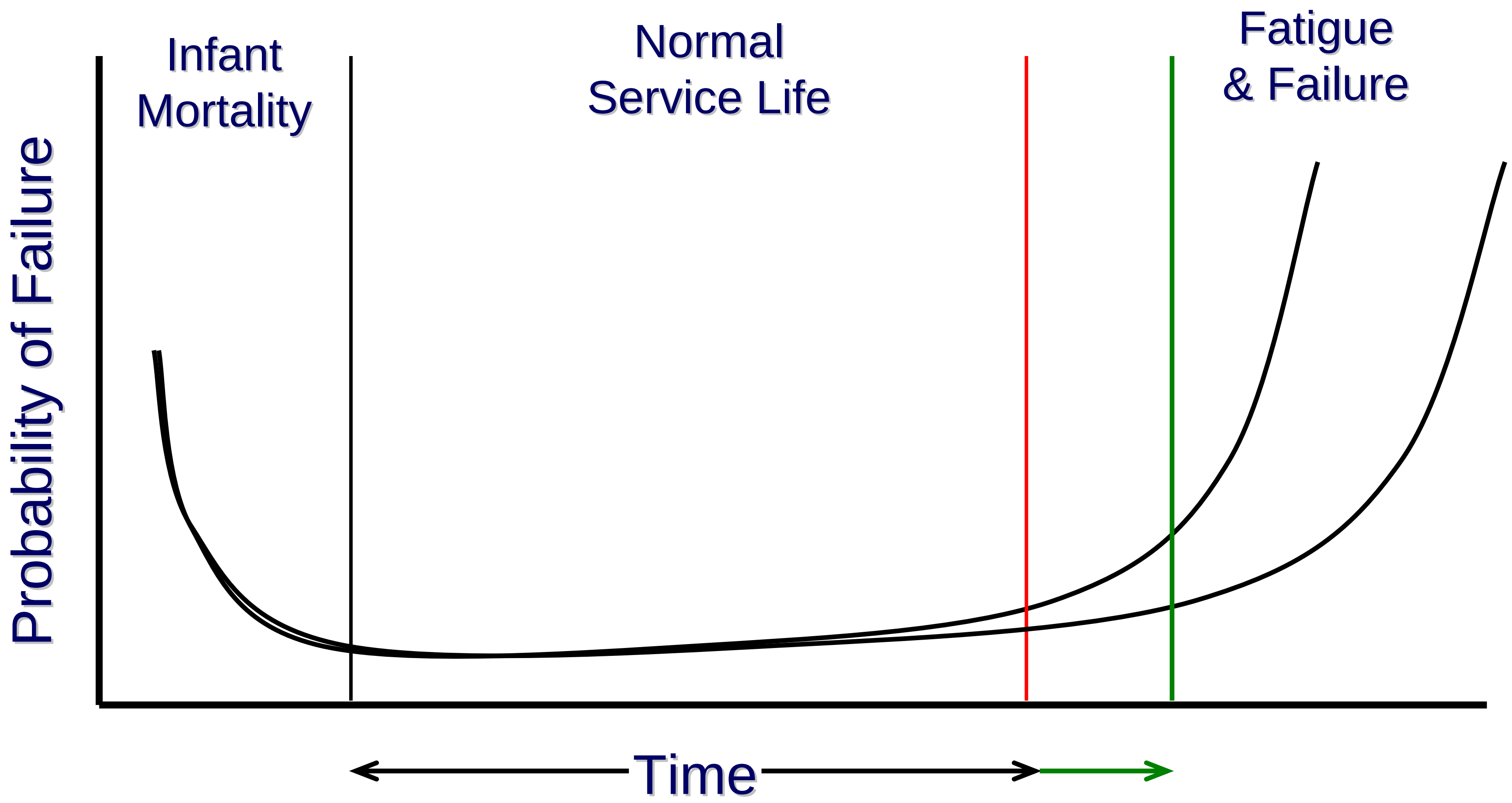
- How do you know when to take action?
- Standards are available.
- ASCENT® removes the guesswork**.**



Reality Check!

Predictive maintenance:

- Monitoring machines regularly with repeatable results requires discipline
  - Not all machines can be monitored
  - Some machines cannot be monitored frequently enough
- Technologies are not perfect
- Recommendations are not always followed
- Some machines will still fail until analysis experience grows



The result is an <u>increase</u> in machine availability with a <u>decrease</u> in total costs