Certification Exam Reference Material

$$T = T_s \times N = \frac{N}{F_S} = \frac{N}{2.56 \times F_{max}} = \frac{lines}{F_{max}}$$

T = Time required to collect the waveform

Ts = Time between each sample

Fs = Sampling rate = Samples per second

N = Number of samples (1024, 2048, 4096, etc.)

$$Resolution = \frac{F_{max}}{lines}$$

$$Bandwidth = Resolution \times Window\ factor$$

Window factor = 1 (no window/uniform/rectangular) or 1.5 (Hanning window)

Separating frequency ≥ 2 x Bandwidth ≥ 2 x Resolution * Window Factor

Required spectral lines ≥ 2 x Window factor x Fmax / Separating frequency

Accuracy of frequency (at peak) = ± ½ x Resolution

Prime numbers: 1, 2, 3, 5, 7, 11, 13, 17, 19…

1 inch = 25.4 mm
1mm = 0.039 inches

Trial weight calculation:

$$W = \frac{F}{K \times R \times N^2}$$

F = 10% of rotor mass divided by the number of bearings in kg
K = 0.011
N = RPM/1000
R = Radius in cm

Unit Conversions

$$D_{pk-pk} = \frac{19098\, V_{pk}}{f_{cpm}} \qquad V_{pk} = \frac{5217\, A_{rms}}{f_{cpm}}$$

$$D_{pk-pk} = \frac{9.958x10^{7} A_{rms}}{f_{cpm}^{2}} \qquad A_{rms} = \frac{f_{cpm} V_{pk}}{5217}$$

$$V_{pk} = \frac{f_{cpm} D_{pk-pk}}{19098} \qquad A_{rms} = \frac{f_{cpm}^{2} D_{pk-pk}}{9.958x10^{7}}$$

D = Displacement: mils pk-pk
V = Velocity: in/sec pk
A = Acceleration: g rms
F = Frequency: CPM

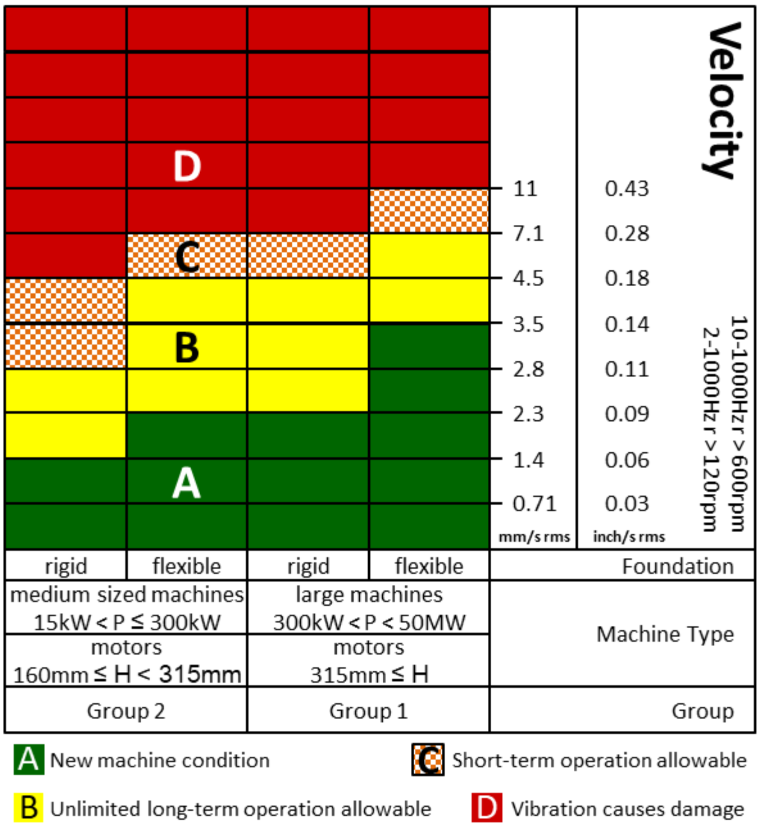
$$D_{pk-pk} = \frac{27009\, V_{rms}}{f_{cpm}} \qquad V_{rms} = \frac{93712\, A_{rms}}{f_{cpm}}$$

$$D_{pk-pk} = \frac{2.53x10^{9} A_{rms}}{f_{cpm}^{2}} \qquad A_{rms} = \frac{f_{cpm} V_{rms}}{93712}$$

$$V_{rms} = \frac{f_{cpm} D_{pk-pk}}{27009} \qquad A_{rms} = \frac{f_{cpm}^{2} D_{pk-pk}}{2.53x10^{9}}$$

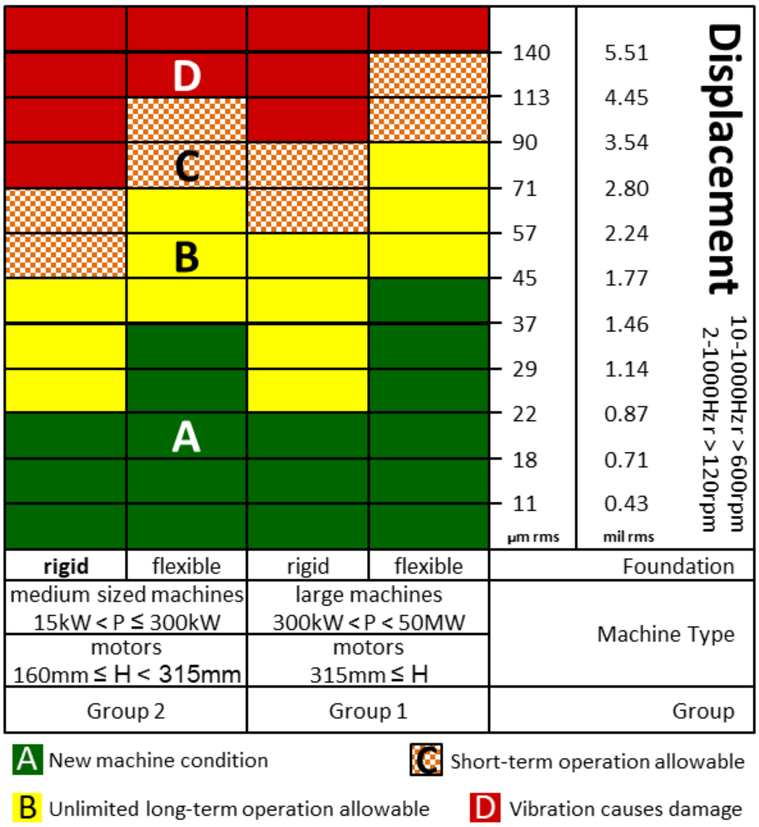
D = Displacement: micron pk-pk
V = Velocity: mm/sec rms
A = Acceleration: g rms
F = Frequency: CPM
1g rms = 9.8m/sec²

ISO 10816-3 Vibration Severity Chart

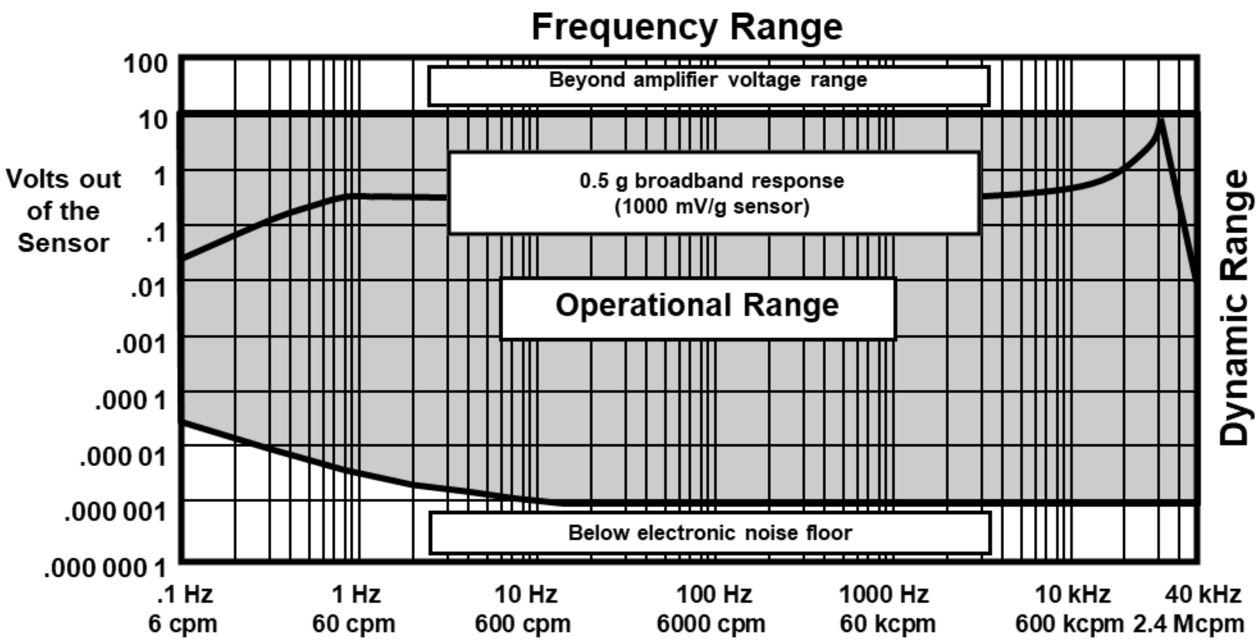


If the lowest natural frequency of the combined machine and support system in the direction of measurement is higher than its main excitation frequency (this is in most cases the rotational frequency) by at least 25 %, then the support system may be considered rigid in that direction. All other support systems may be considered flexible.

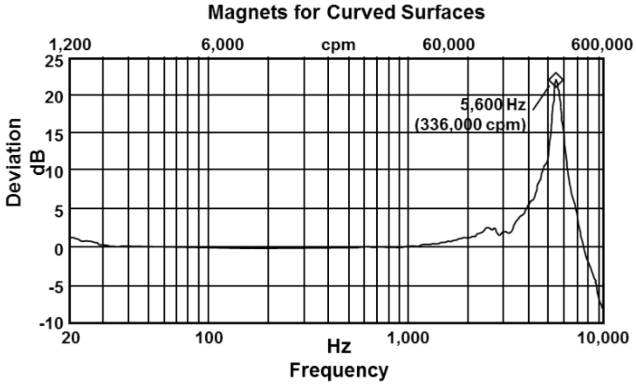
ISO 10816-3 Vibration Severity Chart



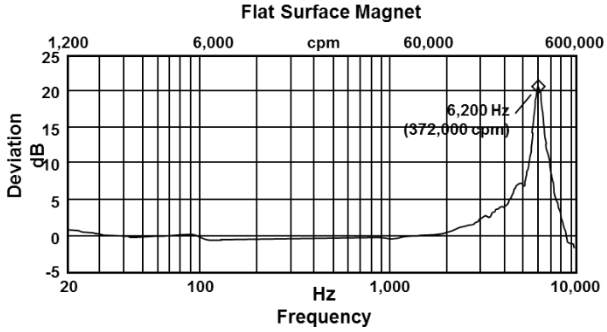
Transducer Operating Regions



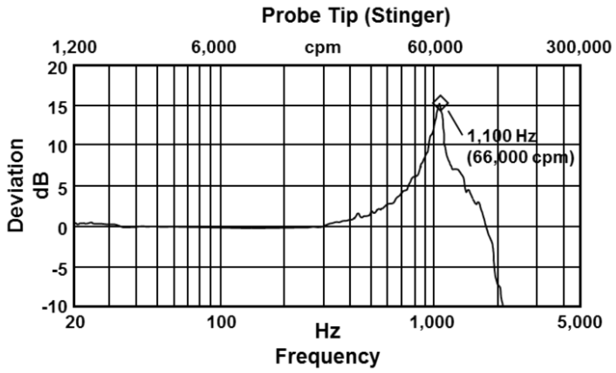
Transducer Frequency Response - Magnets on Curved Surfaces



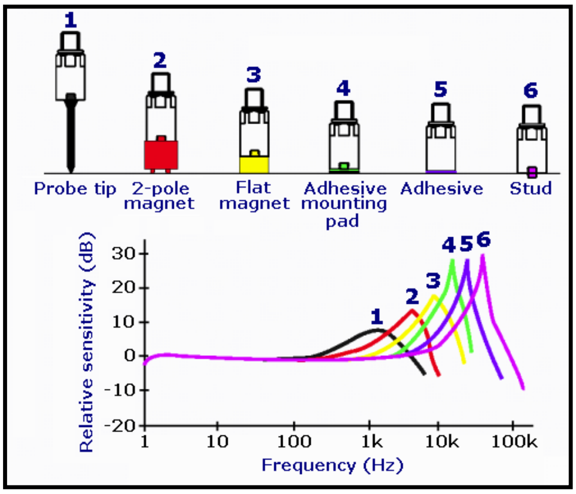
Transducer Frequency Response - Magnets on Flat Surfaces



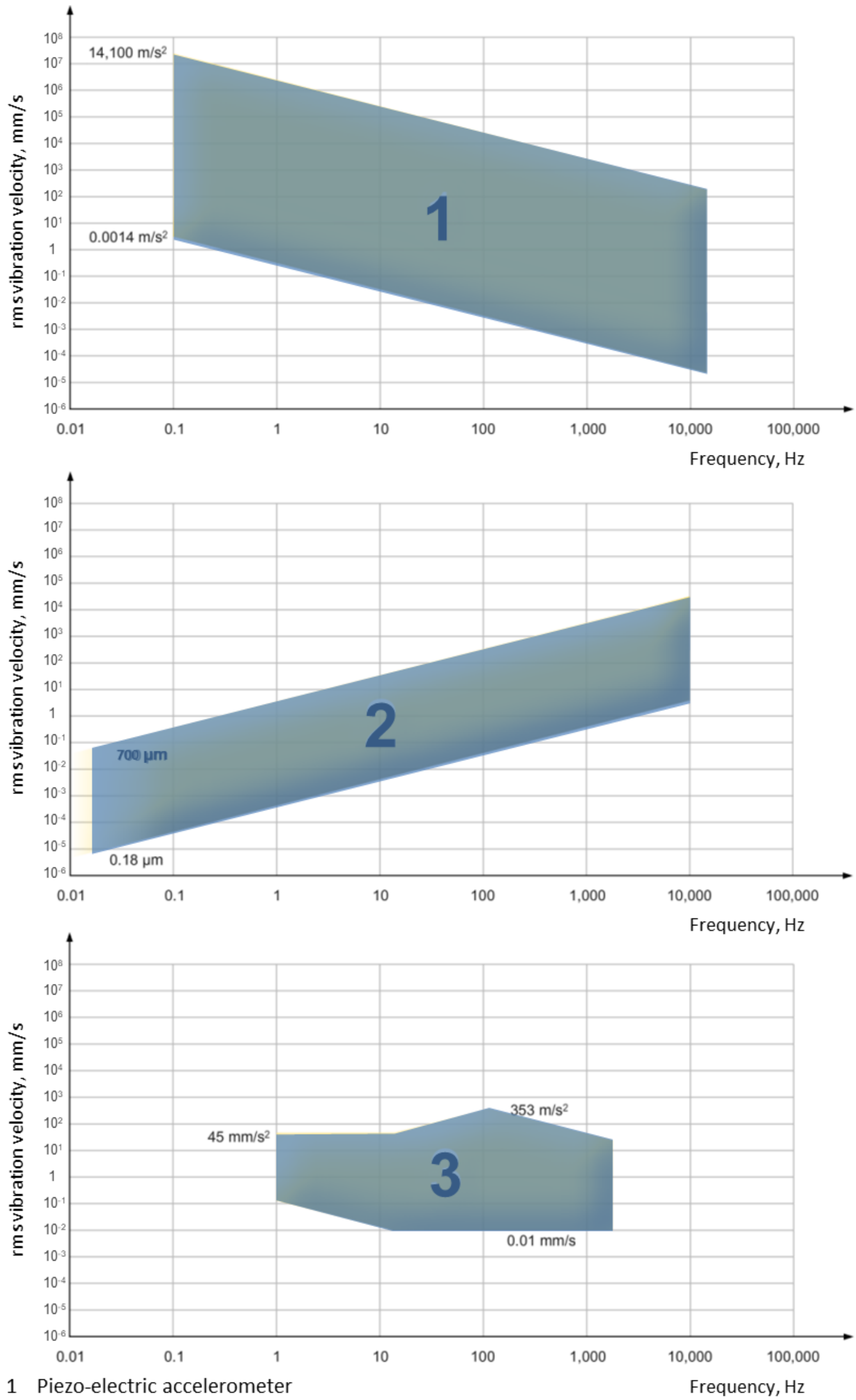
Transducer Frequency Response - Stingers or Hand Held Probes



Transducer Frequency Response Curves

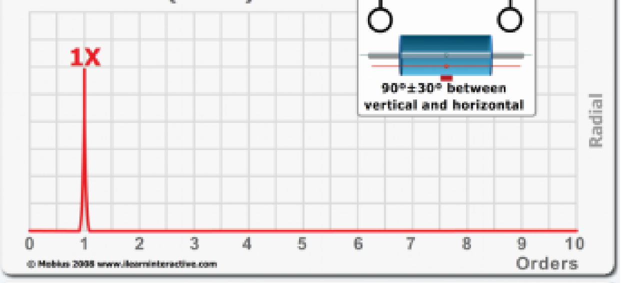


Transducer Effectiveness Regions

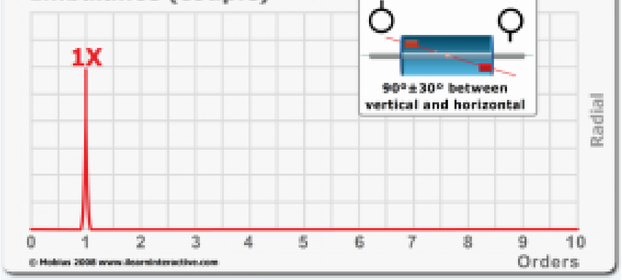


1 Piezo-electric accelerometer
2 Eddy-current proximity probe
3 Electro-mechanical velocity transducer

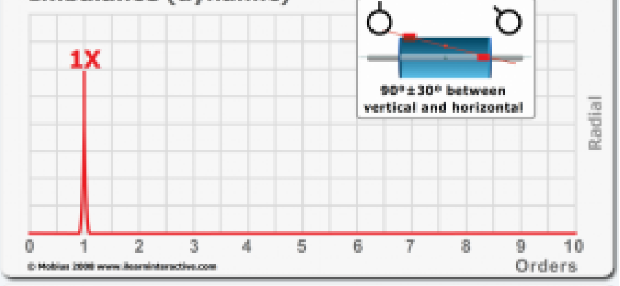
Imbalance (static)



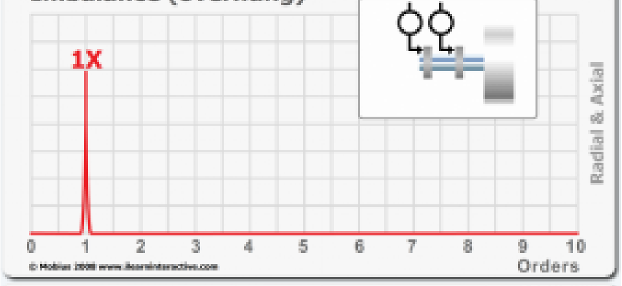
Imbalance (couple)



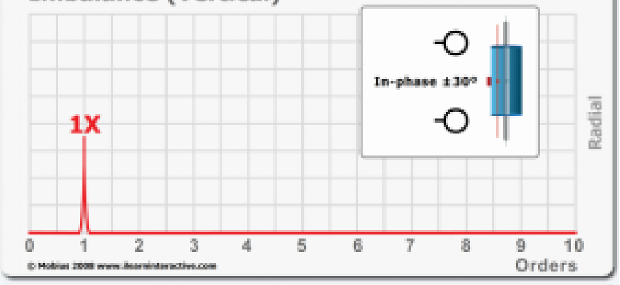
Imbalance (dynamic)



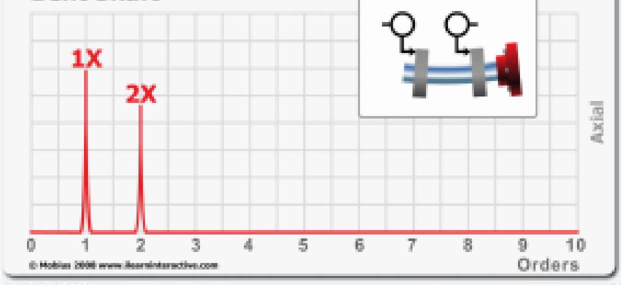
Imbalance (overhung)



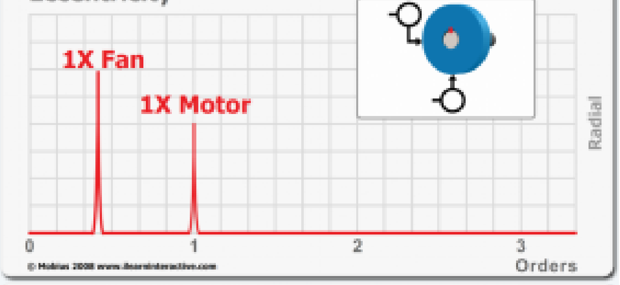
Imbalance (Vertical)



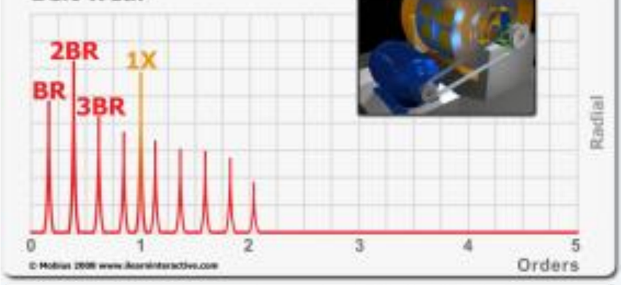
Bent Shaft



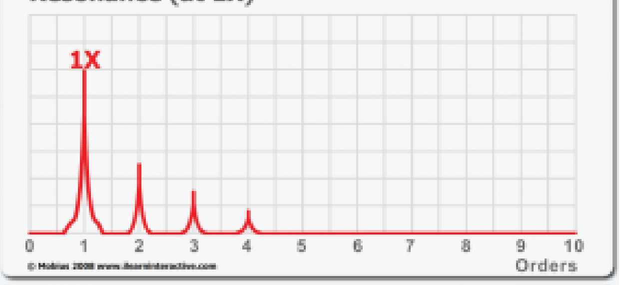
Eccentricity



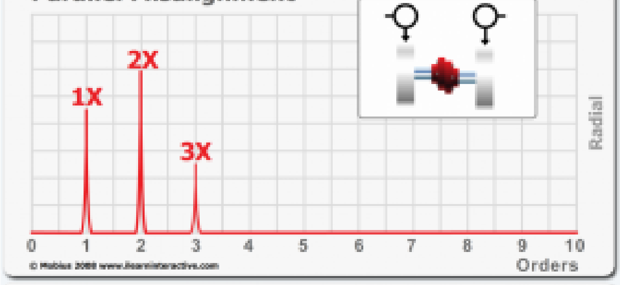
Belt wear



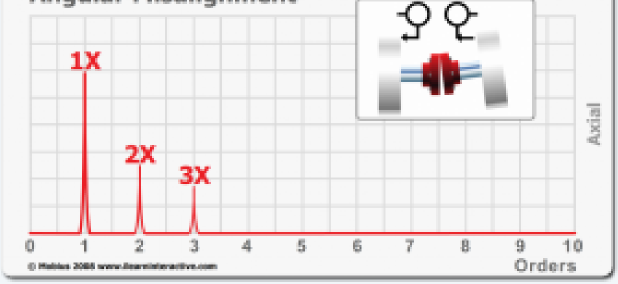
Resonance (at 1X)



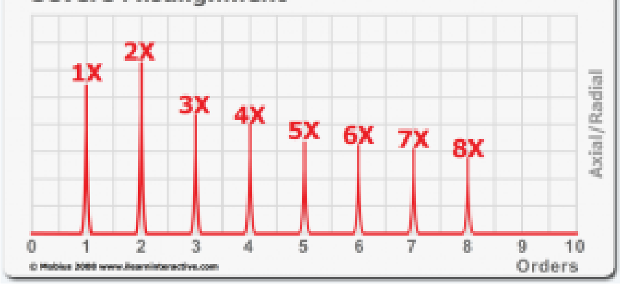
Parallel Misalignment

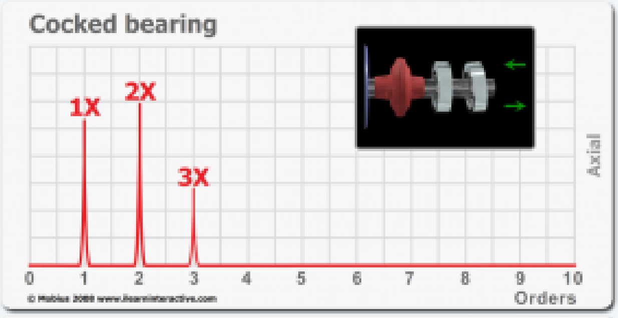


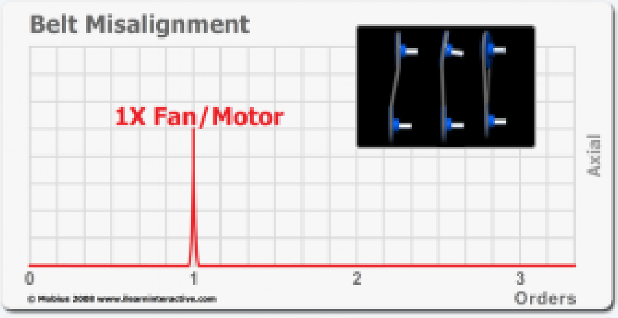
Angular Misalignment

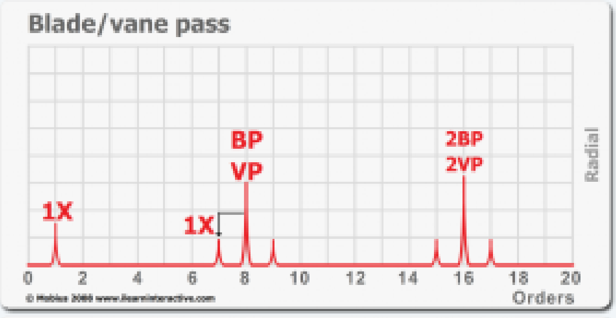


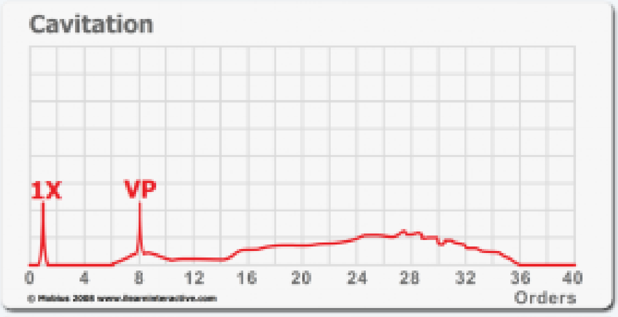
Severe Misalignment



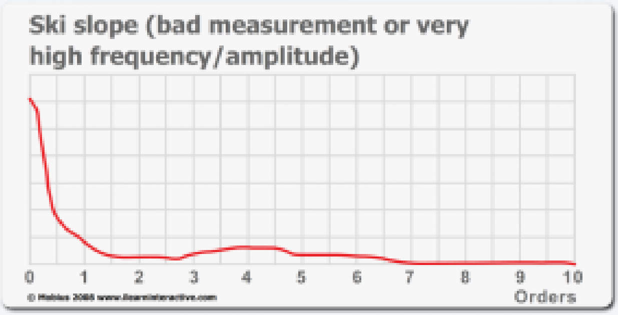

Cocked bearing
1X
2X
3X
Axial
0 1 2 3 4 5 6 7 8 9 10
Orders

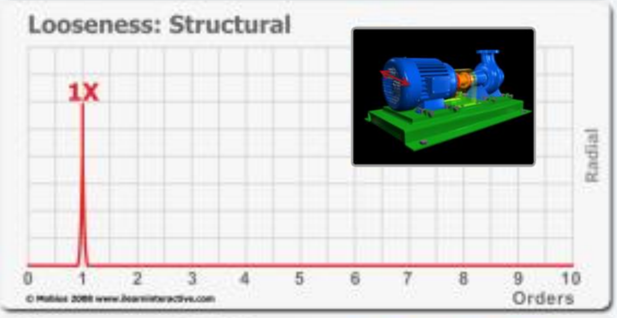

Belt Misalignment
1X Fan/Motor
Axial
0 1 2 3
Orders

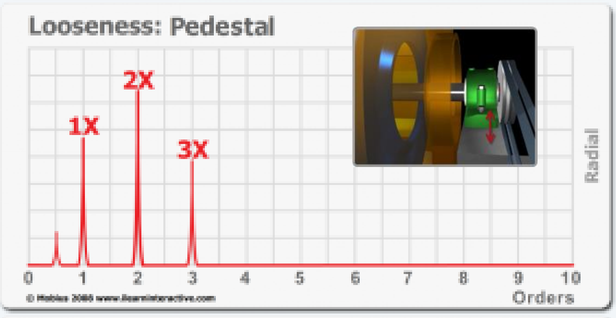

Blade/vane pass
BP
VP
2BP
2VP
1X
1X
Radial
0 2 4 6 8 10 12 14 16 18 20
Orders

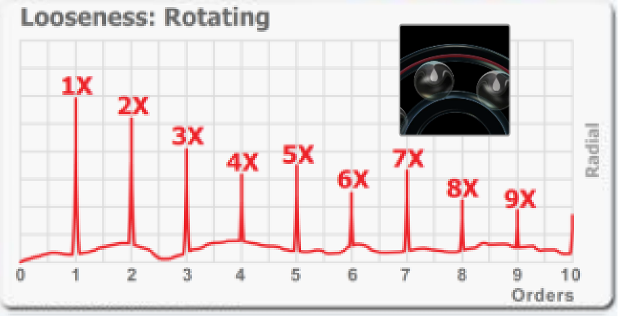

Cavitation
1X
VP
0 4 8 12 16 20 24 28 32 36 40
Orders

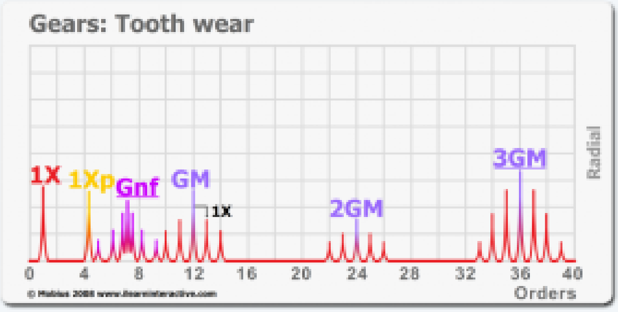

Flow turbulence
1X
0 1 2 3 4 5
Orders

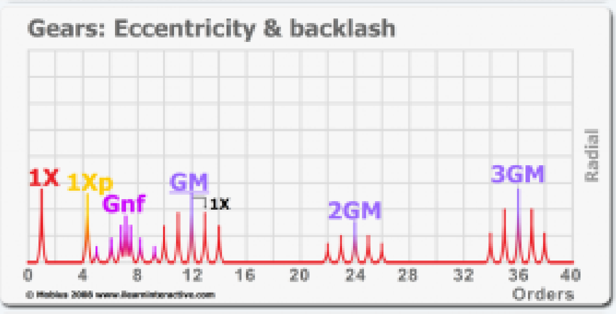

Ski slope (bad measurement or very high frequency/amplitude)
0 1 2 3 4 5 6 7 8 9 10
Orders

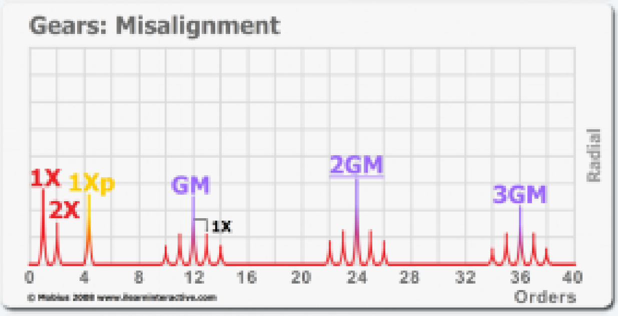

Looseness: Structural
1X
Radial
0 1 2 3 4 5 6 7 8 9 10
Orders

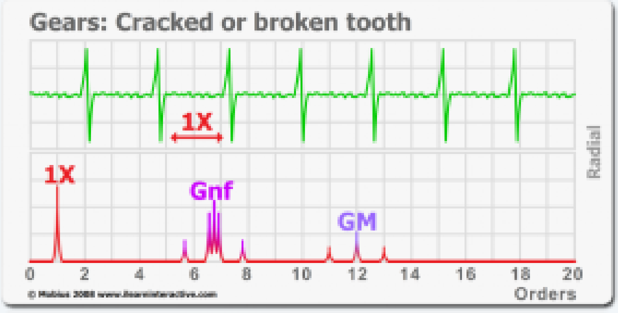

Looseness: Pedestal
2X
1X
3X
Radial
0 1 2 3 4 5 6 7 8 9 10
Orders

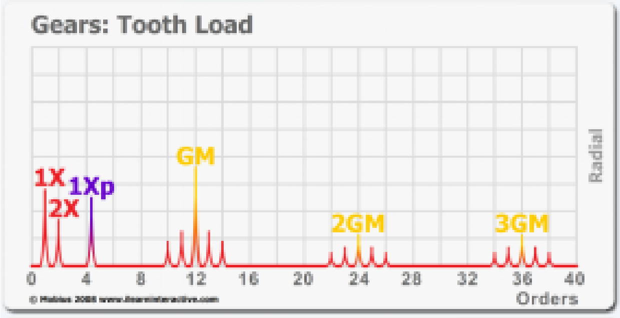

Looseness: Rotating
1X
2X
3X
4X
5X
6X
7X
8X
9X
Radial
0 1 2 3 4 5 6 7 8 9 10
Orders

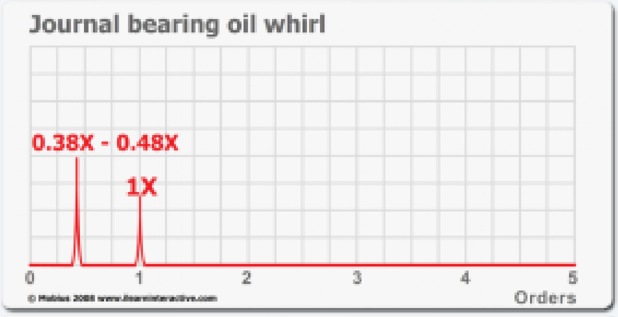

Gears: Tooth wear
1X
1Xp
Gnf
GM
1X
2GM
3GM
Radial
0 4 8 12 16 20 24 28 32 36 40
Orders

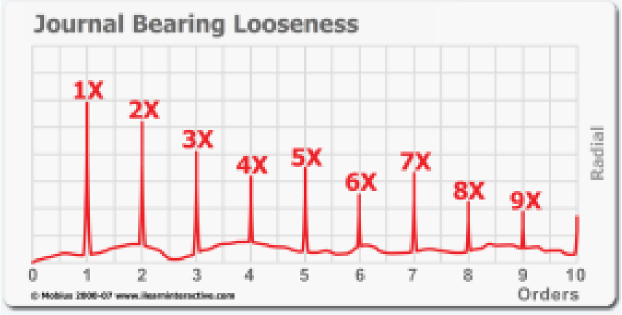

Gears: Eccentricity & backlash
1X
1Xp
Gnf
GM
1X
2GM
3GM
Radial
0 4 8 12 16 20 24 28 32 36 40
Orders

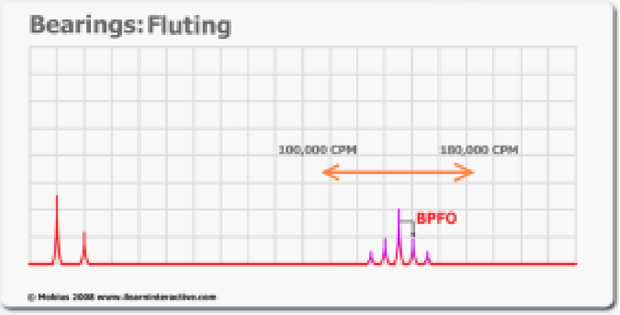

Gears: Misalignment
1X
1Xp
2X
GM
1X
2GM
3GM
Radial
0 4 8 12 16 20 24 28 32 36 40
Orders

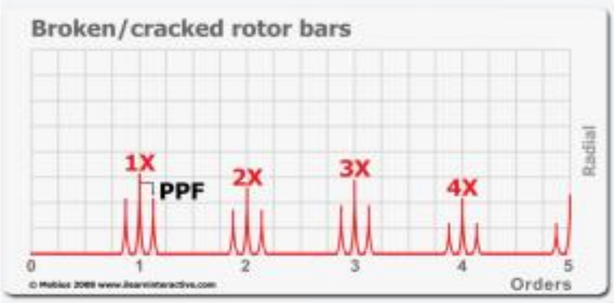

Gears: Cracked or broken tooth
1X
1X
Gnf
GM
Radial
0 2 4 6 8 10 12 14 16 18 20
Orders

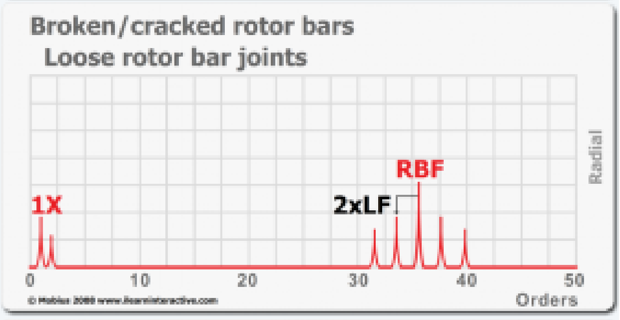

Gears: Tooth Load
1X
1Xp
2X
GM
2GM
3GM
Radial
0 4 8 12 16 20 24 28 32 36 40
Orders

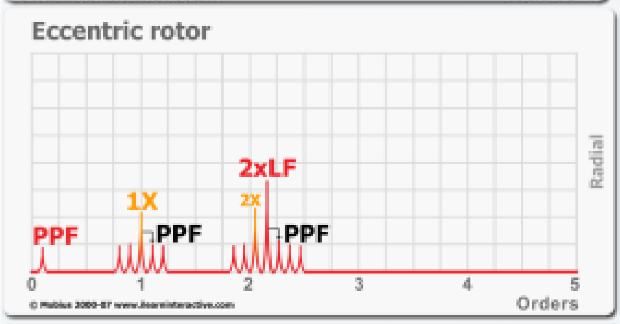

Journal bearing oil whirl
0.38X - 0.48X
1X
0 1 2 3 4 5
Orders

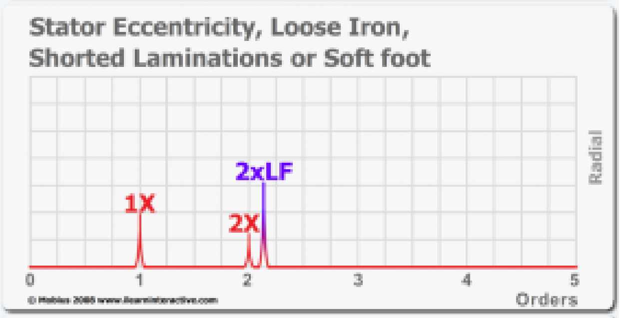

Journal Bearing Looseness
1X
2X
3X
4X
5X
6X
7X
8X
9X
Radial
0 1 2 3 4 5 6 7 8 9 10
Orders

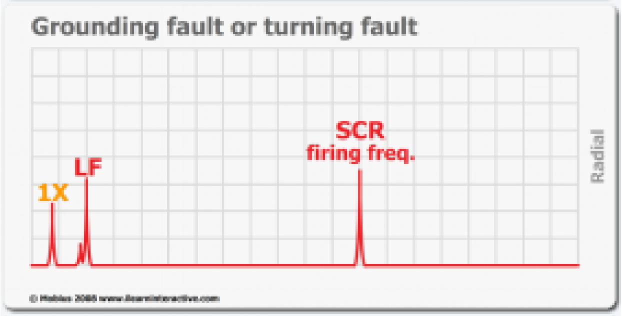

Bearings: Fluting
100,000 CPM
180,000 CPM
BPFO

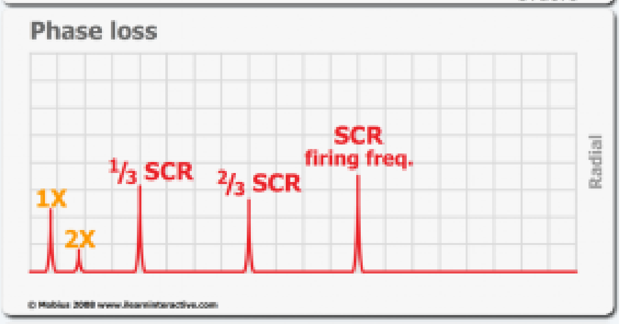

Broken/cracked rotor bars
1X
PPF
2X
3X
4X
Radial
0 1 2 3 4 5
Orders

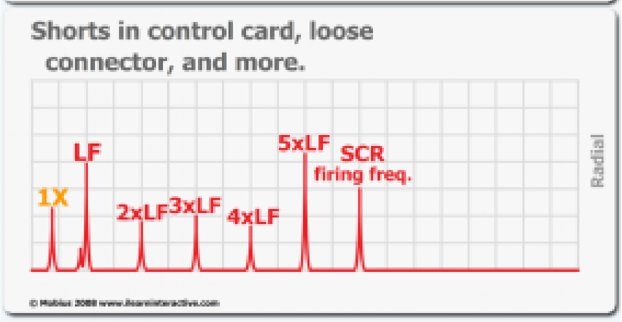

Broken/cracked rotor bars
Loose rotor bar joints
RBF
1X
2xLF
Radial
0 10 20 30 40 50
Orders

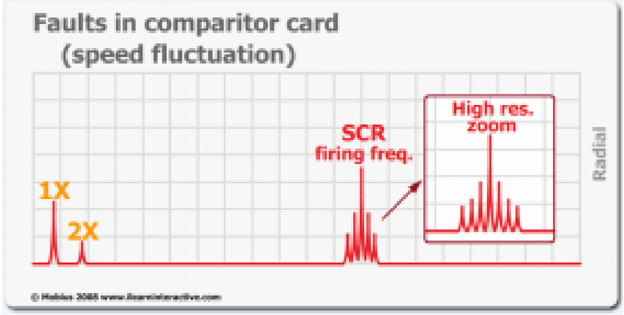

Eccentric rotor
2xLF
1X
2X
PPF
PPF
PPF
Radial
0 1 2 3 4 5
Orders

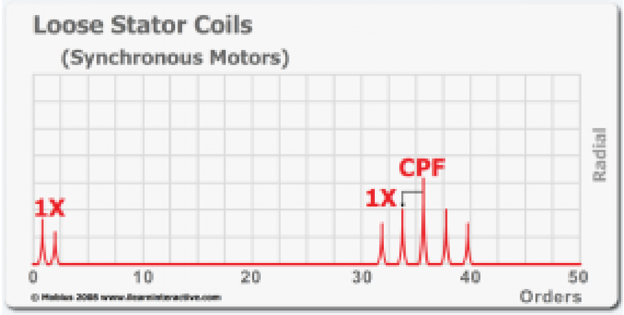

Stator Eccentricity, Loose Iron,
Shorted Laminations or Soft foot
2xLF
1X
2X
Radial
0 1 2 3 4 5
Orders

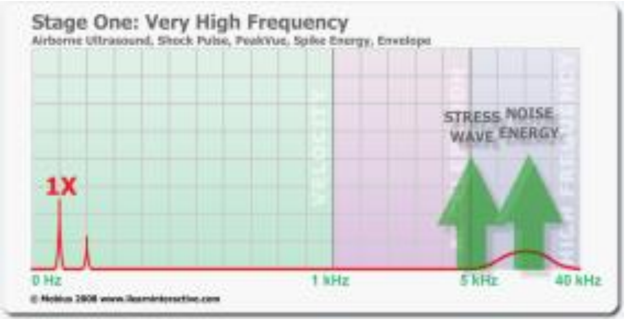

Grounding fault or turning fault
SCR
firing freq.
LF
1X
Radial


Phase loss
SCR
firing freq.
1/3 SCR
2/3 SCR
1X
2X
Radial

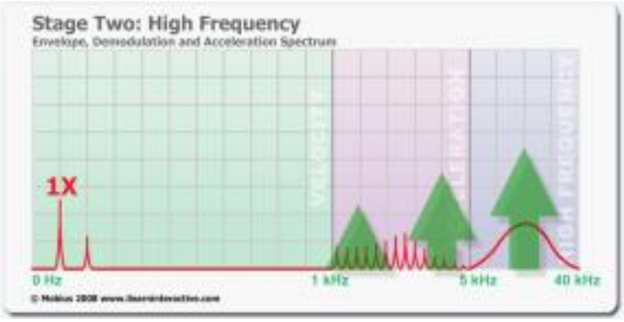

Shorts in control card, loose
connector, and more.
5xLF
SCR
firing freq.
LF
1X
2xLF
3xLF
4xLF
Radial



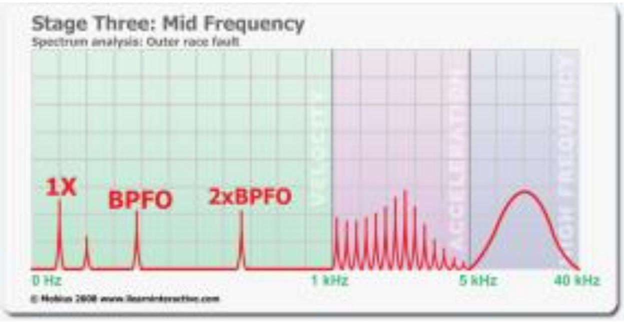




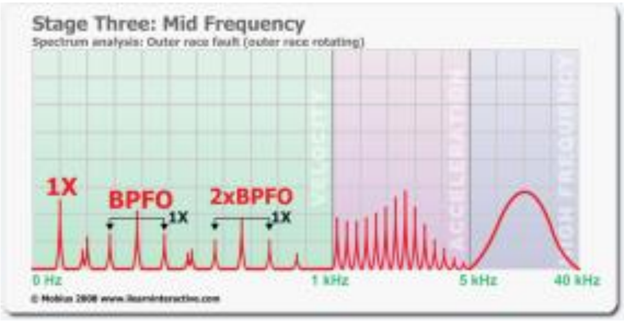
Stage One: Airborne Ultrasound, Shock Pulse, PeakVue, Spike Energy, Envelope



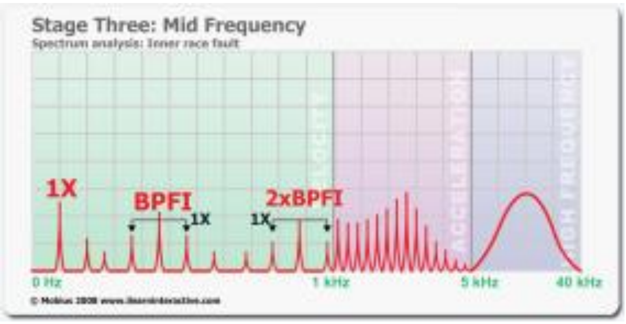
Stage Two: Envelope, Demodulation and Acceleration Spectrum



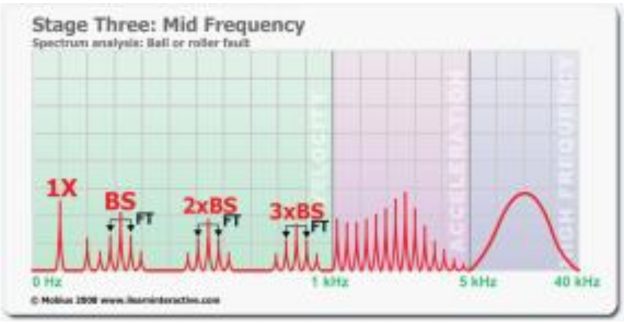
Stage Three: Outer race fault (inner race rotating)



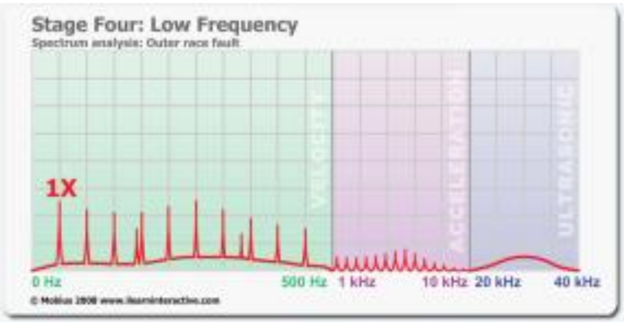
Stage Three: Outer race fault (outer race rotating)



Stage Three: Inner race fault (inner race rotating)



Stage Three: Ball or roller fault (inner race rotating)



Stage Four

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