Vibration Analyst Category I Equations

FORCES

Mass Unbalance

$$F = Me\left(\frac{2\pi N}{60}\right)^2$$

M = W/g
W = weight of rotor or balance weight, lb
e = rotor eccentricity or radius of balance weight, in
g = gravitational constant, 386.1 in/s^2
N = RPM

Spring Force

$F = Kx$

K = stiffness of spring, lb/in
x = relative deflection, in

Damping Force

$F = C\dot{x}$

C = damping constant, lb-s/in
$\dot{x}$ = relative velocity

Inertia Force

$F = M\ddot{x}$

M = mass, lb-s^2/in
$\ddot{x}$ = acceleration, in/s^2

MOTIONS

Velocity (in/s)

$V = D(2\pi f)$

D = peak displacement, in
f = frequency, cycles/s (CPS)
$\pi = 3.14$

Acceleration

$A = V(2\pi f)$

A = acceleration, in/s^2
1 g = 386.1 in/s^2

FREQUENCIES

Bearing Frequencies

$$FTF = \left(\frac{\Omega}{2}\right)\left[1 - \left(\frac{B}{P}\right)\cos CA\right]$$

$$BPFI = \left(\frac{N}{2}\right)\Omega\left[1 + \left(\frac{B}{P}\right)\cos CA\right]$$

$$BPFO = \frac{N}{2}\Omega\left[1 - \left(\frac{B}{P}\right)\cos CA\right]$$

$$BSF = \left(\frac{P}{2B}\right)\Omega\left[1 - \left(\frac{B}{P}\right)^2 \cos^2 CA\right]$$

FTF = fundamental train frequency
BPFI = ball pass frequency, inner race
BPFO = ball pass frequency, outer race
BSF = ball spin frequency
RPM = shaft speed

CA = contact angle
Ω = machine speed
N = number of rolling elements
P = pitch diameter, in
B = ball or roller diameter, in

Bearing defect frequencies are same units as machine speed

General Guideline Bearing Frequencies
(for use in FMax selection ONLY)

BPFO = 0.41 x RPM x N
BPFI = 0.59 x RPM x N
FTF = 0.41 x RPM
BSF = 0.22 x RPM x N

Natural Frequency

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

k = stiffness, lb/in
m = w/g
w = weight, lb

g = gravitational constant, 386.1 in/s^2
f_n = natural frequency of a single-degree-of-freedom system, Hz

Roll Frequency

$$f = \frac{V}{5\pi D}$$

V = web velocity, ft/min
D = roll diameter, in
f = frequency, Hz

SIGNAL PROCESSING

Dynamic Range

$$dB = 20 \log \frac{V_m}{V_r}$$

$$\frac{V_m}{V_r} = 10^{\frac{dB}{20}}$$

V_m = voltage measured
V_r = voltage reference
dB = decibels

RMS

peak = 1.414 rms

Resolution

Resolution = (frequency span x window noise factor x 2)/#FFT lines

window noise factor =
- 1.0 for uniform window
- 1.5 for Hanning window
- 3.8 for flat top window

Data Acquisition Time (DAT)

DAT = # FFT lines/frequency span

Default Frequency Spans

Operating Speed	= 10 x RPM
Rolling Element Bearings	= 10 x BPFI
Fluid Film Bearings	= 10 x RPM
Vane/Blade Pass	= 3 x # Vanes/Blades x RPM
Electrical	= 3 x 2X Line Frequency
Gear Mesh	= 3 x Gear Mesh Frequency