Vibration Institute

ANAB
ANSI National Accreditation Board
ACCREDITED
ISO/IEC 17024
PERSONNEL CERTIFICATION BODY
#0845
Vibration Analyst Certification

Vibration Analysis Certification Exam "Equation Sheets"

English Language
SI Units
Rev: 2023-06-02

Introduction:

The following pages contain a collection of equations, conversions, other vibration related information, and an instructional/example "bubble" style answer sheet. This information has been assembled primarily to aid examinees during the Vibration Institute's ISO 18436-2 based certification examinations and may also have value as a reference.

Beyond the example "bubble" style answer sheet on the last page, these "Equation Sheets" may or may not contain helpful information for examinees at the VA Category I level, however they should prove most helpful at higher VA Categories.

These "Equation Sheets" if received as a portion of a certification exam packet MUST remain with the packet and be placed into the completed exam envelope along with the exam, equation sheets, and bubble answer sheet.

These "Equation Sheets" if received as part of a Vibration Institute training course or downloaded from the Vibration Institute web site may be used freely; however they may NOT be present, may not be in your possession, nor may they used during a Vibration Institute certification examination.

The following sheets include:

- Forces
- Motions
- Frequencies
- Signal Processing
- Instructional/Example "Bubble" Style Answer Sheet

Vibration Analysis Category I & II Equations

FORCES

Mass Unbalance

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

M = kilograms
F = Newtons
e = rotor eccentricity or radius of balance weight, meters
g = gravitational constant, 9.81 m/s^2
N = RPM

Spring Force

F = Kx

K = stiffness of spring, N/m
x = relative deflection, m

Damping Force

$F = C\dot{x}$

C = damping constant, N s/m
$\dot{x}$ = relative velocity

Inertia Force

$F = M\ddot{x}$

M = mass, kg
$\ddot{x}$ = acceleration, m/s^2
F = Newtons

MOTIONS

Velocity (mm/s)

$V = D(2\pi f)$

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

Acceleration

$A = V(2\pi f)$

A = acceleration, mm/s^2
1 g = 9.81 m/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, mm
B = ball or roller diameter, mm

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, N/m
m = mass, kg
f_n = natural frequency of a single-degree-of-freedom system, Hz

Roll Frequency

$$f = \frac{16.66V}{\pi D}$$

V = web velocity, m/min
D = roll diameter, mm
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 (harmonic only)

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

Instructional / Example "Bubble" style answer sheet