Data Simulator

Better Understanding With Better Tools

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Data Simulator

- The data simulator is an Excel spreadsheet with various macros running in the background.
- This Excel sheet can simulate:
  - Compressors
    - Compressor PVs & PTs
    - Calculate Suction and Discharge VEs
    - Calculate IHP for each end
    - Simulate deficiencies
    - API Pulsation Severity
  - Engines
    - 2-Stroke & 4-Stroke PTs & PVs
    - Calculate cylinder and engine IHP
    - Simulate deficiencies
    - 1st & 2nd Derivatives
  - Vibration
    - Build a complex time waveform based on simple time waveforms
    - Calculate FFT based on the complex time waveform
    - Vibration severity chart using 1 frequency and amplitude
    - Calculate ball bearing frequencies, gear mesh frequencies and belt frequencies
    - Spectrum conversion and charts
    - Single plane balancing
    - Fault frequency summary
  - Bolt pre-stress torque table

Data Simulator
Comp PT & PV Sim

How to Read a Compressor PT / PV Card and Deficiencies

Data Inputs

K - Value	1.39	HE Clearance volume (%)	10.00	Cylinder Bore (in.)	8.5	Stroke (in.)	4.50
Specific Gravity	0.967	CE Clearance volume (%)	15.00	RPM	1200	Connecting Rod Length (in.)	13.75
Suction Temp °F	100	Suction pressure (PSIG)	100	Piston Rod Dia. (in.)	2.00	TDC Adjustment ± (deg.)	X
Theoretical Dis. Temp. °F	205	Discharge pressure (PSIG)	210				

Suction Valve	
Pressure peak (%)	4
Valve Loss (%)	3

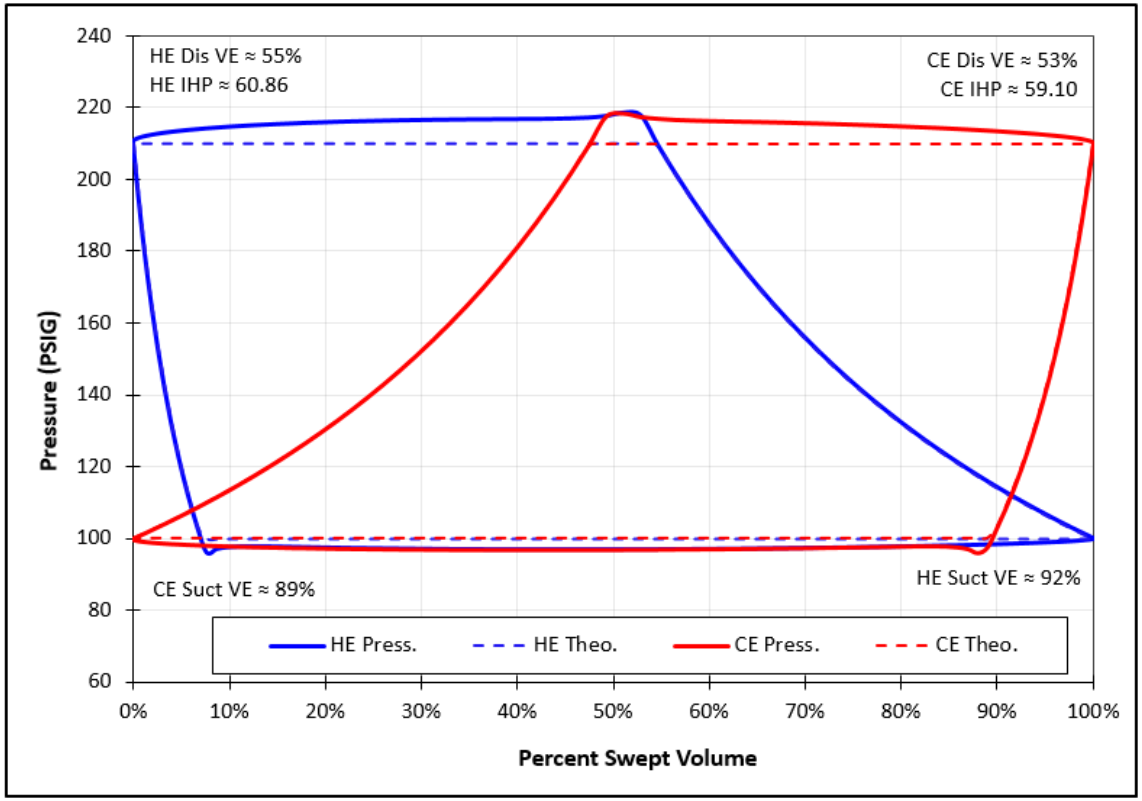
Discharge Valve	
Pressure peak (%)	4
Valve Loss (%)	3

Reset PV **Problems:**

- HE Suction valve leakage
- CE Suction valve leakage
- HE Discharge valve leakage
- CE Discharge valve leakage
- Piston ring leakage
- Pressure Packing leakage

○ PT Trace ◉ PV Card

Y-Axis Re-Scale



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Data Simulator
API 618 Worksheet

API PULSATION SEVERITY WORKSHEET

GENERAL DATA

Location:	Enter text in these type cells	Unit Type		
Date:		Rated Horsepower	BHP	
Tester:		Rated Speed	RPM	
Unit:		Load Step		

API 618 BOTTLE SIZING CRITERIA

Parameter	Units	Value	Parameter
Compressor Speed	RPM	600	Compressor Rod Size
Cylinders per Bottle	#	2	Compressor Stroke
Compressor Cyl. #1 Size	inches	5.25	Specific Gravity
Compressor Cyl. #2 Size	inches	5.25	Suction Temperature
Compressor Cyl. #3 Size	inches	0	Isentropic Exponent, "K"
Compressor Cyl. #4 Size	inches	0	
SUCTION BOTTLE DIMENSIONS/PRESSURE			DISCHARGE BOTTLE DIME
Suction Bottle Length	inches	120	Discharge Bottle Length
Suction Bottle I.D.	inches	15	Discharge Bottle I.D.
Suction Pressure	psig	1958	Discharge Pressure

Note: Enter only the cylinder sizes on the cylinders connected to the bottle bei

CALCULATED RESULTS (SUCTION)			CALCULATED RESUL
Piston Displacement/Rev.	cubic ft	0.53	Molecular Weight
Compressor Ratio		2.152	Cylinders per Bottle
Required Suction Bottle Size	cubic ft	9.6	Required Disch. Bottle Size
Actual Suction Bottle Size	cubic ft	12.3	Actual Discharge Bottle Size
Suction Bottle Condition		GOOD	Discharge Bottle Condition

MAXIMUM ALLOWABLE PULSATION AT COMPRESS

MAXIMUM ALLOWABLE PULSATION AT COMPRESSOR FLANGE

INPUT DATA

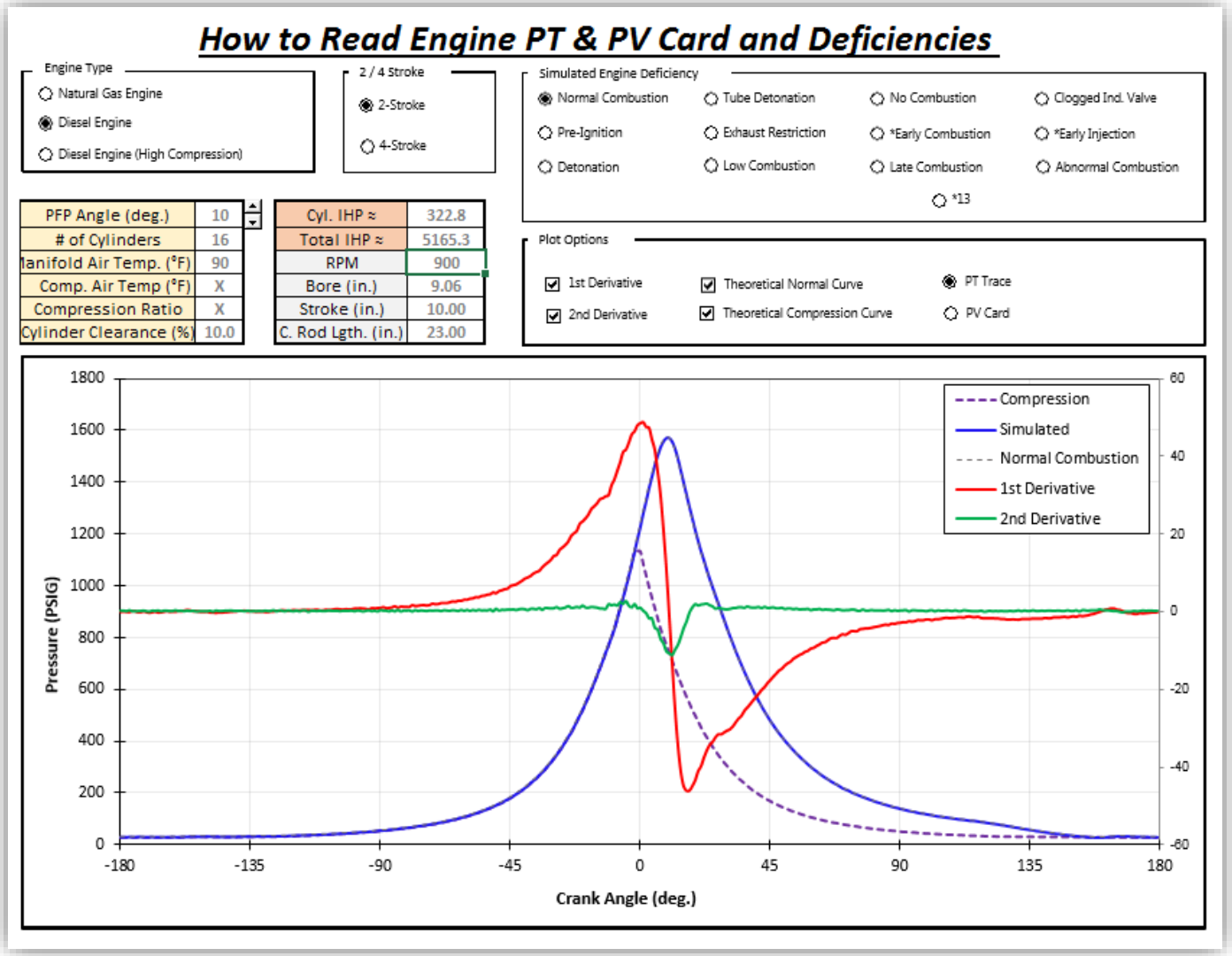
SUCTION			DISCHARGE		
Parameter	Units	Value	Parameter	Units	Value
Suction Pressure	psig	1972	Discharge Pressure	psig	3901
Overall Pressure Pulsation	psi P-P	20.0	Discharge Pressure Pulsation	psi P-P	500.0
Discrete Pressure Pulsation	psi P-P	19	Discrete Pressure Pulsation		19
at the Following Frequency	Hz	35	at the Following Frequency	Hz	35
CALCULATED RESULTS (SUCTION)			CALCULATED RESULTS (DISCHARGE)		
Method A (7% Rule)	psi P-P	139.1	Method A (7% Rule)	psi P-P	274.1
Method B (3R Rule)	psi P-P	117.5	Method B (3R Rule)	psi P-P	231.5
Suction Pulsation Limit	psi P-P	117.5	Discharge Pulsation Limit	psi P-P	231.5
Actual Suction Pulsation	psi P-P	20.0	Actual Discharge Pulsation	psi P-P	500.0
Suction Pulsation Condition		GOOD	Discharge Pulsation Condition		ABOVE 2 X API
Valve Resonance Potential	Y/N	NO	Valve Resonance Potential	Y/N	NO

MAXIMUM ALLOWABLE PULSATION AT THE LATERAL LINES

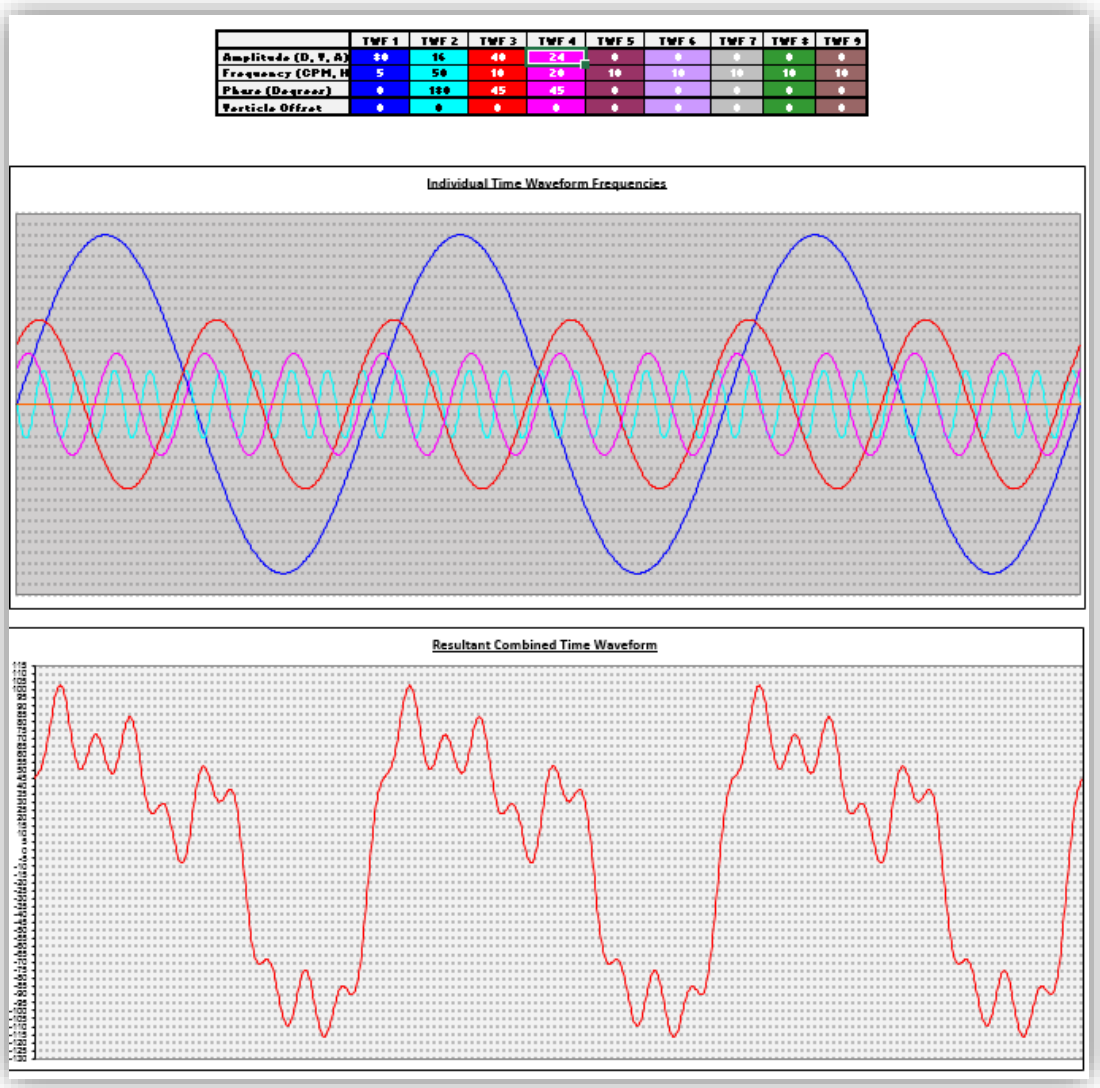
INPUT DATA

SUCTION			DISCHARGE		
Parameter	Units	Value	Parameter	Units	Value
Unit Speed	RPM	300			
Suction Pipe I.D.	inches	15	Discharge Pipe I.D.	inches	13
Suction Pressure	psig	678	Discharge Pressure	psig	937
Overall Suction Pulsation	psi P-P	5	Overall Discharge Pulsation	psi P-P	20
Discrete Suction Pulsation	psi P-P	2	Discrete Discharge Pulsation	psi P-P	10
Suction Pulsation Frequency	Hz	11	Disch. Pressure Frequency	Hz	34.18
CALCULATED RESULTS (SUCTION)			CALCULATED RESULTS (DISCHARGE)		
Average Line Pressure	psia	692.73	Average Line Pressure	psia	951.73
Overall Pulsation Limit	psi P-P	7.8	Overall Pulsation Limit	psi P-P	9.7
Overall Pulsation Condition		GOOD	Overall Pulsation Condition		ABOVE 2 X API
Discrete Amplitude Limit	psi P-P	6.1	Discrete Amplitude Limit	psi P-P	4.4
at the Following Frequency	Hz	11.0	at the Following Frequency	Hz	34.2
Discrete Pulsation Condition		GOOD	Discrete Pulsation Condition		ABOVE 2 X API

Data Simulator
Engine PT & PV Sim



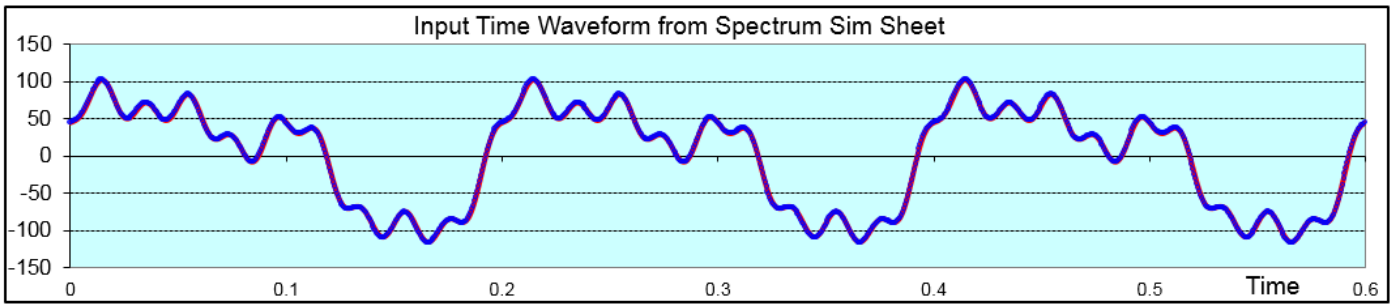
Data Simulator
Twaveform Sim

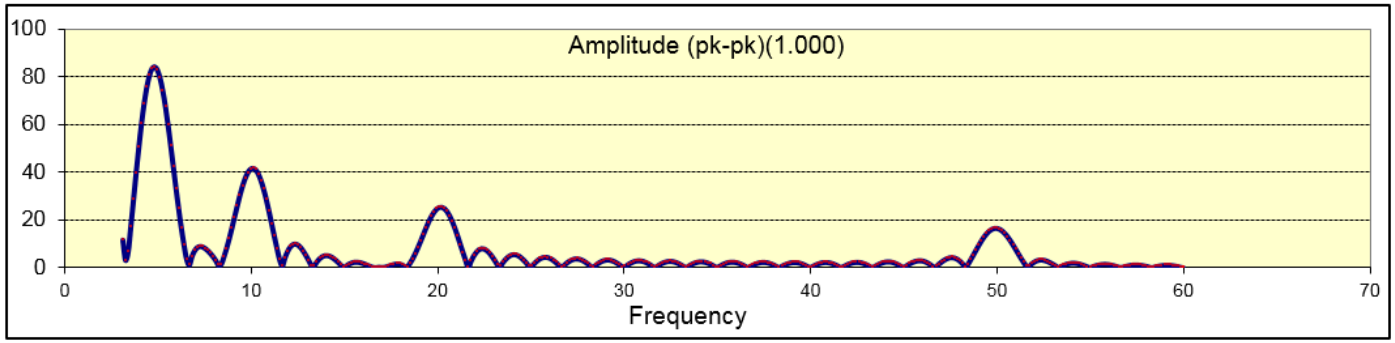


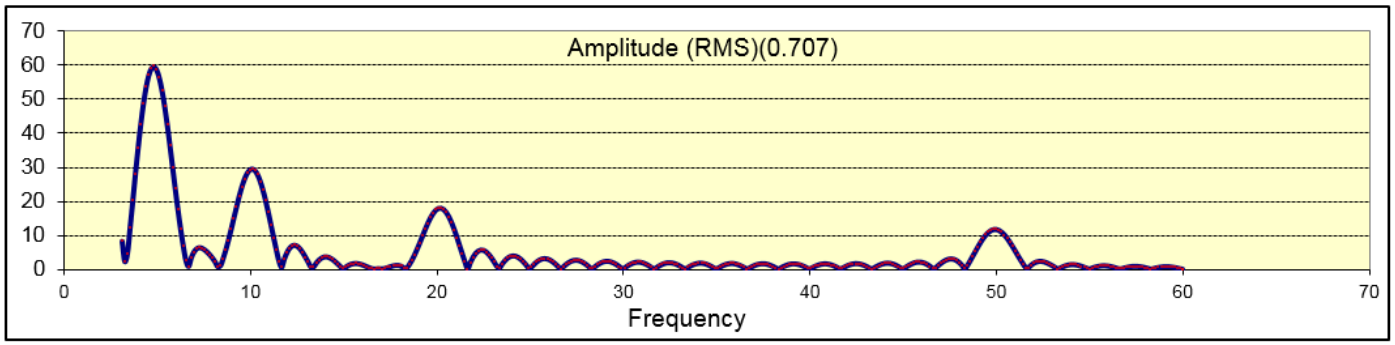
Data Simulator
FFT Spectrum Calc

Start Freq	3
Stop Freq	60
# of Points (Max = 1035)	400
Index#	400

Reset Calculate







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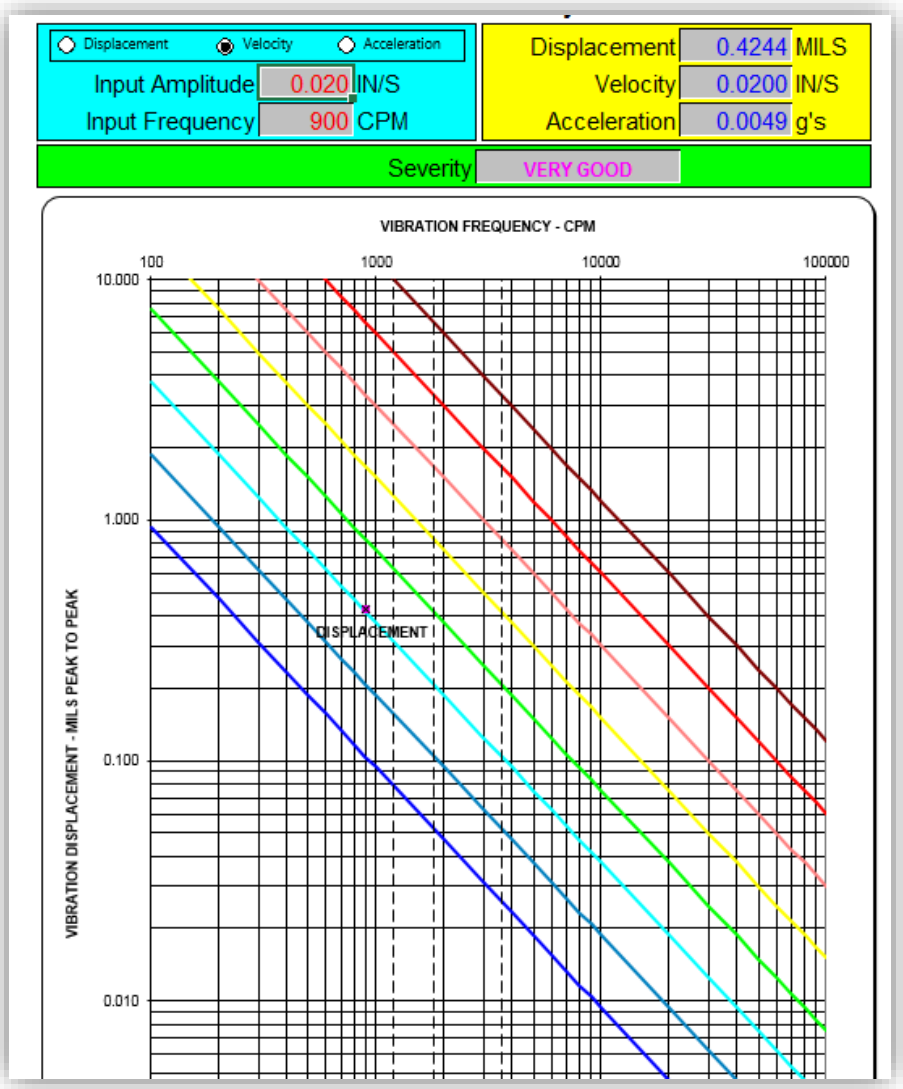
Data Simulator
Severity Chart



Data Simulator
Ball Bearings, Gears and Belts

ANTI FRICTION BEARINGS

BEARING GEOMETRY		
Nb	(number of balls)	9
S	(speed in hertz)	30
Bd	(ball diameter)	0.5
Pd	(pitch diameter)	29.11
angle in degrees		30
angle in radians		**0.5236**
RPM		**1800**

Enter bearing geometry - Requires number of balls and speed minimum

		STATIONARY OUTER RACE	STATIONARY INNER RACE
BPFO	**(Ball pass frequency of outer race (Hz)**	**114.9**	**118.9**
BPFI	**(Ball pass frequency of inner race (Hz)**	**118.9**	**114.9**
FTF	**(Fundamental train frequency)**	**14.8**	**15.2**
BSP (ball spin frequency (Hz)		**862.1**	**862.1**

UNKNOWN GEOMETRY - USES NUMBER OF BALLS & SPEED

BPFO	**(Ball pass frequency of outer race (Hz)**	**99**
BPFI	**(Ball pass frequency of inner race (Hz)**	**171**
FTF	**(Fundamental train frequency)**	**11.0**

GEARS

NUMBER OF TEETH	256
SPEED (Hz)	30
GEAR MESH FREQUENCY (Hz)	**7680**

PLANETARY GEARS

NUMBER OF TEETH - RING	50
NUMBER OF TEETH - SUN	30
NUMBER OF TEETH - PLANET	25
SPEED (Hz)	30
OVERALL GEAR RATIO	**2.6667**
SPEED OF PLANET GEAR (Hz)	**60**
GEAR MESH FREQUENCY (Hz)	**1500**

BELT FREQUENCY (CPM)	**754.0**

THE PITCH DIAMETER IS APPROXIMATELY .25 TO .50 INCH LESS

BELT LENGTH CALCULATION

CENTER TO CENTER SHEAVE DISTANCE	50
PITCH DIAMETER OF SHEAVE 1 (in.)	20
PITCH DIAMETER OF SHEAVE 2 (in.)	10
BELT LENGTH (in.)	145.6
CSI FORMULA	147.6

Data Simulator
Spectrum Conversion and Guidelines

Spectrum Course Conversion and Guidelines Spreadsheet

Usage: Input the three values in **red** (The Parameter, Amplitude, and Frequency).
The remainder of the this spreadsheet will use this information to generate all graphs and calculations.

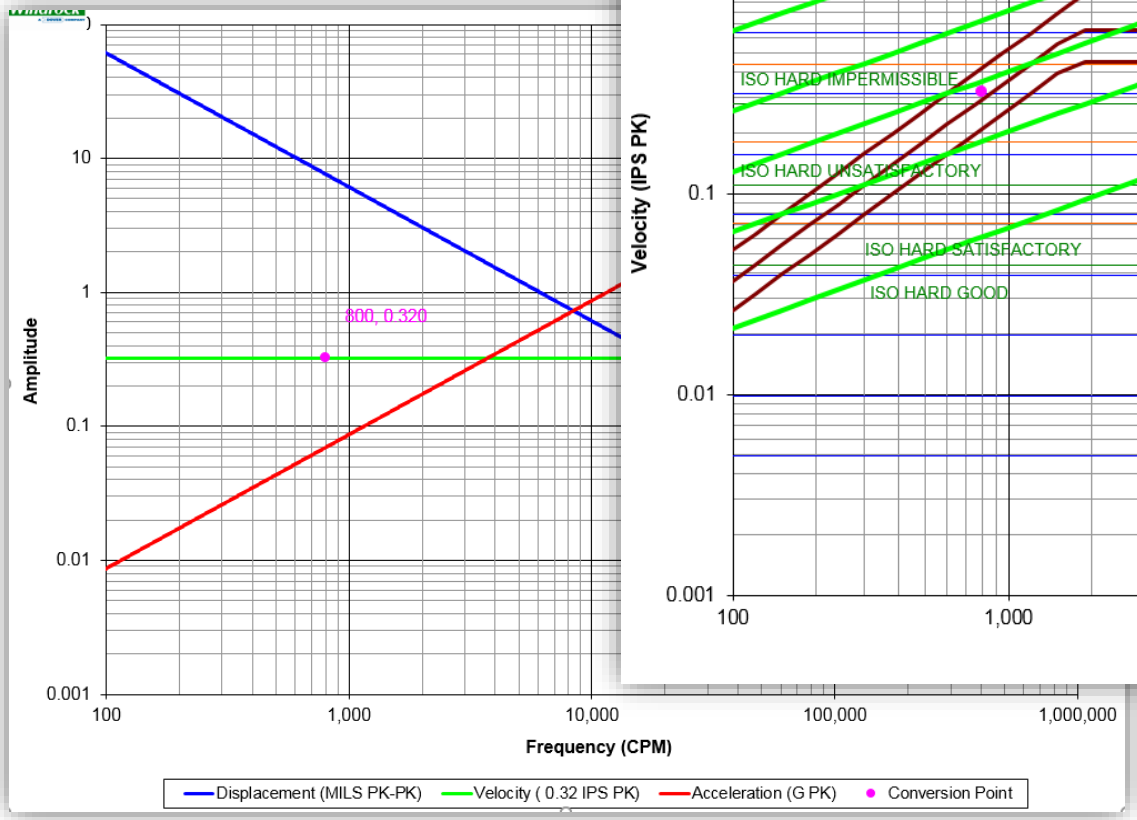
	INPUT	
Input Amplitude	0.32	IPS PK
Input Frequency	800	CPM

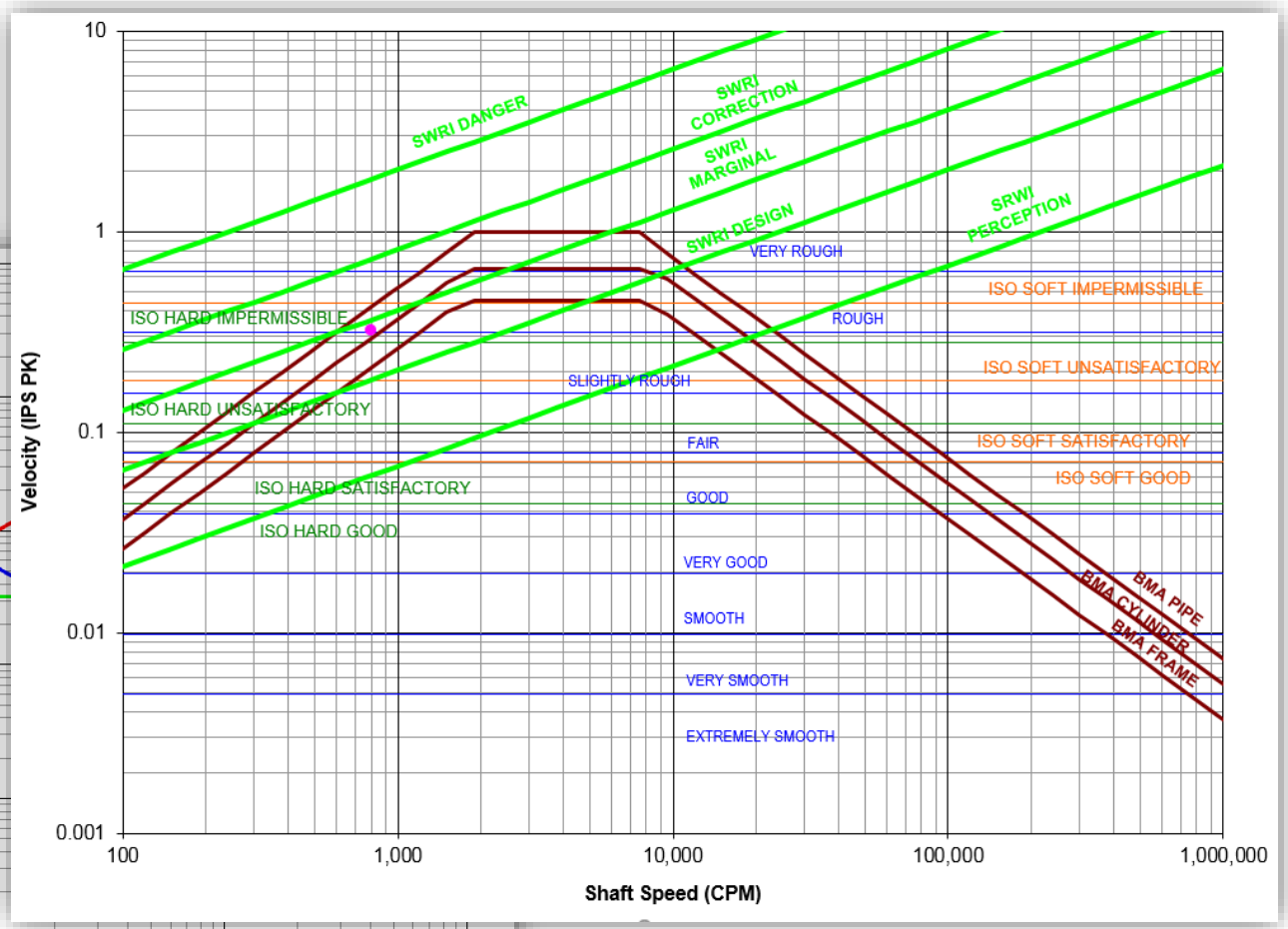
- ○ Displacement
- ◉ Velocity
- ○ Acceleration

Conversion Table				Testpoint		Indicates
Parameter	Type	Value	Units	English	Metric	
Displacement	Peak to Peak	7.639	MILS PK-PK	N/A	N/A	Stress
	Peak	3.820	MILS PK	N/A	N/A	
	RMS*	2.701	MILS RMS	N/A	N/A	
	Pseudo Peak to Peak*	7.639	MILS PK-PK	VIB, DSP	DU	
Velocity	Peak	0.320	IPS PK	IPS	MMS	Fatigue
	RMS*	0.226	IPS RMS	IPR	MMR	
	Pseudo Peak*	0.320	IPS PK	IPP	MMP	
Acceleration	Peak	0.069	G PK	G	G	Force
	RMS*	0.049	G RMS	GR	GR	
	Pseudo Peak*	0.069	G PK	GP	GP	
Guideline Severity	IRD Rotating	Rough				
	ISO Hard Support	Impermissible				
	ISO Soft Support	Unsatisfactory				
	SWRI/ASME	Design				
	BMA Frame	Danger				
	BMA Cylinder	Danger				
	BMA Pipe	Good				

*** - Assumes a simple signal with only one frequency component.**
Complex signals will result in different amplitudes.

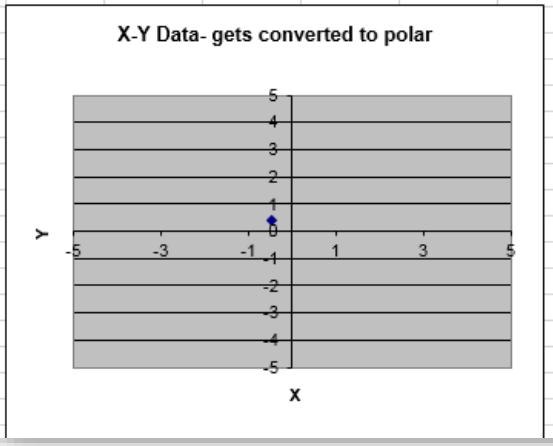
Data Simulator
Spectrum Conversion and Guidelines Associated Charts





Data Simulator
Single Plane Balancing

The amplitude and mass can be in any units, as long as you are consistant.			
R0, amplitude, unbalanced	0.3	units	Vibration amplitude reading at the rotational frequency only
R1, amplitude w/ mass on reference line	0.25	units	Same with an arbitrary mass added at an arbitrary zero line
R2, amplitude w/ mass rotated positive	0.5	units	This direction defines the positve angle, suggest 90 - 120 degrees from reference line
R3, amplitude w/ mass rotated negative	0.35	units	Shift the mass to the other side of the reference line by the same amount
Angle mass was shifted from ref line	120	degrees	120 degrees is optimum as mass locations will be equally spaced for 3 runs
X result	-0.45833		
Y result	0.408956		
U/T ratio of unbalance to test mass	1.627976		
Test mass	1	units	Could be grams, ounces or inches of adhesive weight strip
Material to be removed or added	1.6280	units	
Angle of material removal	138.26	degrees	Note we use ATAN2 here so the quadrants come out correctly
Or, angle of material addition	-41.74	degrees	
If a single removal or addition is not possible, say on a multi-bladed fan assembly, two balance weights can be calculated as follows:			
Angle away from nominal for mass 1	20	degrees	
Angle other way from nominal for mass 2	20	degrees	
Mass 1	0.866228	units	
Mass 2	0.866228	units	



Data Simulator
Fault Frequency Summary

Spectrum Fault Frequency Summary

Very Often
Often
Sometimes
Seldom
Never

	< 600 RPM	> 600 RPM & < 1X RPM	0.45X RPM	1X RPM	1.5X RPM	2X RPM	3X - 10X RPM	1X LF	2X LF	1X GMF	2X GMF	GMF Sidebands	1X - 2X MF	Belt Frequency	Ball Bearing Frequency	Bearing Energy	> 60,000 RPM	Broadband Noise	Radial	Axial
Rotor Imbalance				Very Often		Often													Very Often	Seldom
Misalignment				Often		Often	Sometimes												Often	Often
Bent Gears				Often		Often	Sometimes												Often	Often
Spur Gear Faults				Seldom		Seldom	Seldom			Often	Very Often	Very Often							Often	Seldom
Helical Gear Faults				Seldom		Seldom	Seldom			Often	Very Often	Very Often							Often	Often
Defective Ball Bearings				Seldom		Seldom	Seldom								Often	Often	Often		Often	Sometimes
Pump Cavitation																		Often	Often	Often
Pump Impeller Problems													Very Often						Often	Sometimes
Mechanical Looseness				Seldom		Often	Sometimes												Often	Sometimes
Electrical Problems				Seldom				Very Often	Very Often										Very Often	Sometimes
Piping/Mounting Resonance	Sometimes	Often		Seldom		Seldom	Seldom												Often	Often
Faulty Drive Belts														Very Often					Very Often	Seldom
Worn Journal Bearings				Seldom		Often	Sometimes												Very Often	Seldom
Oil Whirl			Very Often																Very Often	Seldom
Forced Piping/Uneven Base				Often		Often	Sometimes												Often	Often
Unbalanced Pulley				Very Often										Sometimes					Very Often	Seldom
Instrument Grounding								Seldom	Seldom										Often	Often
Resonance				Seldom		Seldom	Seldom												Often	Often
Instrument Noise	Often																		Often	Often
Pulsation				Very Often		Very Often	Often													
Cylinder Stretch				Very Often		Often	Often													
Torque Fluctuations			Often	Often	Often	Often														

Possible Malfunctions

	Motor	Fan	Pump	Turbo	Gearbox
Balance	Y	Y	Y	Y	Y
Alignment	Y		Y		
Electrical	Y				
Cavitation		Y	Y	Y	
Blade/Vane pass		Y	Y	Y	
Roller Bearing	Y	Y	Y		Y
Sleve Bearing	Y			Y	Y
Bent Shaft	Y	Y	Y	Y	Y
Gear mash					Y
Mechanical Loosness	Y	Y	Y	Y	Y
Cocked roller bearing	Y	Y	Y		Y
Belt	Y	Y			
Shive	Y	Y			
Resonance	Y	Y	Y	Y	Y
X-Talk, Process pipe			Y	Y	
X-Talk, Support				Y	
Rub	Y	Y	Y	Y	Y

Data Simulator
Band Alarm Calculator

Push to	Set Preliminary Band alarm levels for Equipment with **Roller Bearing**. Examples would be, AC and DC motors, and Gear boxe bearings.
Push to	Set Preliminary Band alarm levels for Equipment with **Sleve Bearing**. Examples would be, AC and DC motors, and Gear boxe bearings.
Push to	Set Preliminary Band alarm levels for Equipment with **Gear Boxes**
Push to	Set Preliminary Band alarm levels for Equipment with **AC Motor, Electrical**
Push to	Set Preliminary Band alarm levels for Equipment with **Pumps, Blowers, and Fans, with roller bearings.**
Push to	Set Preliminary Band alarm levels for Equipment with **Pumps, Blowers, and Fans, with sleve bearings**
Push to	Set Preliminary Band alarm levels for **Turbochargers or Turbocoolers**

This spread sheet is used to set the band starting and ending frequencies. It can help set the band alarm levels, by adjusting the percent of the overall level, if desired. These band widths, and levels are only a starting point. Use the history of the unit, while in good condition, to make the finial adjustments.

Data Simulator
Band Alarm Calculator

Input Data in Yellow

Menu

Station	Montezuma	
Unit	KVT Scav Air Fan Motors	
Test Point	Motor #1, and #2	
Vibration Type, Mills, G's, or Ips	Ips	
RPM	1195	
Overall Vibration Level	0.4	Ips
F-max	95,600	CPM
Machine Type	Roller Bearings, No vaines. Examples AC and DC motors, and Gear box bearings	

		Order's		Frequency, CPM		Level			
Band	Description	Start	Stop	Start	Stop	%of overall	Warning	Alarm	Comments
1		0.1	1.2	120	1,434	90%	0.29	0.36	Set your own alarm levels
2		1.2	2.2	1,434	2,629	30%	0.10	0.12	
3		2.2	3.2	2,629	3,824	25%	0.08	0.10	
4		3.2	12.2	3,824	14,579	20%	0.06	0.08	
5		12.2	40.0	14,579	47,800	15%	0.05	0.06	
6		40.0	Fmax	47,800	95,600	10%	0.03	0.04	
7									
8									
9									
10									

Data Simulator
Questions and Comments