OPERATOR'S MANUAL

653CS VIBRATION METER AND BEARING TESTER KIT

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412537-240 Rev. C

1st Important Notice

Because of the high sensitivity of this unit over a wide frequency range, (5 Hz to 10,000 Hz, 300 to 600,000 CPM) the following is highly recommended for all displacement (mils) readings.

1. Use the 20 or 200 mils range. The 2 mil range should only be used on finely balanced equipment, or in a laboratory environment.

2. Use the magnetic pickup clamp or the 1/4"-28 stud mount provision in bottom of pickup to mount the pickup on the machine being tested. Hand-held pickup readings taken with pencil probe may be erratic.

2nd Important Notice

This instrument is equipped with rechargeable nickel cadmium batteries.

CAUTION: Do not recharge batteries until "LO BATT" indication appears on the display.

1. You can use the instrument for approximately 2 hours after "LO BATT" appears on the display before readings become unacceptable.

2. If readings become unacceptable the instrument can be used with battery charger connected.

3. Do not use any other battery charger than the one which is supplied with your instrument.

RECEIVING AND HANDLING

PRODUCT WARRANTY

The Vitec Model 653 CS is warranted to be free from defects in material and workmanship for a period of one year from the date of shipment to the original user or 18 months from date of shipment by company to buyer, whichever period is shorter. Damage in shipment, abuse, and misuse, are not part of this warranty.

Claims of defects in this apparatus must be submitted to the company in writing in the above mentioned time period. The buyer shall be responsible for all transportation charges.

ACCEPTANCE

Vitec terms of sale are F.O.B. point of orgin, freight prepaid. Thoroughly inspect this shipment before accepting from the transportation company. If any of the packaging is damaged or the quantity listed in the bill of lading or express receipt is short, do not accept until the freight or express agent makes an appropriate notation on your freight bill or express receipt. Request him to make an inspection. Claims for loss or damage in shipment may not be deducted from the Vitec invoice, nor may payment of the Vitec invoice be withheld awaiting adjustment of such claims since the carrier guarantees safe delivery.

If damage or loss has occurred to your shipment and the situation is urgent, contact the nearest Vitec District Office for assistance.

INTRODUCTION

This manual has been prepared to instruct operating personnel in the proper operation, application, and maintenance of the Vitec Model 653 CS Vibration Meter and Bearing Tester (figure 1). In order to obtain maximum usage from the instrument, the contents of this manual should be studied thoroughly.

The Model 653 CS Vibration Meter and Bearing Tester is simple to use, and should present no problems to the operator. Any repairs or service should be performed only by qualified personnel or by a Vitec service representative.

MODEL 653 CS VIBRATION METER AND BEARING TESTER

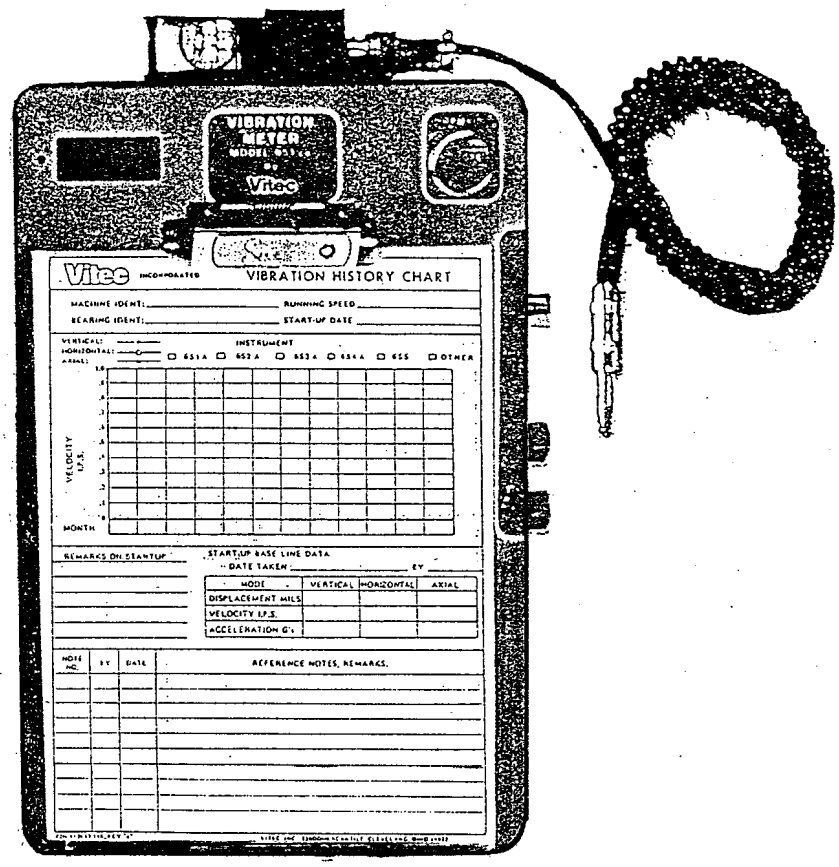


FIGURE 1

DESCRIPTION

GENERAL

The Vitec Model 653 CS Digital Vibration Meter and Bearing Tester (fig. 1) is a portable instrument intended for general purpose vibration measurements. The Model 653 CS is packaged in a clipboard which allows vibration readings to be recorded much easier than was possible before. The unit is ideally suited for performing in-plant product testing, machinery start-up and checkout, and in preventive maintenance programs.

The Model 653 CS responds to vibration in units of displacement (mils), velocity (inches/second), and acceleration (G's). The meter used with its associated high output accelerometer is capable of making accurate vibration measurements over a frequency range of 300 CPM to 60,000 CPM (cycles per minute).

The basic controls necessary for operation of the Model 653 CS are located on the right hand side of the instrument.

The Model 653 CS is powered by a Ni-Cad battery pack assembly.

The Model 653 CS adds a Bearing Test mode to the standard measured modes to detect possible upcoming anti-friction bearing (ball, roller) and gear problems.

The principle of operation of the Bearing Test mode of the 653 CS Meter is quite simple. It is a commonly accepted fact that faulty bearings ("Bearings" include only anti-friction type bearings [ball, roller, tapered roller, etc.]) and gears generate a high frequency vibration signal that can be 20 to 50 times (or more) the rotating speed of the machine. The Bearing Test Mode of the Model 653 CS allows the user to measure this high frequency component of vibration, while ignoring the lower frequencies of vibration normally associated with common problems such as unbalance, misalignment, etc.

VIBRATION LEVEL READOUT (fig. 2)

The vibration level is easily read on the large LCD (Liquid Crystal Display) on the face of the meter. The meter will read out directly in mils, inches/sec., or G's depending upon the setting of the mode switch. The direct readout display eliminates the need for multiple scales or scale multipliers. Should the vibration level be higher than the range selected, the last three digits of the display will be blanked out to indicate an "over ranged" condition.

The LCD display also provides a "Lo Batt" display in the upper left hand corner of the display when the batteries are low and should be recharged. Readings can, however, be taken for approximately 2 hours after the "Lo Batt" indication first appears. Use of the unit beyond this period may result in faulty or incorrect readings.

DESCRIPTION (Continued)

IMPORTANT - As with all Ni-Cad batteries, recharging before required will decrease the duration which the unit can hold a charge. Therefore care should be taken to recharge only when indicated by "LOW BATT " lite on LCD.

MODE SWITCH (fig. 2)

The Mode Switch selects the mode of vibration to be measured. The vibration can be measured in acceleration, velocity, or displacement (refer to application section). Merely turn the selector switch to the mode desired.

The "OFF" position of this switch shuts off power to the instrument (the instrument must be in this position when not being used to prevent battery drain.)

RANGE SWITCH (fig. 2)

The range switch selects the full scale range for the vibration mode being measured, and causes the decimal point to be located on the display accordingly.

NOTE: If no prior readings or typical levels are available it is advisable to start in the G's mode, 200 range, and select lower ranges as needed until the meter reading is .1 or more. Use of this procedure will help to eliminate over-range errors.

OUTPUT JACK (fig. 2)

The Model 653 CS has a BNC type connector on the side which provides an A.C. signal representative of the actual A.C. vibration signal. The calibrated output is representative of the actual waveform seen by the transducer.

IMPORTANT: Because of the high sensitivity accelerometer used with the Model 653 CS Meter, the selection of the proper range is very important in order to obtain an accurate reading.

To assure proper range position, a reading position will establish the lowest range that can be used in the velocity or displacement mode. Of course, higher ranges can always be used, and can, in fact, verify that the proper minimum range selected was correct.

"INPUT SIGNAL" JACK

The input signal jack receives a 1/4" phone plug (heavy duty), which is used to feed the transducer signal into the system.

NOTE: In order to assure data integrity, the plug must be fully inserted.

DESCRIPTION (Continued)

VIBRATION TRANSDUCER (Pickup)

The transducer, (pickup), converts the mechanical vibration being measured into an electrical signal which is transmitted to the vibration meter. The high sensitivity accelerometer used with the Model 653 CS provides very accurate measurements over a wide range of frequency measurements, (300 to 60,000 CPM).

NOTE: Specially calibrated Model 653 CS meters are available to measure frequencies as low as 120 CPM.

The 1/4"-28 x 1/4" deep tapped hole in the bottom of the transducer is provided for installation purposes. To assure accurate and repeatable readings, a 1/4"-28 stud (i.e. a 1/4"-28 x 1/2" setscrew, available from local suppliers) should be installed in the bearing cap or other monitoring site, so that the transducer may be quickly and rapidly installed when measurements are to be taken.

The pencil probe or magnetic mount supplied with the instrument may be used for non-precision or survey type measurements. A vice-grip type clamp is also available as an optional accessory for similar applications.

DESCRIPTION (continued)

BEARING TEST

Procedure

1. It is recommended that vibration readings be taken in the acceleration, velocity and displacement modes prior to taking readings in the bearing test mode. This procedure will bring attention to unacceptable vibration levels due to common problems noted above.

2. Turn the mode switch to the "Bearing Test" position and tune the "RPM" dial to the rotating speed of the machine being tested. The meter will then indicate only the high frequency component of vibration normally associated with faulty gears or bearings (the Model 653CS will filter out all vibration frequencies up to the fifth harmonic of the speed set on the "RPM" dial.). The higher the reading, the higher the destructive energy that is being generated by these high frequency problems.

3. The following values taken in the bearing test mode can be used as a "rough" estimate of the bearing condition. Do not use these values as absolute values, as the bearing geometry (inner to outer race diameter ratio, shaft size, rolling element type, rolling element size, etc.) can affect these values.

Bearing New:	.3 to .6 G's
Bearing in service, good:	.5 to 1.0 G's
Bearing with defects:	1.5 to 2.5 G's
Bearing shutdown:	3 to 6 G's
Bearing failure:	8 to 12 G's

4. Although the above values are only general, absolute values for a certain size and type of bearing in a specific machine can be determined by accurately recording a history of the "Bearing Test" values of vibration until a visual inspection of the bearing is done. The condition of the bearing can then be referenced to the "Bearing Test" readings, and can be used as a gauge for evaluating the condition of the bearing for future readings.

Should you have any questions concerning the use of the Model 653 CS Vibration Meter and Bearing Tester, feel free to contact Vitec's home office at any time (1-216-464-4670).

DESCRIPTION (Continued)

EXAMPLES

The following data represents reading taken on bearings with various defects. The bearings were mounted in a test fixture so that the predominant cause of vibration was due to the bearing only.

BRG	CONDITION	ACCEL. G's	VEL. In/Sec	DISPL. Mils	BRG TEST G's
A	New	.10	.06	1.40	.10
B	Narrow nicks in outer race	1.95	.08	1.50	1.8
C	Wide groove outer race/ball nicks	2.50	.09	1.34	2.3
D	Good used brg.	.12	.05	1.30	.12
E	Defective Ball/ Groove in race	1.30	.08	1.71	.90
F	Excessive Clearances	4.18	.13	1.40	3.9

It is obvious from the above examples that the displacement mode of measurement is entirely ineffective in detecting bearing problems. The velocity mode indicates a relative difference between good and bad bearings, but not a significant difference. The bearing test mode, however, shows bad bearing readings of up to 40 times larger than readings taken on a good bearing. (e.g. Bearing F vs. Bearing A) NOTE: Because the defective bearings were the only major cause of vibration, the G's readings are approximately the same as the bearing test mode of measurement. When other problems exist, such as unbalance, this will not be the case.

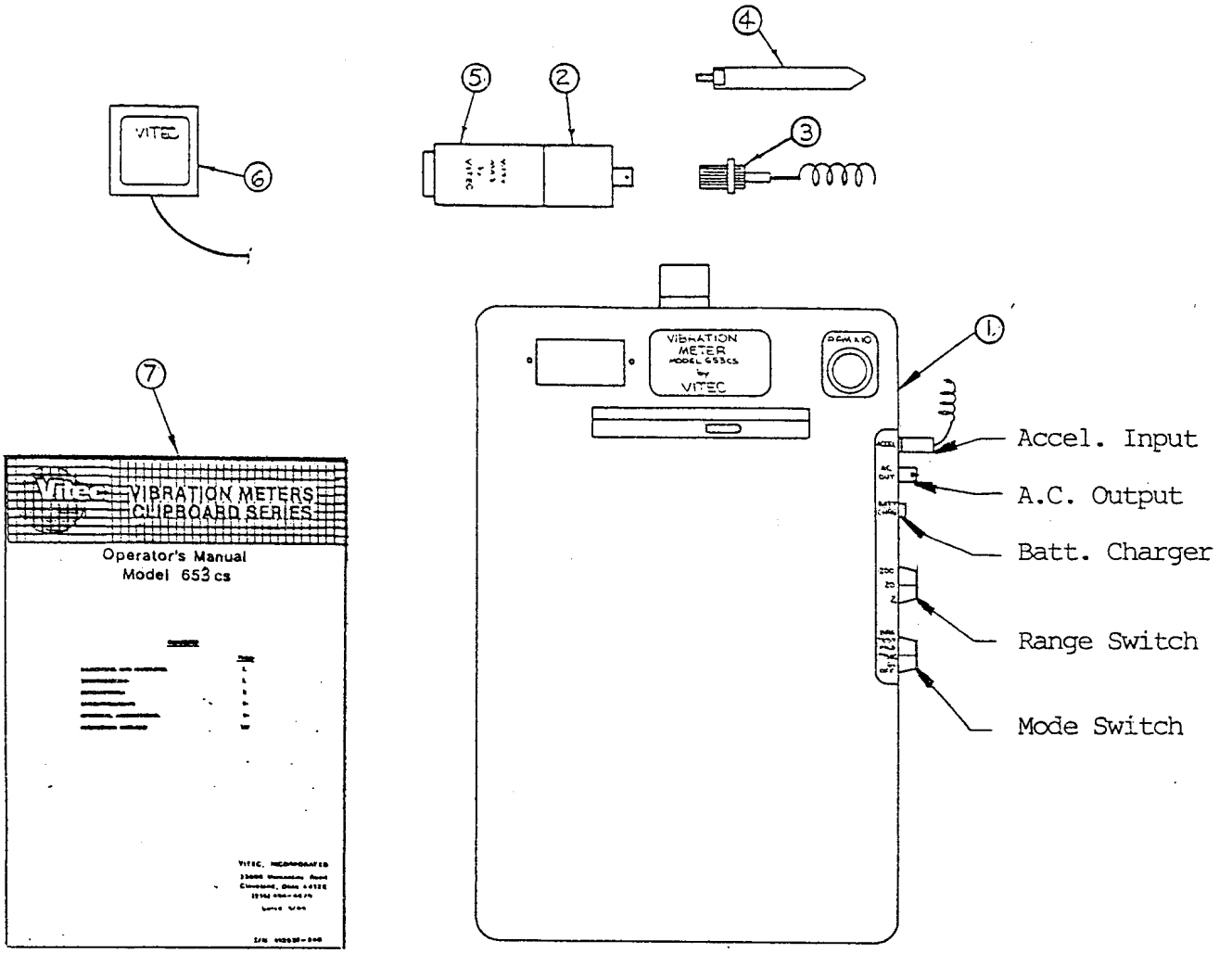


FIGURE 2

YOUR VITEC MODEL 653 CS VIBRATION METER KIT INCLUDES:

1.) Model 653 CS Vibration Meter
2.) Accelerometer Pickup, Model 4071
3.) Coiled Pickup Cable
4.) Pencil Probe
5.) Mity Mag
6.) Battery Charger
7.) Instruction Manual

SPECIFICATIONS

Modes:	Displacement, Velocity, Acceleration
Full Scale Ranges:	0-2, 20,200 in all three modes
Accuracy:	± 5% from 5 to 1000 Hz (300-60,000 rpm) Note: Specially calibrated units available for ± 5% 2-1000 Hz (120-60,000 cpm)
Meter:	Large easy to read LCD digital display
Pickup:	Piezoelectric accelerometer with Coiled Cable.
Batteries:	Ni-Cad Rechargeable Battery pack
Battery Life:	Approximately 40 Hrs. "LO BATT" appears in LCD display when battery level gets low.
A.C. Output:	Side mounted BNC output jack provides a calibrated A.C. signal proportional to mode and range selected.
Operating Temp:	33°F to 150°F
Weight:	3 Lbs.

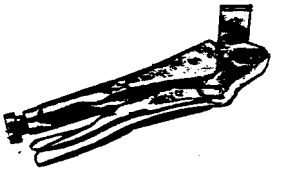
OPTIONAL ACCESSORIES

Several accessories are avialable to make the Model 653 CS Meter easier to use: They are:

UNIVERSAL VISE GRIP CLAMP (fig.3) allows for direct clamping of accelerometer to surface being measured. Ideal for clamping pickup to non-magnetic or irregular surfaces. Ask for P/N 602885-11RB.

VIBRATION HISTORY CHART (fig. 3) is a preprinted form for recording vibration levels for predictive maintenance. Ask for form 412512-110.

UNIVERSAL VICE GRIP CLAMP



VIBRATION HISTORY CHART

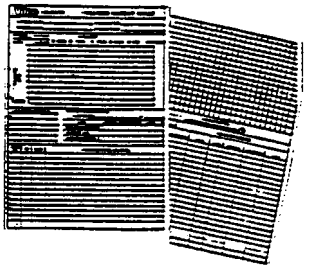


Figure 3

TYPICAL APPLICATIONS

1. Preventive Maintenance - Probably the most useful application of this instrument. When used to make periodic measurements, data comparisons can be made which will detect an increasing trend in vibration. This further investigation can be made to determine the exact nature of the problem area. (A useful tool for complete analysis and/or dynamic balance is the Vitec Balance Analyzer.)

2. Field Service - With a few simple measurements, a field service engineer can determine the amount of vibration. This can avoid costly shut-down to inspect parts needlessly.

3. Incoming Inspection - Vibration tolerances are often included in specifications for purchased parts to prevent excess vibration in final products. The Model 653 CS is ideally suited for receiving or assembly line inspection.

4. Final Assembly Test - Vibration tests on finished products can be made prior to shipment to assure compliance with production quality standards.

OPERATIONAL DETAILS

GENERAL

One of the primary uses for the Model 653 CS Vibration Meter and Bearing Tester is to measure machinery vibration over a period of time. An increasing trend in the amount of vibration detected is a good indication that the machine will soon need repairs because of bearing wear, loose or worn internal parts, or a general condition of unbalance. Early scheduling of such repairs will often result in avoiding costly, non-scheduled down-time caused by failure of a defective component.

If vibration exceeds allowable limits the machine should definitely be inspected for the cause of trouble.

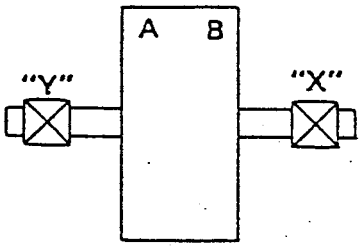
The best point on a machine to measure vibration is on the bearing housing. If bearing housings are not readily accessible, place the pickup on a nearby associated support or structure. See Figure 4 examples.

Keep in mind, however, that excessive vibration detected at a bearing housing may not mean that the cause is a faulty bearing. For example, a loose rotor component in a motor or generator can result in vibration that would be transmitted along the rotor shaft to the bearing housing.

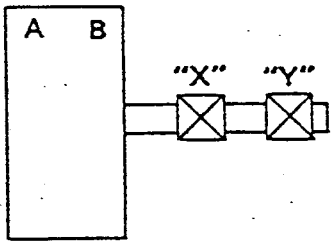
VIBRATION TOLERANCES

The allowable limit of vibration which can be tolerated in a machine depends on many factors, including:

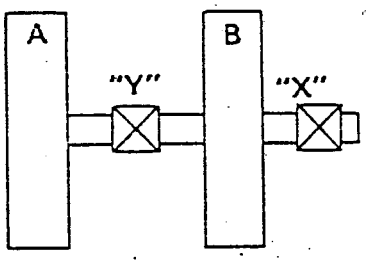
1. The product desired from the machine. (grinding and finishing)
2. Stiffness of the bearing supports and the base.
3. Alignment of the couplings and bearings.
4. Operating speed as related to resonance and critical speed.
5. Transmitted vibration from other sources.



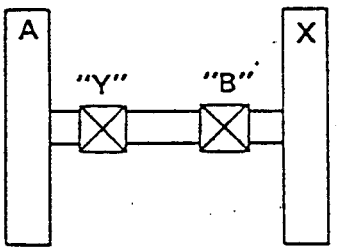
SUSPENDED ROTOR
Readings taken for Plane "A" at Bearing "Y".
Readings taken for Plane "B" at Bearing "X".



OVERHUNG ROTOR
Readings taken for Plane "B" at Bearing "X".
Readings taken for Plane "A" at Bearing "Y".



COMBINATION OVERHUNG SUSPENDED ROTOR
Readings taken for Plane "A" at Bearing "Y".
Readings taken for Plane "B" at Bearing "X".



DOUBLE OVERHUNG ROTOR
Readings taken for Plane "A" at Bearing "Y".
Readings taken for Plane "B" at Bearing "X".

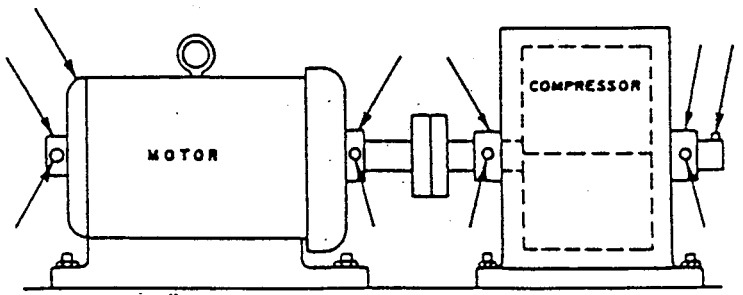


Figure 4. Points for Measuring Vibration (Example).

Machine products tested satisfactorily for allowable vibration limits during manufacture may offer different results when the same tests are performed under actual field installation and operating conditions. For this reason, it is sometimes difficult for a manufacturer to supply standard allowable limits of vibrations for each item delivered. However, tentative guides can be set up for certain types of machinery listing vibration tolerances as a standard for comparison.

Effective guidelines for your particular applications can only be established through your own experience.

TAKING MEASUREMENTS

Hold the pickup probe against the machine... preferably the bearing housings. Take readings with the pickup in both vertical and horizontal plane with respect to the machine. An axial measurement is also recommended if obtainable. Record readings for future reference.

Be sure to apply enough pressure to the pickup to maintain solid contact with the machine and to prevent the probe from chattering. The pickup should be held perpendicular to the rotating shaft of the machine. Be very careful to take successive or future readings for trending or comparison at the same location on the machine. Readings taken at different points on the machine being measured cannot be used for measuring changes in vibration levels.

NOTE: Although the pencil probe is most useful for spot-checking and diagnostic survey applications, it is generally more advisable to use a mounting stud, for purposes of long term history and analytical work.

MEASURING DISPLACEMENT

Measuring vibration in a peak-to-peak displacement mode results in detection of actual physical displacement or movement of the surface to which the pickup is attached. The vibration is measured in mils pk. to pk. (1 mil = .001").

MEASURING ACCLERATION

Measuring vibration in the peak acceleration mode results in detection of the rate of change of velocity, or how fast a surface is accelerating with respect to a fixed reference. The acceleration is measured in terms of peak acceleration or "G's". One G = 386 Inches/Sec^2.

The acceleration mode of measurement is especially effective in detecting small displacement, high frequency vibration such as would be produced by antifriction bearings, gears, etc. For example - - - a very small displacement of .01 MILS (.00001") occuring at 60,000 cpm produces an acceleration signal of .51 G's. Obviously a .0001" signal is hard to measure, but a .51 G signal would be easy to measure.

CROSSOVER FREQUENCY ANALYSIS

"Cross-over Frequency" analysis gives an easy indication of how a machine is performing.

First, measure the "broad band" measurement of MILS. Without changing the location of the pickup, take a reading in velocity (in inches per second). Now use the nomograph printed (fig. 5) to see where these points "cross-over".

If the cross-over point had been higher than rotational (2 MILS and 0.6 IN/SEC, for example, which gives a cross-over frequency of approximately 5500 cpm), there would probably be looseness or possible misalignment. This is because the wave form of the vibration would not be a sine wave but instead would be a distorted shape having high frequency harmonics. This condition is much more harmful to the machine than the simple sine wave motion.

If the cross-over point is lower than rotational speed, such items as oil whip (foaming) or structural resonance may be the cause. These are also more potentially damaging than plain imbalance.

A rule-of-thumb says that if the cross-over frequency is greater or lesser than rotational frequency (plus or minus 10%) further investigation using a Vitec Analyzer should be done.

A similar cross-over analysis using acceleration and displacement will indicate and be more sensitive to problems of a high frequency nature.

MEASURING VELOCITY

Measuring vibration in the peak velocity mode results in detection of the rate of change of displacement. This vibration is measured in terms of peak velocity or IN/SEC peak. Refer to Figure 4a example.

Velocity is a function of both displacement and frequency, and therefore will have additional sensitivity to higher frequency vibration. For example, a 1 MIL displacement will have the same vibration meter reading at 1000 cpm as at 10,000 cpm. The velocity for 1 MIL at 100 cpm is .052 IN/SEC, while at 10,000 cpm, the velocity is .52 IN/SEC, or 10 times larger. (The latter being a truer indication of force.)

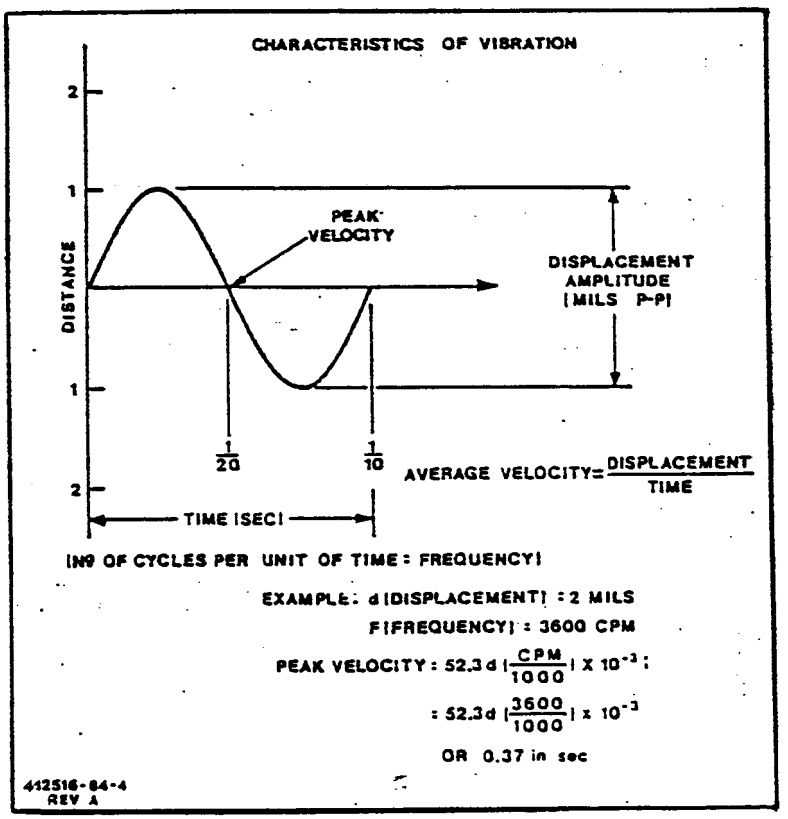


Figure 4a

CIRCUIT DESCRIPTION

The Model 653 CS uses four amplifier stages. A6, in conjunction with the range switch, determines the operating range of the instrument. A5 is an A.C. integrator circuit, which integrates the acceleration signal to obtain velocity. A3 is also an A.C. integrator, which integrates the velocity signal to obtain displacement. A 5 Hz., 12 db octave high pass filter A4 precedes the displacement integrator to reduce the noise when measuring displacement. Amplifier A1B is a voltage buffer providing low impedance A.C. output at the BNC.

U1 is a true RMS to D.C. converter which supplies the input signal to the A/D converter, U1 (located on the display board). U1 is an A/D converter and LCD driver chip which drives LCD1 (also located on the display board).

U3 in conjuction with the range switch establishes the decimal point for the LCD display.

U2 is a low voltage sensing circuit which automatically senses the low voltage condition of the batteries and displays a "LO BATT" condition on the LCD. Typical battery life is approximately 40 hours.

CHECKING CALIBRATION

I. ACCELEROMETER

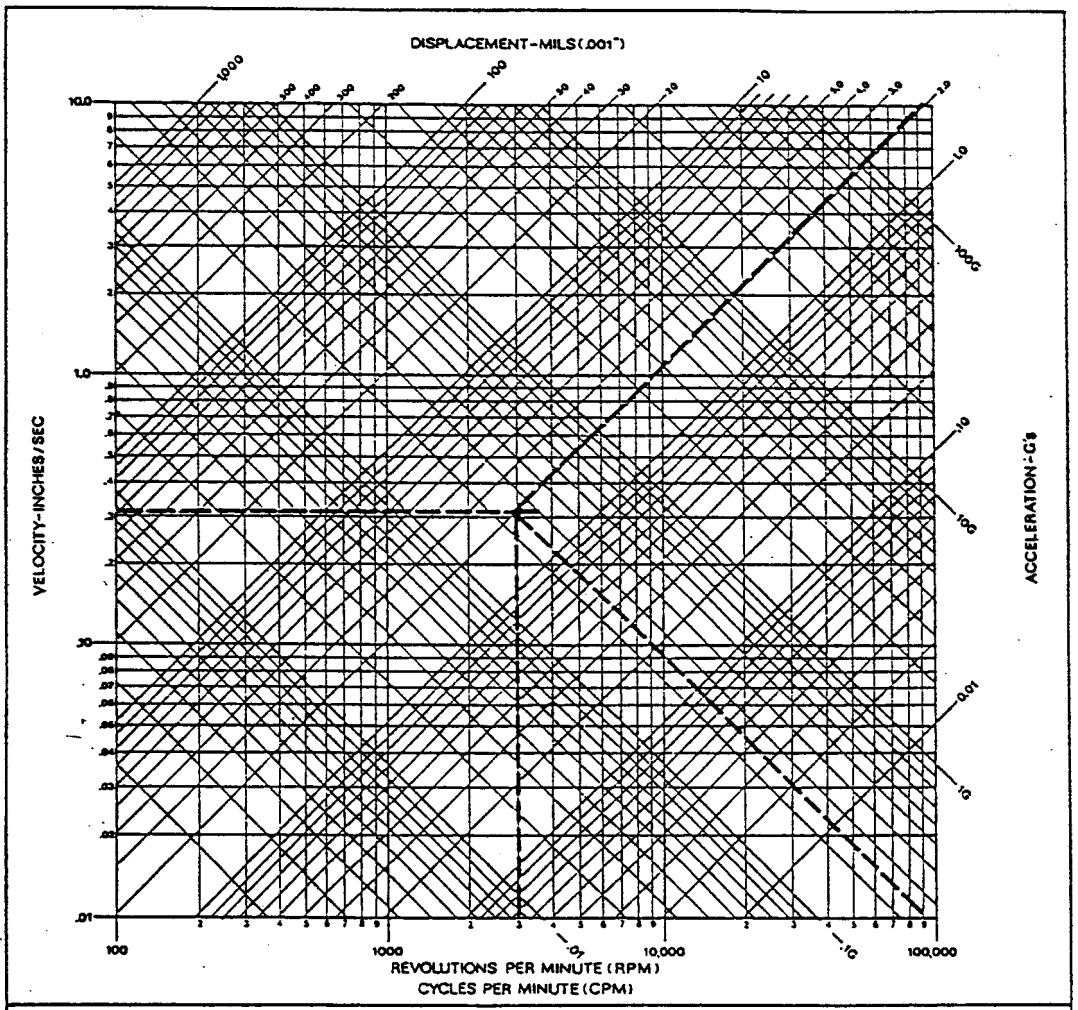
The calibration of the accelerometer can only be verified on a shaker table. Please contact factory.

II. MODEL 653 CS

The calibration of the M653 CS can be checked by removing the accelerometer from the cable and applying a 70.7 MV RMS signal @ 100 Hz to Pin "C" of the cable plug, using Pin "A" for signal common. Turn Mode switch to "G's", reading should be 1G. Turn Mode switch to "IN/SEC", reading should be .614 IN/SEC. Turn Mode switch to "MILS", reading should be 1.96 MILS. If your instrument does not give you these readings, consult factory.

Sample: Shaft Speed is 3000 RPM
Displacement Reading is 2 mils
Velocity Reading is 0.3 in/sec.

Go from left to right across the 0.3 in/sec. until it crosses the 2.0 mil line. From the point where they cross, go straight down and read the CPM. In this case, it is about 3000 CPM. Since this is almost shaft speed, it is probably the result of unbalance.



CONVERSION FORMULAS

Symbols:
D = Displacement: Inches peak to peak
d = Displacement: Mils peak to peak
V = Velocity: Inches per second peak
A = Acceleration: G's peak
Hz = Cycles per second
CPM = Cycles per minute

$D = 0.318 \frac{V}{Hz}$
$D = 19.607 \frac{A}{(Hz)^2}$
$V = \pi(Hz)(D)$
$V = 61.440 \frac{A}{Hz}$
$A = 0.051 (Hz)^2 (D)$
$A = 0.016 (V)(Hz)$

$d = (1.910)(10^4) \frac{V}{CPM}$
$d = (7.059)(10^7) \frac{A}{(CPM)^2}$
$V = (5.236)(10^{-5})(CPM)(d)$
$V = (3.696)(10^3) \frac{A}{CPM}$
$A = (1.417)(10^{-3})(CPM)^2 (d)$
$A = (2.704)(10^{-4})(CPM)(V)$

EXAMPLE: 2.00 Mils at 3000 RPM
By Chart V = 0.3 inches per second
A = 0.25 G's
By Formula V = $(5.236)(10^{-5})(3000)(2.00)$ = 0.31 inches per second
A = $(1.417)(10^{-3})(3000)^2(2.00)$ = 0.26 G's

Vibration Nomograph

Figure 5

APPENDIX

4071 ACCELEROMETER INSTALLATION AND SPECIFICATIONS

Vitec, Inc.

4071 ACCELEROMETER INSTALLATION AND SPECIFICATIONS

APPLICATION

The 4071 Accelerometer is a high quality transducer used for general purpose machine vibration measurement. It has a 100 mV/G output that can be used with cable runs of up to 1,000 feet, and is suitable for use in temperatures up to 180°F.

INSTALLATION, ELECTRICAL

Cable Type: Use high quality, twisted, shielded cable between the transducer terminals and monitor terminals. Use of Vitec supplied cable assemblies is recommended.

Cable Length: Transducer to monitor cable length should not exceed 1,000 ft.

Cable Splicing: If cable splices are made, complete shielding must be maintained.

Cable Routing: Proper cable routing is required to avoid false signals being introduced into the measuring device (monitor). Avoid running accelerometer wires adjacent to, or parallel to, AC power lines. Where possible, provide a separate, grounded conduit to enclose the accelerometer cable. Route cable away from radio transmission equipment, motors, generators, and transformers. Avoid running cable through areas prone to ESD (Electro Static Discharge) or EMI (Electromagnetic Interference).

Cable Grounding: Connect the cable shield to a good, earth ground connection, at one end only (preferably at the monitor end of the cable). Vitec monitors provide this connection as a terminal block connection point.

INSTALLATION, MECHANICAL

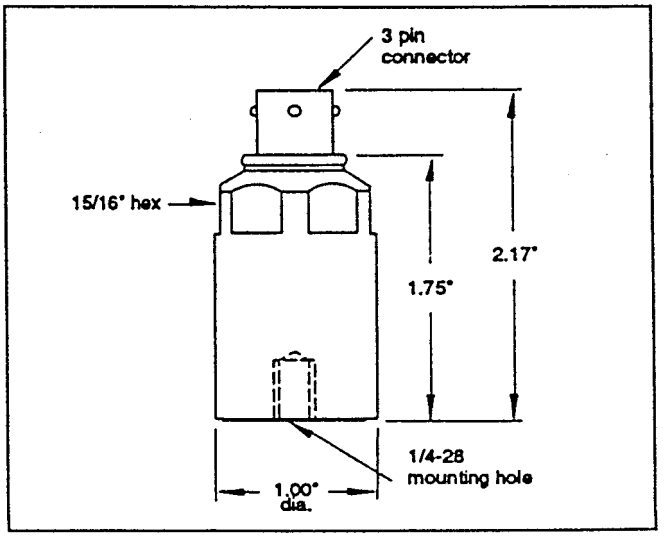
Location: Mount on, or as close as possible to, the bearing being monitored. Preferable mounting location is on the bearing cap.

Direction: The accelerometer is only sensitive to vibrations that are occurring in the direction of the transducer's axis (the imaginary line running through the center of the connector and the mounting stud). Therefore, mount the transducer in a direction that will sense the vibrations to be measured.

Operating Position: The 4071 Accelerometer can be mounted in any position, there are no mounting position restrictions.

Surface Preparation: The mounting surface must be flat and smooth. For best results, mounting surface should be flat to within 0.001 in TIR (Total Indicated Runout) over the full base dimension of the transducer, with a minimum 63 μin finish.

Stud Mounting: If stud mounting is used, drill and tap the mounting point for a 1/4-28 UNF stud, with a minimum thread depth of 3/8 in.



SPECIFICATIONS

Dynamic:	
Output, mV/G, +/- 5%	100
Dynamic Range, Gs, peak	0.01 to 60.0
Frequency Response, Hz, +/- 5%	2.1 to 3,500
First Mounted Resonant Frequency, KHz	≥ 7
Transverse Axis Sensitivity, % maximum	5
Shock Level, Gs maximum, peak	5,000

NOTE: When this transducer is used with either a 653 Vibration Meter and Bearing Tester or 654 Vibration Meter and Mini Analyzer, the frequency response range is limited to 5.0 to 1,000 Hz by the 653 and 654 electronics.

Electrical:	
Power Requirements, volts DC	8 to 30
Current Draw, mA	1.0 to 20
Connections (Connector): Pin A Pin B Pin C	 0 Volts + Volts Signal

Environmental:	
Temperature Range, °F	-58 to 180
Humidity Limit, % relative	100

Physical:	
Vitec Part No.:	412790-39A
Weight, oz.	3.4
Case Material	Stainless Steel
Dimensions: Height, inches Body Diameter, inches Center Mounting Hole Wrench Flats, inches, at top	 2.18 1.00 1/4-28 UNF x 3/8 in Deep 15/16
Mating Cable Assembly	Varies with application, contact factory

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