instructions for

MODEL VI-90
Vibration Integrator
Operators Manual

MODEL VA-508C
Vibration Measurement System

QUEST® TECHNOLOGIES

58-655
Rev. B
7/99

Model VI-90 Vibration Integrator
Model VA-508C Vibration Measurement System

GENERAL DESCRIPTION

Measurement of vibration is used in engineering and research work, noise control, machinery acceptance tests, quality control, preventive maintenance, and product insurability tests.

The VI-90 Vibration Integrator is an electronic module that buffers and converts the signal of an accelerometer (vibration sensor) in order to measure the three components of vibration: displacement, velocity and acceleration. The integrator, together with an accelerometer and readout meter, provides a quick, precise way to measure and analyze all types of industrial vibration.

The Model VA-508C measurement system can be used with any of the following Quest Sound Level Meters:

Models 1700, 1800 or 1900 Precision Sound Level Meter
Models 2700, 2800 or 2900 Sound Level Meter

The Model VA-508C system consists of the following:

Model 508 Accelerometer
Model AC-5 Accelerometer Cable
Model VI-90 Vibration Integrator
Model 59-746 Input Cable
Model 59-72 Probe
58-406 Vibration Chart
58-407 Vibration Chart

This system is intended to mate with any of the four Quest Sound Level Meters. A slide switch on the face of the VI-90 has three positions DISPLACEMENT, VELOCITY, and ACCELERATION. By referring to a table the reading in dB on the sound level meter can be converted to displacement (meters rms), velocity (meters/second rms) or acceleration (g's rms) depending on the switch position.

Vibration readings can be taken in various octave bands if the sound level meter is equipped with an octave band filter. Such octave band analysis permits the operator to determine if the equipment being tested is operating within safe and acceptable limits.

The VI-90 is powered by a 9-volt transistor battery. The battery condition can be easily verified by means of an LED indicating light. A standard carbon battery will last approximately 100 hours. The integrator is housed in a rugged aluminum case and uses the latest integrated circuit technology.

VIBRATION FUNDAMENTALS

A weight suspended on a spring as shown in Figure 1 can be used to illustrate the fundamentals of vibration.

If the weight is held at height A and then released, it would descend through the equilibrium point to level B where it would stop and then return through the equilibrium point to height A. In a friction-less system the cycle would be repeated in a simple sinusoidal path.

The displacement of the weight is illustrated in the first curve. Displacement can be measured in any linear unit such as meters or inches. Displacement from the top position A to the equilibrium point and from the bottom position B to the equilibrium point are each designated PK. Total peak-to-peak displacement is designated PK-PK. The rms displacement value is equal to .707 PK or .354 PK-PK.

The meter measures rms values which can of course be converted to PK and PK-PK values.

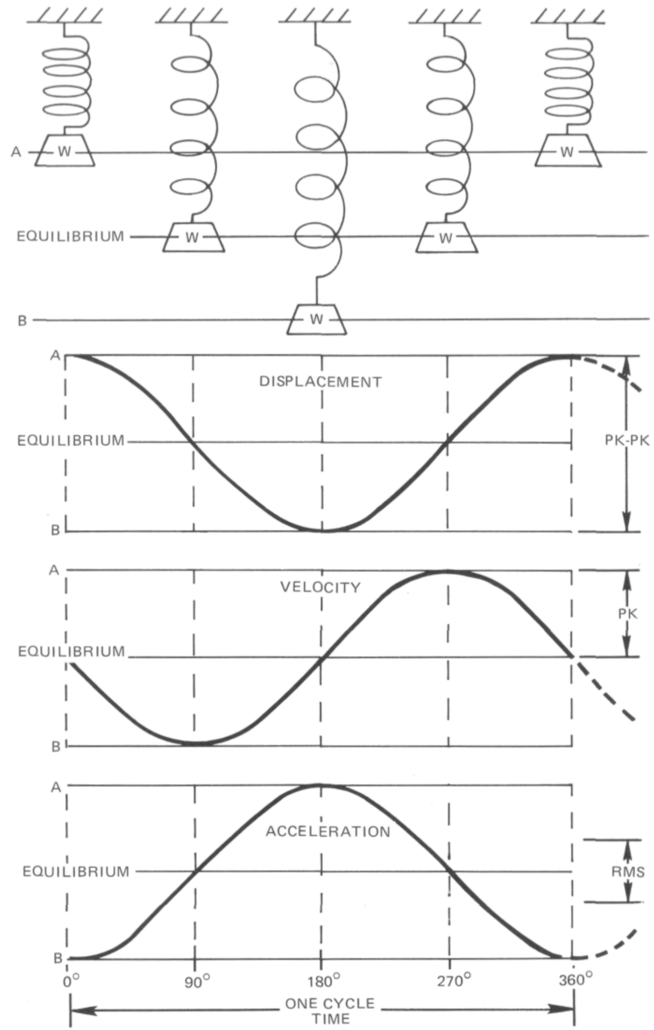

Figure 1. Vibration Fundamentals

The velocity of the weight is illustrated in the second graph. Velocity is zero prior to release of the weight. After release it reaches maximum negative velocity at the equilibrium point. At point B when the weight stops and reverses direction, the velocity is zero. At the equilibrium point on the return travel the weight reaches maximum positive velocity. Velocity is expressed in units such as meters per second or inches per second. It can also be expressed as an rms, PK or PK-PK value.

Acceleration of the weight is illustrated in the third graph. When the weight is released, gravity is exerting the maximum force to accelerate the weight downward. The weight decelerates and reaches zero acceleration at the equilibrium point. Beyond that, the stretching of the spring further decelerates the weight and stops it at point B. The spring at that point is exerting the maximum force to accelerate the weight upward. On the return travel, acceleration decreases to zero at the equilibrium point and then decelerates under the force of gravity and stops at point A. Acceleration is expressed in units such as meters per second per second (or meters per second squared) and inches per second squared.

Since gravity is a form of acceleration (32 feet per second squared), acceleration is often expressed in units of gravity or g's.

Vibration frequency is the number of complete up and down cycles the weight moves through in one second. Frequency is expressed in cycles per second or Hertz.

The frequency of the vibration often determines whether displacement, velocity, or acceleration is the most appropriate component to measure. If the frequency of the vibration is low (5 Hz to 200 Hz), clearance of the vibrating part may be the primary consideration, and the amount of movement or displacement would be the most appropriate component to measure. When the frequency of the vibration is high (above 2000 Hz), even small displacements may cause excessive forces which could damage the machine. Since force is directly proportional to acceleration, it is the acceleration value that would in that case provide the most information. For medium frequencies (100 Hz to 2000 Hz), or where the frequency of vibration is not known, the velocity measurement is the most useful. Velocity varies directly with frequency. A given velocity has the same potential for causing failures at all frequencies.

VIBRATION ASSEMBLY SPECIFICATIONS

Dynamic Measurement Range:

Displacement: 1x10 to 3 x 10 meters (rms)

Velocity: 1 x 10 to 3 meters/second (rms)

Acceleration: 1 x 10" to 150 g's (rms)

(All values are read in dB's on sound level meter and converted to the above vibration units via charts in Figures 6 and 7 of this manual.)

Frequency Range: 10 Hz to 10 kHz (See Figure 2)

Accelerometer Type: Model 508 High Sensitivity Piezoelectric. l0mV/g ± 5% (+10% at -50°C, -15% at + 120°C).

Mounting Thread: 10-32 Tapped Hole, 0.12" deep Connector: Microdot S-50, Female

Weight: 12 grams

Input Connector: Microdot S-50, Female

Input Configuration: 0.5mA constant current to supply power to the Model 508 accelerometer. Signal rides on same conductor as D.C. current. AC impedance is 45K ohms with current source removed.

Output Connector: Accepts Switchcraft type 780 Tini-plug or equivalent. (3.5mm phone plug)

Output Impedance: Effectively 0 ohms if output current is kept under 3 mA rms.

Temperature Range: Model VI-90 Integrator: -10°C to +50°C Model 508 Accelerometer: -50°C to +120°C

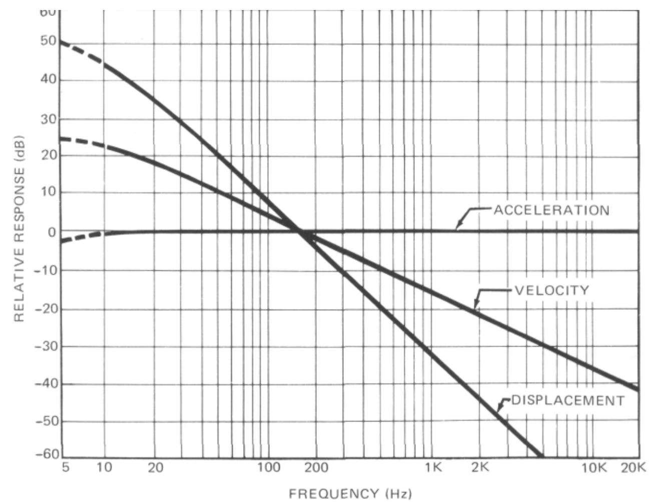

Figure 2. Relative Response of VI-90

Gain Accuracy: ±0.5 dB at 25°C, ±1.0 dB over temperature range. Output referred to input. See graph, Figure 2.

Relative Humidity: 0% to 95%. Accuracy within ±1.0 dB over entire dynamic range.

Power: One 9-volt transistor battery.

Battery Life: Approximately 100 hours at 4 hours of use per day.

Battery Indicator: L.E.D. will light in BATTERY TEST position if battery power is sufficient to operate unit.

Construction: Active electronic integrator in a rugged aluminum housing.

Size: 4.7 x 2.5 x 1.2 inches (120 x 64 x 30mm) Weight: 8 oz. (227 grams)

PRINCIPLES OF OPERATION

The block diagram (Figure 3) depicts the basic operation of the integrator.

The Model 508 Accelerometer requires a 0.5mA constant current source to power the built-in impedance converter. When a vibration is being measured, the acceleration component is sensed by the accelerometer and produces a voltage that is presented to the Buffer Amplifier. This acceleration voltage is applied directly to the VI-90 output when in the ACCELERATION mode.

The acceleration voltage is also passed through successive stages of integration to produce two other frequency-dependent output voltages. These are VELOCITY and DISPLACEMENT, and are selected by the mode switch.

When switched to the BATTERY TEST position, the L.E.D. will glow if the battery voltage is higher than the reference. This indicates sufficient battery power to operate the unit.

The Regulated Power Supply consists of switching-type voltage doublers to produce the indicated voltages.

CALIBRATION PROCEDURE

The Model VI-90 is designed to be compatible with most sound level measuring devices having an AC input, linear weighting, octave or 1/3 octave filter provision, and dB readout.

Calibration of a Quest Sound Level Meter for use with the VI-90 is as follows:

1. The preamp of the meter must be removed (see instructions in the meter manual for preamp removal). Connect the Input Cable (59-746) to the top of the meter (preamp input socket).

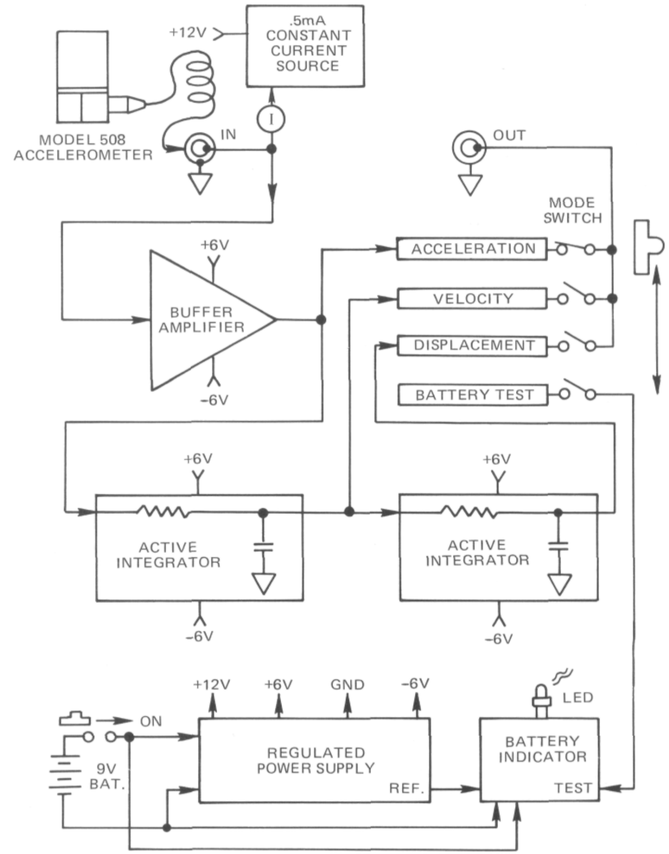

Figure 3. Block Diagram, Model VI-90 Vibration Integrator

2. Plug the other end into either a Quest calibrator or other 1 volt rms, 1 kHz voltage source.

3. Calibrate the Quest Sound Level Meters as follows:

A. Quest Models 1700, 1800 and 1900

1. Switch the meter to ON, LIN, SLOW or FAST, SPL, and the 80 to 140 dB RANGE.

2. With the calibrator ON and at 1 kHz, carefully adjust the Meter Calibration Screw for a reading of 120.0 dB.

B. Quest Models 2700, 2800 and 2900

1. Switch the meter to ON, LIN, SLOW or FAST, SPL, and the 80 to 140 dB RANGE.

2. With the calibrator ON and at 1 kHz, carefully adjust the Meter Calibration Screw for a reading of 134.0 dB.

4. Unplug input cable from voltage source and plug into the VI-90.

5. Refer to the 58-406 Vibration Chart, Figure 6, when converting 2700, 2800 or 2900 measurements to vibration units. Refer to the 58-407 Vibration Chart, Figure 7, when converting 1700, 1800 or 1900 measurements to vibration units.

TAKING A MEASUREMENT

For convenience of use mount the VI-90 to the back of the Sound Level Meter using the tripod mounting nut as illustrated in Figure 4. This makes the system portable and convenient for "on the spot" readings.

Take all measurements with the sound level meter in the LIN (linear) position. To obtain amplitude/frequency information, we recommend that you use external bandpass filter modules on the sound level meters. Available filter modules are as follows:

The Model OB-300 1/3-1/1 Octave Filter Set contains 33 selectable center frequencies from 12.5 Hz to 20 kHz when in the 1/3 mode and 11 selectable center frequencies from 16 Hz to 16 kHz when in the 1/1 mode. The frequency is changed either manually or automatically.

The Model OB-100 Octave Filter Set contains 10 selectable center frequencies from 31.5 Hz to 16 kHz. The frequency is changed either manually or automatically.

The Model OB-50 Octave Filter Set contains 9 selectable center frequencies from 31.5 Hz to 8 kHz. The frequency is changed manually.

Study EXAMPLES 1 and 2 which follow. They describe the use of the dB conversion charts, Figures 6 and 7, in converting dB values to vibration values.

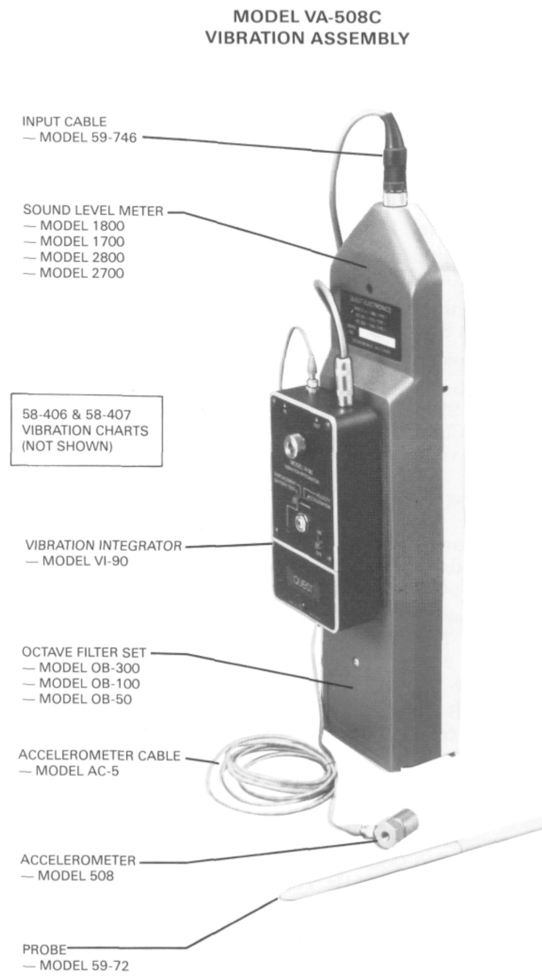

Figure 4. Connecting the VI-90 to the Sound Level Meter

It may be of interest to connect an oscilloscope to the AC output of the sound level meter to visually observe the results of the vibration. The use of an oscilloscope is optional and should be considered if the user is able to obtain any additional meaningful data. Generally, the dB values read from the sound level meter with octave or 1/3-octave information is sufficient for most measurements.

The 508 Accelerometer is usually mounted on a 10-32 screw stud that has been fastened to the machinery in the proper location and plane of vibration. The accelerometer is sensitive to vibration along the axis of the threaded hole.

Fastening an accelerometer to the machinery with the screw stud is the best method to insure good vibrational transfer. However, generally more than one point of measurement is needed to keep a good record of vibration throughout the entire machine. To make this task easier, Quest supplies a low-mass Probe (Model 59-72). This probe is screwed into the accelerometer. Grasping the knurled shaft with one hand, the pointed end of the probe is firmly pressed against the vibrating mass being measured, but not so firmly as to dampen the vibration. The vibration transfers through the low-mass probe directly to the accelerometer.

Since various types of machinery can become very hot during operation, the probe will prevent this heat from reaching and possibly damaging the accelerometer. If the accelerometer is to be stud-mounted directly to the device under test, the temperature of the device shall not exceed 120°C.

The manufacturers of machinery should specify or be able to specify proper test points for placement of accelerometers. Each test point specification should consist of the following:

1. Location of accelerometer.

2. Direction of vibrating force to be measured.

3. Which measurement to use — Acceleration, Velocity, or Displacement.

4. Approximate frequency or frequencies where possible trouble may occur.

5. Maximum allowable vibration before repair of machine is needed and/or danger is immanent.

These test points should be periodically measured and recorded (possibly in the form of a graph). As the machine begins to fail, certain vibration measurements will increase, indicating possible trouble in bearings, etc. As more and more experience is gained by relating data to specific failures, a preventive maintenance program can be enacted to correct machine defects before they become much more costly and dangerous.

CONVERTING dB's TO VIBRATION UNITS

When taking measurements with the VI-90, the results appear on the sound level meter as dB's. Figure 6 provides the necessary conversion numbers to convert dB values from the 2700, 2800 and 2900 meters to vibration units. Figure 7 provides the conversion numbers to convert dB values from the 1700, 1800 and 1900 meters to vibration units.

The vibration units that Quest uses are as follows:

Acceleration	g's rms
Velocity	meters/second rms
Displacement	meters rms

After conversion to rms vibration units, Figure 5 can be used to convert to other units.

Example 1

A Quest Model 1700 or 1800 sound level meter reads 77 dB of Acceleration at 2 kHz on octave band.

Use Figure 7. Look up 77 and list the number (7.0) directly to the right. Since this is Acceleration, multiply this number by 10^{-1} (or 0.1).

The final value is:

7.0×10^{-1} g's rms at 2kHz

or

(0.7 g's rms at 2kHz)

Example 2

A Quest Model 1700 or 1800 sound level meter reads 89 dB of Velocity at 500 Hz on octave band.

Use Figure 7. Look up 89 and list the number (2.8) directly to the right. Since this is Velocity, multiply this number by 10^{-2} (or 0.01).

The final value is:

2.8×10^{-2} meters/second rms at 500 Hz

or

(.028 meters/second rms at 500Hz)

DISPLACEMENT	SYMBOLS
1 meter rms = 2.82 meters PK-PK = 111 inches PK-PK = 39.37 inches rms	D = meters rms V = meters/sec rms A = g's rms Hz = cycles/sec
VELOCITY 1 meter/sec rms = 1.41 meters/sec PK = 55.7 inches/sec PK = 39.37 inches/sec rms	**EQUATIONS** $D = \frac{.248\ (A)}{(Hz)^2}$ $D = \frac{.159\ (V)}{(Hz)}$ $V = 6.28\ (D)\ (Hz)$ $V = \frac{1.56\ (A)}{(Hz)}$ $A = 4.03\ (D)\ (Hz)^2$ $A = .641\ (V)\ (Hz)$
ACCELERATION 1 g rms = 1.41 g PK = 9.8 meters/sec² rms = 13.9 meters/sec² PK = 27.7 meters/sec² PK-PK = 386 inches/sec² rms = 545 inches/sec² PK = 1090 inches/sec² PK-PK	

For 2700, 2800 and 2900, insert dB and calculate:

$$\text{ACC.} = 10^{\frac{dB-94}{20}}\ \text{g's rms}$$

$$\text{VEL.} = 10^{\frac{dB-134}{20}}\ \text{meters/sec rms}$$

$$\text{DIS.} = 10^{\frac{dB-194}{20}}\ \text{meters rms}$$

For 1700, 1800 and 1900, insert dB and calculate:

$$\text{ACC.} = 10^{\frac{dB-80}{20}}\ \text{g's rms}$$

$$\text{VEL.} = 10^{\frac{dB-120}{20}}\ \text{meters/sec rms}$$

$$\text{DIS.} = 10^{\frac{dB-180}{20}}\ \text{meters rms}$$

Figure 5. Conversion Unit Table

dB-to-VIBRATION CONVERSION CHART 58-406

for use with the VI-90 VIBRATION INTEGRATOR

dB		dB		dB	
	ACC. x 10^2 VEL. x 10^0 DIS. x 10^{-3}		ACC. x 10^1 VEL. x 10^{-1} DIS. x 10^{-4}		ACC. x 10^0 VEL. x 10^{-2} DIS. x 10^{-5}
153	8.9	133	8.9	113	8.9
152	8.0	132	8.0	112	8.0
151	7.0	131	7.0	111	7.0
150	6.3	130	6.3	110	6.3
149	5.6	129	5.6	109	5.6
148	5.0	128	5.0	108	5.0
147	4.5	127	4.5	107	4.5
146	4.0	126	4.0	106	4.0
145	3.6	125	3.6	105	3.6
144	3.2	124	3.2	104	3.2
143	2.8	123	2.8	103	2.8
142	2.5	122	2.5	102	2.5
141	2.2	121	2.2	101	2.2
140	2.0	120	2.0	100	2.0
139	1.8	119	1.8	99	1.8
138	1.6	118	1.6	98	1.6
137	1.4	117	1.4	97	1.4
136	1.3	116	1.3	96	1.3
135	1.1	115	1.1	95	1.1
134	1.0	114	1.0	94	1.0

Figure 6. Model 58-406 Vibration Chart

ACCELERATION: g's rms VELOCITY: meters/sec rms DISPLACEMENT: meters rms						2700/2800/2900 Sound Level Meters Cal: 1 V rms, 1 kHz = 134 dB Add 3 dB for PK, 9 dB for PK-PK
93	8.9		73	8.9		EQUATIONS
92	8.0	ACC.	72	8.0	ACC.	
91	7.0		71	7.0		$A = .641\,(V)\,(Hz)$
90	6.3	$\times 10^{-1}$	70	6.3	$\times 10^{-2}$	
89	5.6		69	5.6		$A = 4.03\,(D)\,(Hz)^2$
88	5.0		68	5.0		
87	4.5		67	4.5		
86	4.0		66	4.0		$V = \frac{1.56\,(A)}{(Hz)}$
85	3.6	VEL.	65	3.6	VEL.	
84	3.2		64	3.2		
83	2.8	$\times 10^{-3}$	63	2.8	$\times 10^{-4}$	$V = 6.28\,(D)\,(Hz)$
82	2.5		62	2.5		
81	2.2		61	2.2		$D = \frac{.248\,(A)}{(Hz)^2}$
80	2.0		60	2.0		
79	1.8		59	1.8		
78	1.6	DIS.	58	1.6	DIS.	$D = \frac{.159\,(V)}{(Hz)}$
77	1.4		57	1.4		
76	1.3	$\times 10^{-6}$	56	1.3	$\times 10^{-7}$	
75	1.1		55	1.1		Hz = cycles/second
74	1.0		54	1.0		

Figure 6. Model 58-406 Vibration Chart

for use with the VI-90 VIBRATION INTEGRATOR								dB-to-VIBRATION CONVERSION CHART 58-407
139	8.9		119	8.9		99	8.9	
138	8.0	ACC.	118	8.0	ACC.	98	8.0	ACC.
137	7.0		117	7.0		97	7.0	
136	6.3	$\times 10^{2}$	116	6.3	$\times 10^{1}$	96	6.3	$\times 10^{0}$
135	5.6		115	5.6		95	5.6	
134	5.0		114	5.0		94	5.0	
133	4.5		113	4.5		93	4.5	
132	4.0		112	4.0		92	4.0	
131	3.6	VEL.	111	3.6	VEL.	91	3.6	VEL.
130	3.2		110	3.2		90	3.2	
129	2.8	$\times 10^{0}$	109	2.8	$\times 10^{-1}$	89	2.8	$\times 10^{-2}$
128	2.5		108	2.5		88	2.5	
127	2.2		107	2.2		87	2.2	
126	2.0		106	2.0		86	2.0	
125	1.8		105	1.8		85	1.8	
124	1.6	DIS.	104	1.6	DIS.	84	1.6	DIS.
123	1.4		103	1.4		83	1.4	
122	1.3	$\times 10^{-3}$	102	1.3	$\times 10^{-4}$	82	1.3	$\times 10^{-5}$
121	1.1		101	1.1		81	1.1	
120	1.0		100	1.0		80	1.0	

Figure 7. Model 58-407 Vibration Chart

ACCELERATION: g's rms VELOCITY: meters/sec rms DISPLACEMENT: meters rms			1700/1800/1900 Sound Level Meters Cal: 1 V rms, 1 kHz = 120 dB Add 3 dB for PK, 9 dB for PK-PK			
79	8.9		59	8.9		EQUATIONS
78	8.0	ACC.	58	8.0	ACC.	
77	7.0		57	7.0		A = .641 (V) (Hz)
76	6.3	$\times 10^{-1}$	56	6.3	$\times 10^{-2}$	
75	5.6		55	5.6		A = 4.03 (D) $(Hz)^2$
74	5.0		54	5.0		
73	4.5		53	4.5		
72	4.0		52	4.0		$V = \frac{1.56\ (A)}{(Hz)}$
71	3.6	VEL.	51	3.6	VEL.	
70	3.2		50	3.2		
69	2.8	$\times 10^{-3}$	49	2.8	$\times 10^{-4}$	V = 6.28 (D) (Hz)
68	2.5		48	2.5		
67	2.2		47	2.2		$D = \frac{.248\ (A)}{(Hz)^2}$
66	2.0		46	2.0		
65	1.8		45	1.8		
64	1.6	DIS.	44	1.6	DIS.	$D = \frac{.159\ (V)}{(Hz)}$
63	1.4		43	1.4		
62	1.3	$\times 10^{-6}$	42	1.3	$\times 10^{-7}$	
61	1.1		41	1.1		Hz = cycles/second
60	1.0		40	1.0		

Figure 7. Model 58-407 Vibration Chart

QUEST SERVICE POLICY

The Quest product you have purchased is one of the finest acoustic instruments available. It is backed by our full one year warranty which seeks complete customer satisfaction. This is your assurance that you can expect prompt courteous service for your equipment from the entire Quest service organization.

Should your Quest equipment need to be returned for repair or recalibration, please contact the Service Department at (800) 245-0779 (USA) or Fax (262) 567-4047 for a Return Authorization Number. The RA number is valid for 30 days, and must be shown on the shipping label and purchase order/cover letter. If you are unable to return instruments in that time call for a new RA number. Send it prepaid and properly packed in the original shipping carton directly to Quest Technologies, 1060 Corporate Center Drive, Oconomowoc, WI 53006 U.S.A.

Repair or replacement work done under warranty will be performed free of charge, and the instrument will be returned to you prepaid. Your copy or a photocopy of the Quest Registration Card will serve as proof of warranty should the factory require this information.

If for any reason you should find it necessary to contact the factory regarding service or shipping damage, please direct your calls or letters to the attention of the Service Manager, Quest Technologies, (262) 567-9157 or (800) 245-0779. Office hours are from 7 AM to 6 PM (Central Standard Time) Monday through Friday.

For service or recalibration outside the U.S.A., please contact your local Quest Dealer or fax Quest U.S.A. at 1-262-567-4047.

QUEST WARRANTY POLICY

Quest Technologies warrants our instruments to be free from defects in materials and workmanship for one year under normal conditions of use and service. For U.S.A. customers we will replace or repair (our option) defective instruments at no charge, excluding batteries, abuse, misuse, alterations, physical damage, or instruments previously repaired by other than Quest Technologies. Microphones, sensors, and printers may have shorter warranty periods. This warranty states our total obligation in place of any other warranties expressed or implied. Our warranty does not include any liability or obligation directly resulting from any defective instrument or product or any associated damages, injuries, or property loss, including loss of use or measurement data.

For warranty outside the U.S.A., a minimum one year warranty applies to the same limitation and exceptions as above with service provided or arranged through the authorized Quest distributor or our Quest European Service Laboratory. Foreign purchasers should contact the local Quest distributor for details.