

**Quad/Graphics, Inc.**

**EQUIPMENT ACCEPTANCE STANDARD**

**FOR NEW AND REBUILT MACHINERY AND EQUIPMENT**

Version 1.1

1/31/06

Includes Specifications for Motors and Fans.

## **Revision History**

- Version 1.0 – 12/12/05 - Original Document
- Version 1.1 – 1/31/06 - Added Band 7 (0 – 120,000 CPM) with overall limits of 0.15 ips (3.688 mm/s), no peak limits specified within this band.

## Table of Contents

<b>1.</b>	Purpose .....	1
<b>2.</b>	Scope .....	1
<b>3.</b>	Instrumentation .....	1
	3.1. Hardware – FFT Analyzer .....	1
	3.2. Measurement System Accuracy .....	2
	3.3. Measurement System Calibration .....	3
	3.4. Vibration Sensor Requirements .....	3
<b>4.</b>	Accelerometer Mounting Requirements .....	4
<b>5.</b>	Technical Requirements .....	5
	5.1. Vibration Measurement Units .....	5
	5.2. Frequency Bands .....	5
	5.3. Frequency Resolution .....	6
	5.4. Shaft Alignment .....	6
	5.5. Dynamic Balancing .....	7
	5.6. Resonance .....	8
<b>6.</b>	Vibration Measurement Locations for Motors and Fans .....	9
<b>7.</b>	Equipment Quotation, Certification, and Acceptance .....	11
	7.1. Quotation .....	11
	7.2. Measurement Requirements for Certification .....	11
	7.3. Acceptance .....	12
<b>8.</b>	Electric Motors – Vibration Level Limits .....	12
	8.1. Electric Motor Measurement Requirements .....	12
	8.2. AC and DC Motor Limits .....	14
	8.3. Electrical Motor Certification .....	14
	8.4. Rebuilt Motors .....	15
<b>9.</b>	Fans – Vibration Level Limits .....	15
	9.1. Fan Definition .....	15
	9.2. Resonance and Beat Frequencies .....	15
	9.3. Mechanical Aspects .....	15
	9.4. Balancing .....	16
	9.5. Limits .....	16
	9.6. Fan Certification .....	17
	Appendix A – Recommended Template for Recording Vibration Data.....	19
	Appendix B – DC Motor Repair Information Sheet.....	20
	Appendix C – AC Motor Repair Information Sheet.....	22

# Quad/Graphics, Inc.

## VIBRATION STANDARD

### FOR NEW AND REBUILT MACHINERY AND EQUIPMENT

#### 1. PURPOSE

The purpose of this standard is to:

- Improve the life and performance of rotating machines and equipment purchased by Quad/Graphics, Inc.
- Reduce operating costs at Quad/Graphics, Inc. plants by establishing acceptable vibration levels for new and rebuilt rotating machinery and equipment.
- Provide a uniform procedure for evaluating the vibration characteristics of a machine for certification and acceptance.

#### 2. SCOPE

This standard establishes:

- Acceptable limits for vibration levels generated by new and rebuilt rotating machinery and equipment purchased by Quad/Graphics, Inc.
- Measurement procedures – including standardized measurement axis directions and locations, calibration and performance requirements of instrumentation, and procedures for reporting vibration data for machine certification and acceptance.

#### 3. INSTRUMENTATION REQUIREMENTS

Vibration measurements will be made with an FFT analyzer. The type, model, serial number(s) and latest certified calibration date of all equipment used in the measurement of vibration levels for machine certification shall be recorded and made available upon request

##### 3.1. Hardware – FFT analyzer

- The FFT analyzer shall use a maximum FFT bin size of 100 CPM and a minimum of 400 lines of resolution over the measured frequency range. Note that higher resolution may be required to resolve “Side Bands,” or to resolve machine vibration between 0.3X and 0.8X Running Speed in band 1.
- The FFT analyzer shall apply a Hanning window to all spectra.

- The FFT analyzer shall employ linear, non-overlap averaging.
- The FFT analyzer shall use anti-aliasing filters.

### 3.2. Measurement System Accuracy

#### 3.2.1. Amplitude Accuracy

The measurement system (FFT analyzer, cables, transducer and mounting) used to measure vibration for machine certification and acceptance must have an amplitude accuracy of  $\pm 5\%$  over the selected frequency range.

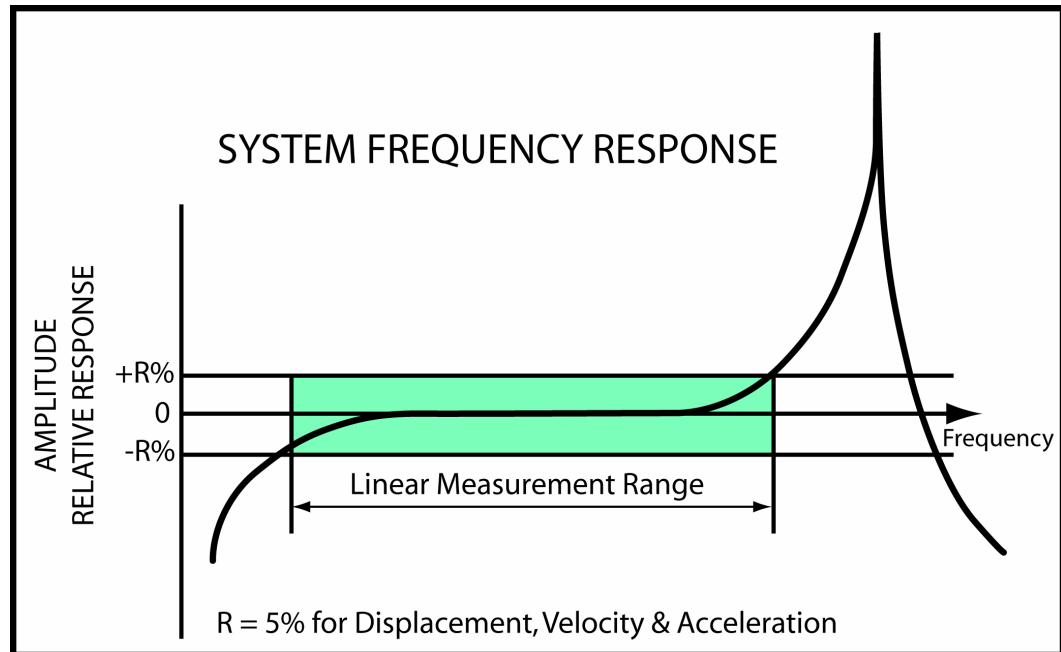


Figure 3. Measurement System Frequency Response

### **3.3. Measurement System Calibration**

Vibration equipment (transducer, preamplifier, FFT analyzer, recorder and connection cable) used to measure vibration for machine certification and acceptance must be calibrated by a qualified instrumentation laboratory in accordance with ANSI S2.17 -1980 "Technique of Machinery Vibration Measurement" within one (1) year prior to the date of machine certification.

Calibration shall be traceable to the National Institutes of Standards and Technology (NIST) in accordance with MIL-STD-45662A "Military Standard Calibration System Requirements" (01 Aug 1988) or latest revision.

### **3.4. Vibration Sensor Requirements**

The following vibration sensor requirements shall be considered as minimum acceptable requirements for machinery and equipment acceptance certification.

- 3.4.1.** An accelerometer shall be used in the collection of data for machine certification and acceptance. The accelerometer must be selected and attached to the machine in such a way that the minimum frequency ( $F_{min}$ ) and maximum frequency ( $F_{max}$ ) required for the specific test, are within the usable frequency range of the transducer and can be accurately measured (for further information reference ANSI S2.17-1980).
- 3.4.2.** The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range. The mass of the accelerometer and its mount should not exceed 10% of the dynamic mass of the structure upon which the accelerometer is mounted.
- 3.4.3.** Integration is acceptable for converting acceleration measurements to velocity or displacement.
- 3.4.4.** Accelerometers used for machinery and equipment acceptance certification shall meet the requirements specified in Table 3 (Vibration Sensor Requirements).

Transducer Class	Class 1A	Class 2A	Class 3A	Class 4A	Class 5A
Frequency Type	Ultra Low Frequency	Low Frequency	Mid-range Frequency	Broad-range Frequency	High Frequency
Frequency Range Stud-Mounted, ( $\pm 5\%$ )	0.2 - 200 Hz	0.5 - 2,000 Hz	10 - 5,000 Hz	10 - 9,000 Hz	10 - 25,000 Hz with $\pm 10\%$ sens. Tolerance
Frequency Range Adhesive-Mounted ( $\pm 5\%$ )	0.2 - 200 Hz	0.5 - 2,000 Hz	10 - 5,000 Hz	10 - 9,000 Hz	
Frequency Range Magnet Mounted ( $\pm 5\%$ )		0.5 - 1,700 Hz	10 - 2,000 Hz	10 - 3,000 Hz	
Sensitivity ( $\pm 5\%$ )	10,000 mV/g	500 mV/g	100mV/g	100 mV/g or 10 mV/g	10 mV/g
Resolution (g)	0.000001	0.00001	0.0002	0.0002	0.005
Transverse Sensitivity	< 3%	< 5%	< 5%	< 5%	< 5%
Package	Industrial	Industrial	Industrial	Industrial or Laboratory	Industrial or Laboratory
Shock Protect		5000g	5000g	5000g	5000g
Output Voltage	Shall be in direct proportion to acceleration				
Electromagnetic Sensitivity	Conform to EMC CE Requirements				

**Table 3. Vibration Sensor Requirements**

#### 4. ACCELEROMETER MOUNTING REQUIREMENTS

**4.1.** The vibration sensor must be mounted such that the measurement system amplitude accuracy over the selected frequency range meets or exceeds the requirements specified in Section 3.

**4.2.** Mounting methods for equipment with nominal motor speeds at or below 3600 RPM should be one of the following.

##### 4.2.1 Magnetic Mount

The machine's surface where the vibration measurement is to be taken shall meet the following requirements:

- During measurement, the mounting surface shall be clean and free of debris so the magnetic base can be attached firmly without rocking.
- Refer to the accelerometer manufacturer's literature for additional mounting requirements (torque, grease, etc.).

##### 4.2.2 Stud Mount

The machine's surface where the vibration measurement is to be taken shall meet the following requirements:

- The measurement surface shall be machined (faced) or cast to a size of 1.1x the diameter of the base of the sensor.

- The measurement surface shall be flat to within 1 mil (25• m).
- The measurement surface shall have a minimum surface finish (surface texture) of 1 mil (25• m).
- The tapped hole shall have a minimum depth of at least two threads deeper than the stud, and the hole shall be perpendicular to the mounting surface to within  $\pm 1^\circ$ .
- Refer to the accelerometer manufacturer's literature for additional mounting requirements (torque, grease, etc.).

#### **4.2.3 Adhesive Mount**

- Adhesive mounted pads must be attached using Lock-Tite Depend 330 glue and 7387 activator, or equivalent.
- The adhesive bond layer must be less than 1mm in thickness.
- Paint should be removed from the surface prior to adhering the pad.
- For an adhesive mounted pad with a tapped hole, the hole must have a minimum depth of at least two threads deeper than the stud, and the hole shall be perpendicular to the mounting surface to within  $\pm 1^\circ$ . Refer to the accelerometer manufacturer's literature for additional mounting requirements (torque, grease, etc.).

#### **4.2.4 Hand-held sensors**

Hand-held sensors are not acceptable for certification measurements.

## **5. TECHNICAL REQUIREMENTS**

### **5.1. Vibration Measurement Units**

For certification and acceptance, all vibration measurements must be of peak velocity with units in inches per second (ips).

### **5.2. Frequency Bands**

The frequency range of measurements shall be divided into subgroups called bands. The minimum frequency (Fmin) and the maximum frequency (Fmax) for each band will be defined in units of frequency or orders of running speed of the machine.

#### **5.2.1 Mandatory Bands**

Band 1 [0.3 – 0.8] x Running speed

Band 2 [0.8 – 1.2] x Running speed

Band 3 [1.2 – 3.5] x Running speed

#### **5.2.2 Other Bands**

Bands 4 through n shall be defined by the specific machine application.

Bands 4 through n may also overlap one another if required by a specific

application.

### **5.2.3 Maximum Frequency [Fmax]**

Vibration spectra plots consisting of Amplitude vs. Frequency (or orders of running speed) shall span a range with an upper frequency limit of Fmax, and have sufficient resolution so as to include and resolve frequencies of interest, such as those due to imbalance, looseness, drive belts, bearing defects, gear mesh and applicable side bands, etc. As a general guideline, Fmax should be 3.25 times the gear mesh frequency or 50 times running speed, whichever is greater.



### **5.3. Frequency Resolution**

A line of resolution within an FFT spectrum shall have a maximum bin size of 100 CPM ( $\bullet f$ ) and the spectrum must have a minimum of 400 lines of resolution across the frequency range of interest. In other words, each line can represent a span of no more than 100 CPM. Note that greater resolution may be required for slow speed equipment, to resolve side bands, or to resolve machine vibration between 0.3x and 0.8x running speed in Band 1.

The maximum peak velocity amplitude at any line of resolution, within any band in the spectrum shall not exceed the velocity amplitude acceptance limit for that band.

### **5.4. Shaft Alignment**

All coupled rotating machines consisting of consecutive shafts connected through a coupling (whether flexible or rigid) shall be aligned to the following acceptable tolerance values (Table 5) based on the operating speed:

	Angular Misalignment Mils per inch .001/1"		Offset Misalignment Mils per inch .001"	
				
RPM	Excellent	Acceptable	Excellent	Acceptable
3600	0.3/1"	0.5/1"	1.0	2.0
1800	0.5/1"	0.7/1"	2.0	4.0
1200	0.7/1"	1.0/1"	3.0	6.0
900	1.0/1"	1.5/1"	4.0	8.0

**Table 5 – Alignment Tolerances**

Consideration shall be given to any thermal growth that might occur during the normal operation of the machine that would cause the machine to “grow out of alignment” to the extent that the alignment tolerances of this standard would not be met.

## 5.5. Dynamic Balancing

- 5.5.1 During all balancing operations the shaft keyway shall be filled with a half-key that extends the full length of the keyway and is flush with the outer diameter of the shaft.
- 5.5.2 Permanently attached balancing weights must be secured by welding, bolting, pop riveting, or using a secure clip-on design. If bolted, a hardened bolt must be used in conjunction with a mechanical locking device (e.g. lock-washer or locknut).
- 5.5.3 All components (rotor, shaft, or pulley) shall be balanced individually and then trim balanced as a total assembly.
- 5.5.4 The use of solder or similar deposits to achieve balance is not acceptable.
- 5.5.5 Any parent material removed to achieve dynamic or static balance shall be removed in such a manner that the structural integrity of the component is

maintained.

### 5.5.6 Shaft and Fitment Key Convention

For rotating machines and machine components with keyed shafts, this standard requires balancing be achieved using a standard half-key in the key seat in accordance with ISO 8821-1989(E).

The final assembly key length shall be determined by calculating the total volume of metal missing from each component due to its keyway and replacing it with a length of key that will make up for the total missing volume. (Reference Figure 5)

This applies to rotors balanced in balancing machines, in their own housing, or *in situ*, and applies to keys of constant rectangular or square cross section, stepped keys, keys mounted on tapered shaft surfaces, woodruff, gib, dowel, and other special keys.

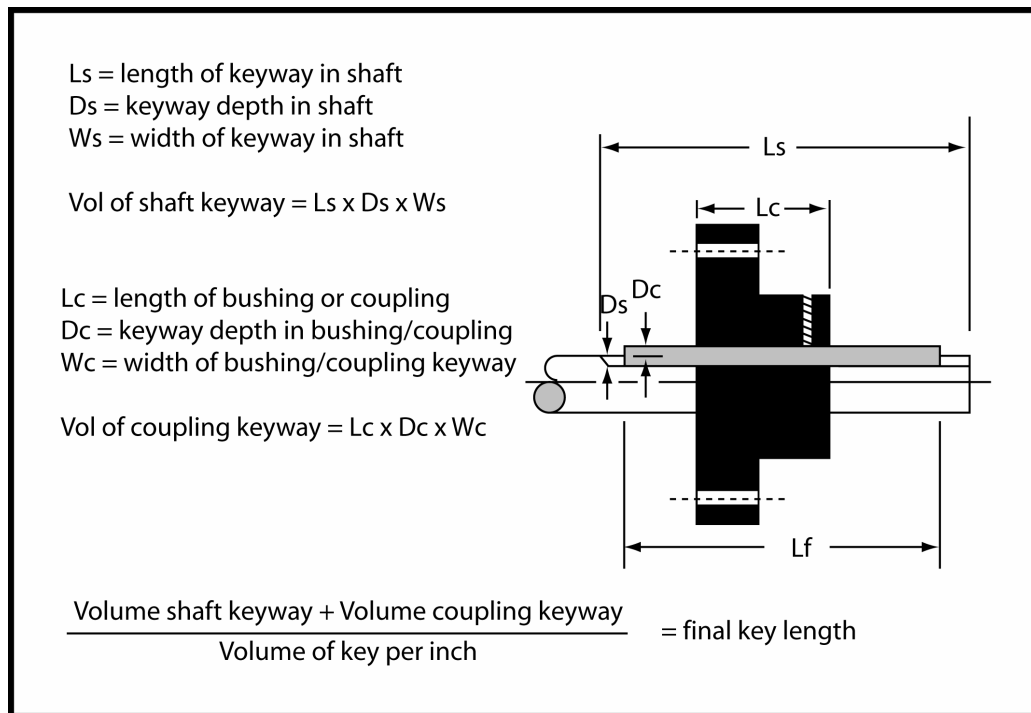
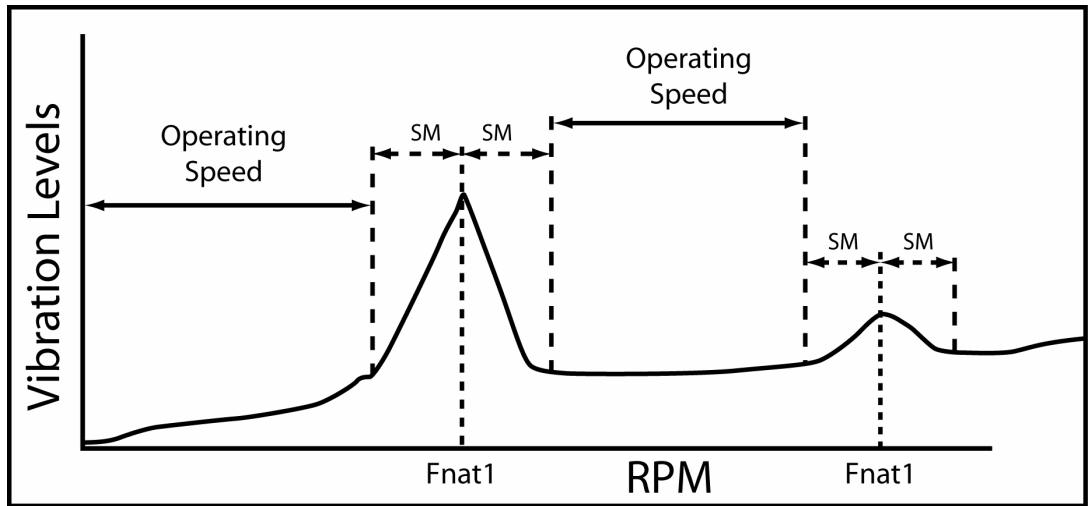


Figure 5 – Key Formula

### 5.6. Resonance

If the frequency of a periodic forcing phenomenon, or any of its harmonic components, approximates a natural frequency of a machine, a condition of resonance might exist. To avoid resonance, operating speeds should have a separation margin of at least 20% from any natural frequency of the machine. If

this 20% separation margin can not be met due to design limitations, the resonant condition must not cause vibration levels to exceed the maximum allowable vibration for that machine type and the frequency of resonance must be documented.



**Figure 5.1 – Resonance Separation Margin (SM)**

## 6. VIBRATION MEASUREMENT LOCATIONS

**6.1.** Vibration measurements shall be taken at each bearing location on the machine as close to the bearing as possible.

**6.2.** The following 3 measurements shall be made at each bearing location on a machine.

**6.2.1.** Axial measurement (A)  
Parallel to the shaft

**6.2.2.** Radial – Vertical (V)  
Perpendicular to the shaft with the sensor-sensitive axis perpendicular to the floor or base of the machine.

**6.2.3.** Radial – Horizontal (H)  
Perpendicular to the shaft with the sensor-sensitive axis parallel to the floor or base of the machine.

**6.3.** Each measurement location shall be clearly labeled on the machine layout drawings and/or on the machine itself.

- 6.3.1. Measurement locations should be labeled sequentially beginning with the bearing at the Non-Drive-End of the driving component and ending with the bearing at the Non-Drive-End of the driven component. (Reference Figure 6)
- 6.3.2. Measurement location labels should indicate the sensor orientation. (i.e. A for axial, V for radial-vertical, H radial-horizontal)
- 6.4. If an obstruction or a safety concern prevents locating a transducer as specified, locate it as close as possible to the standardized position.
- 6.5. Vibration measurement locations shall be on a rigid member of the machine, as close to each bearing as feasible.
- 6.6. Vibration measurement location shall **NOT** be on a flexible cover or shield such as fan covering on an electric motor or a sheet-metal belt guard.

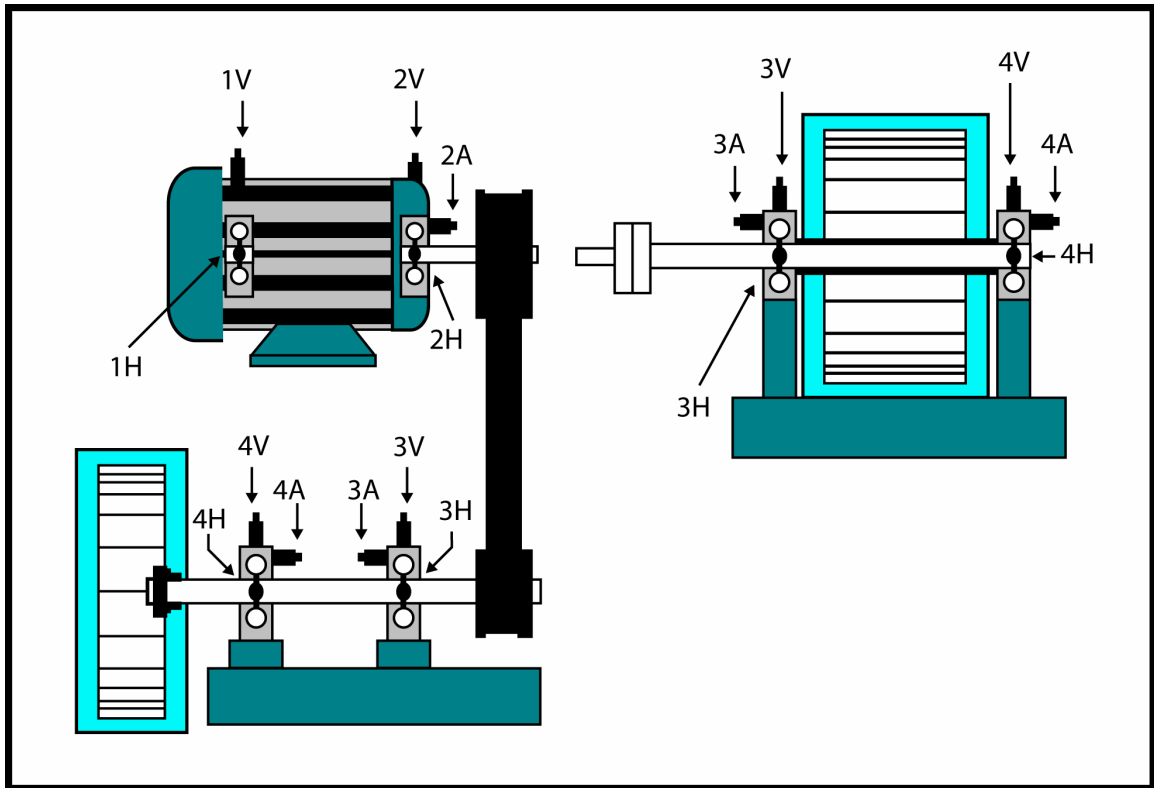


Figure 6 Vibration Measurement Locations

## **7. EQUIPMENT QUOTATION, CERTIFICATION, and ACCEPTANCE**

### **7.1. Quotation**

The Quotation shall specify that the equipment will meet the applicable vibration level limits in the section relating to the appropriate equipment type of this Specification – or the vibration level limits specified by Quad/Graphics in the “Request for Quote.”

### **7.2. Measurement Requirements for Certification**

Vibration measurements shall:

- 7.2.1** Be the responsibility of the supplier unless otherwise specified by Quad/Graphics.
- 7.2.2** Be presented in the format specified in Section 5 of this document.
- 7.2.3** Be performed by a technically qualified person, trained and experienced in vibration measurement.
- 7.2.4** Be taken after the machine is “run in,” reaches its operating speed and is thermally stable.
- 7.2.5** The amplitude and frequency of the highest peak amplitude within each measurement band must be recorded and submitted electronically. A sample template is available in Appendix A.
- 7.2.6** The overall amplitude within each measurement band must be recorded and submitted electronically. A sample template is available in Appendix A.
- 7.2.7** Vibration data, as required by this Specification, shall be submitted in electronic form to the Quad/Graphics Predictive Maintenance Group or other authorized representative before acceptance of the machinery or equipment will be authorized. Sample templates for recording data in a Microsoft Excel spreadsheet are available upon request.
- 7.2.8** Vibration data for machine certification shall be measured during machine run-off at the vendor’s facility. Where it is impractical to set up a complete machine at the vendor’s facility, arrangements shall be made to perform the measurements at a Quad/Graphics facility. In the case of measurements being performed at Quad/Graphics, shipment of the equipment does not relieve the vendor of their responsibility to meet the specified vibration level limits.
- 7.2.9** Quad/Graphics shall have the option of verifying the equipment’s vibration data during machine run-off at the vendor’s test site prior to

shipment, or at the plant site per Section 7.2.6, prior to final acceptance authorization.

**7.2.10** The machine layout drawing shall be submitted as part of the Machine Vibration Certification. Vibration measurement locations on the machine where measurements are taken shall be designated on the drawing per Section 5.

**7.2.11** Documentation detailing a machine's shaft speeds, the bearing manufacturer's name, the bearing type, number and class, the number of gear teeth, gear mesh frequency and gear type, where applicable, shall be provided to Quad/Graphics as part of the machine's vibration certification.

### **7.3. Acceptance**

Authorization for machine or equipment acceptance indicating compliance with this specification requires submission of equipment documentation, including machine part descriptions and vibration test result as specified in this standard for each equipment type. Documentation must be submitted electronically in the form of a Microsoft Excel spreadsheet. Spreadsheet templates and examples are available in appendices A, B, and C and can be downloaded via [www.qg.com](http://www.qg.com).

Email the forms to : **EquipmentReports@qg.com**

## **8. ELECTRIC MOTOR – VIBRATION LEVEL LIMITS**

### **8.1. Electric Motor Measurement Requirements**

New and rebuilt motors of 30HP and greater shall be tested in accordance with the following:

**8.1.1** The frequency range at which a motor is tested for this certification must be from  $F_{min} = (0.3 \times \text{Running Speed})$  to  $F_{max} = 120,000 \text{ CPM (2000 Hz)}$ .

#### **8.1.2 Speed of motor under test**

- Alternating Current (AC) motors must be tested at the rated voltage and frequency and not under load.
- Single speed AC motors must be tested at synchronous speed.
- Multiple speed AC motors must be tested at all rated synchronous speeds.
- AC motors with Variable Frequency Drives (VFD) and Direct Current (DC) motors must be tested at their highest rated speed.
- Series and universal motors must be tested at operating speed.

### 8.1.3 Motor Mounting

- **Foot-Mounted**

Foot-mounted motors shall be mounted on one of the following:

- **Rigid foundation**

The motor must be attached directly to a foundation with the following characteristics:

- Ø While under test, the vibration in any direction at the foundation must be less than 25% of the maximum amplitude measured at the adjacent bearing of the motor.
- Ø The natural frequency of the foundation, in any direction, must be at least 25% less than the running speed frequency of the motor under test.

- **Resilient mount**

The motor must sit on a steel plate, which sits on a rubber pad.

- Ø **The plate** must have the following characteristics:

- Ø The plate must weigh less than 1/20 the weight of the motor.
- Ø The dimensions of the plate shall not be more than 10% larger than the projected motor base.
- Ø Care must be taken that the motor does not exhibit “soft foot,” or rocking, on the plate.

- Ø **The pad** must meet the following specifications:

- Ø The pad thickness shall be such that the deflection of the pad due to the static load weight of the motor and plate will be greater than or equal to that shown in Table 8, but in no case more than ½ the original thickness of the pad.
- Ø For any speed not listed in Table 8, use the following formulae:
  - Deflection (inches) =  $[900/\text{RPM}]^2$
  - Deflection (millimeters) =  $25.4 \times [900/\text{RPM}]^2$
- Ø The resilient support pad shall support the entire base plate.
- Ø The dimensions of the pad shall not be more than 10% larger than the plate.

- **Vertically Mounted**

Motors designed to be mounted vertically shall be tested in such a way that the motor is in a vertical orientation while under test.

- **Flange-Mounted**

Any cradle used to support a flange-mounted motor must weigh less than 1/20<sup>th</sup> the weight of the motor.

Motor Synchronous Speed	Isolation Pad Minimum Compression		
	RPM	Inches	
900	1.0000	1	26
1200	0.5625	9/16	15
1800	0.2500	1/4	7
3600	0.0625	1/16	2

**Table 8**

Note: The required deflection is inversely proportional to the square of the speed of the motor.

### 8.2. AC and DC Motor Limits

Electric motors shall meet the following requirements:

- 8.2.1** The peak amplitude of velocity at any line of resolution within any band, measured at all bearing positions in any radial or axial direction, shall not exceed the Velocity Amplitude Acceptance Limits values as indicated in Table 8.1.

Maximum Allowable Vibration Levels For Motors					
Velocity Amplitude Band Limits					
Band	Frequency Range	Peak Amplitude		Overall Amplitude	
		Inch/Sec - Peak	mm/Sec - RMS	Inch/Sec - Peak	mm/Sec - RMS
1	[0.3 - 0.8] x RPM	0.040	0.718	0.08	1.44
2	[0.8 - 1.2] x RPM	0.075	1.350	0.15	2.70
3	[1.2 - 3.5] x RPM	0.040	0.718	0.08	1.44
4	[3.5 - 8.5] x RPM	0.030	0.540	0.06	1.08
5	[8.5 x RPM] - 60,00 CPM	0.030	0.540	0.06	1.08
6	60,000 - 120,000 CPM	0.030	0.540	0.06	1.08
7	0 - 120,000 CPM	-	-	0.15	3.68

**Table 8.1 Amplitude Acceptance Limits for Motors**

### 8.3. Electrical Motor Certification

- 8.3.1** The maximum peak velocity amplitude of vibration in each band at all bearing positions in any direction (radial and axial), as defined in Table 8.1, shall be listed in tabular form.

- 8.3.2** Vibration signatures (FFT spectra) of velocity for radial measurements taken at locations 001 and 002 at 0° and 90°, and at location 002 axial shall be submitted as part of the motor certification. If, due to machine

mounting, radial vibration readings at 0° and 90° are not accessible, radial readings 90° apart shall be taken at locations 001 and 002.

**8.3.3** The following measurement parameters must accompany the vibration signatures:

- Start frequency
- End frequency
- Low frequency cut-off
- Lines of resolution
- Type of window filter applied
- Type and number of averages

**8.3.4** Data shall be supplied electronically, as a Microsoft Excel spreadsheet, identifying the motor model number, frame number, serial number, horsepower, synchronous speed, and greasable vs. non-greasable bearings.

**8.3.5** Vibration data must be submitted electronically to the Quad/Graphics Predictive Maintenance Department or authorized representative before acceptance of the equipment will be authorized. Templates for data recording are available as Microsoft Excel spreadsheets.

#### **8.4. Rebuilt Motors**

A Motor Repair Information Sheet must be completed and submitted electronically to Quad/Graphics for each rebuilt motor. Motor Repair Information Sheets for AC and DC motors are in Appendices B and C and will be provided in Microsoft Excel spreadsheet format upon request.

### **9. FANS - VIBRATION LEVEL LIMITS**

#### **9.1. Fans are defined as:**

All non-positive displacement air handling units including Overhung Fans, Center-hung Fans, Centrifugal Fans, Vane-axial and Tube-axial Fans.

#### **9.2. Beat Frequencies**

There should be at least a 10% difference between the operating speeds of the motor and fan to reduce beat frequencies. If a 10% difference can not be achieved due to design limitations, the resultant beat frequency must not cause the periodic vibration amplitude to exceed the maximum allowable vibration as specified in Table 9.

#### **9.3. Mechanical Aspects**

**9.3.1** Fan shaft tolerances shall meet bearing manufacturer specifications for ground shaft tolerances.

- 9.3.2 Belt driven fans shall have their pulleys checked for rim and face run-out using a dial indicator setup and not allow more than .003 inch TIR (total indicated run-out) in either of the axes.
- 9.3.3 Variable speed pulleys (sheaves) shall not be used.
- 9.3.4 Guarding over the fan shaft bearings shall have access holes to allow for vibration sensor mounting.

#### **9.4. Balancing**

- 9.4.1 Access to the fan rotor shall be designed into the system.
- 9.4.2 Permanently attached weights must be secured by welding, bolting, pop-riveting, or using a secure clip-on design.
- 9.4.3 If bolted, a hardened bolt must be used in conjunction with a mechanical locking device (e.g. lock nut or lock washer).
- 9.4.4 Clip-on balancing weights can only be used on centrifugal type fans and must be located and attached on the ID pitch of the blades such that the rotational motion of the fan creates positive seating of the clip-on weight against the fan blade.
- 9.4.5 Balancing weights and their method of attachment must be stable at fan operating temperature, and of a material compatible with the parent material of the fan to which the balancing weight is attached.
- 9.4.6 The use of stick-on weights or lead weights is not acceptable.
- 9.4.7 Any parent material removed to achieve dynamic or static balance shall be removed in a manner that will maintain the structural integrity of the rotor or pulley.

#### **9.5. Limits**

Fans shall be tested under installation mounting conditions. If such conditions are unknown, the fan shall be tested using isolation mounting per the requirements set forth in Section 8 on motors. If spring-mounted, the tolerance limits increase by 50% at the rotating speed of the fan.

- 9.5.1 New and rebuilt fans shall conform to the vibration limits specified in Table 9 when operating at specified system CFM and fan static pressure.
- 9.5.2 The frequency for fan certification shall be from  $F_{min} = (0.3 \times \text{running speed of fan})$  to  $F_{max} = 120,000 \text{ CPM (2000 Hz)}$ .

**9.5.3** For fan speeds up to 3600 RPM, the maximum Velocity amplitude of vibration at all bearing positions in any direction shall not exceed the velocity amplitude acceptance limit values specified in Table 9.

Acceptance limits for fans running over 3600 RPM shall be specified by Quad/Graphics.

<b>Maximum Allowable Vibration Levels For Fans</b>					
<b>Velocity Amplitude Band Limits</b>					
Band	Frequency Range	Peak Amplitude		Overall Amplitude	
		Inch/Sec - Peak	mm/Sec - RMS	Inch/Sec - Peak	mm/Sec - RMS
1	[0.3 - 0.8] x RPM	0.040	0.718	0.08	1.44
2	[0.8 - 1.2] x RPM	0.075	1.350	0.15	2.70
3	[1.2 - 3.5] x RPM	0.040	0.718	0.08	1.44
4	[3.5 - 8.5] x RPM	0.030	0.540	0.06	1.08
5	[8.5 x RPM] - 60,00 CPM	0.030	0.540	0.06	1.08
6	60,000 - 120,000 CPM	0.030	0.540	0.06	1.08
7	0 - 120,000 CPM	-	-	0.15	3.68

**Table 9 Maximum Vibration Levels for Fans**

**9.6. Fan Certification**

**9.6.1** The maximum peak velocity amplitude of vibration in each band at all bearing positions in any direction (radial and axial) as defined in Table 9 shall be listed in tabular form.

**9.6.2** Vibration signatures (FFT spectra) of velocity for radial measurements taken at 0° and 90° at all bearing locations and one axial measurement at location 001 or 002 shall be submitted as part of the fan certification. If, due to machine mounting, radial vibration readings at 0° and 90° are not accessible, radial readings shall be taken 90° apart.

**9.6.3** The following measurement parameters must accompany the vibration signatures:

- Start frequency
- End frequency
- Low frequency cut-off
- Lines of resolution
- Type of window filter applied
- Type and number of averages

**9.6.4** Data shall be supplied electronically, as a Microsoft Excel spreadsheet, identifying the bearing manufacturer and model number, the sheave sizes, the belt manufacturer and model number, and the number of blades. For

systems with an integrated motor, motor data must also be supplied as per Section 8.3.4.

- 9.6.5** Vibration data must be submitted electronically to the Quad/Graphics Predictive Maintenance Department or authorized representative before acceptance of the equipment will be authorized. Templates for data recording are available as Microsoft Excel spreadsheets.

## Appendix A

### Recommended Template for Recording Vibration Measurement Data

<b>Machine Description</b>				
<b>Measurement Location</b>				
<b>Measurement Parameters</b>				
Date				
Fmin				
Fmax				
Low Freq Cutoff				
Lines of Resolution				
FFT Window Type				
# of Averages				
Averaging Type				
<b>Band</b>	<b>Frequency Range</b>	<b>Maximum Peak Amplitude</b>	<b>Frequency at Maximum Peak Amplitude</b>	<b>Overall Amplitude</b>
1				
2				
3				
4				
5				
6				

**Appendix B**  
DC Motor Repair Information Sheet

**Quad Graphics DC Motor Repair Information Sheet**

PLANT _____	Master Component Name _____ (i.e. Press M-55)
DATE _____	Specific Component Name _____ (i.e. Sec drive moto)
Sent to _____	Removed because _____
P.O. _____	Quoted Price \$ _____
	JOB NO. _____

**Name Plate Data**

MFG _____	MODEL _____	S/N _____
HP _____	FRAME _____	TYPE _____
RPM _____	Arm Volts _____	Arm Amps _____
ENCL. _____	Field Volts _____	Field Amps _____

**Incoming No-Load Test Run**      RUN ON      Resilient ( )      Rigid ( )      MOUNTING

Megger @ \_\_\_\_\_ VDC      Armature \_\_\_\_\_ Megohms      Field \_\_\_\_\_ Megohms

Vibration	(in IPS)	Horizontal	Vertical	Axial	Arm Volts _____	Arm Amps _____		
	overall NDE						Field Volts _____	Field Amps _____
	overall DE							
	pk 1xshaft NDE							
pk 1xshaft DE								

RPM \_\_\_\_\_  
Runtime \_\_\_\_\_

**Mechanical Inspection Results**

Condition of:      Armature \_\_\_\_\_      Shunt Fld \_\_\_\_\_      Series Fld \_\_\_\_\_  
                          Interpoles \_\_\_\_\_      Brush hldr \_\_\_\_\_      Comm \_\_\_\_\_

Item	DE	Tolerance -Inches	NDE	Tolerance -Inches
Shaft TIR				
Shaft Diameter				
Brg Journal				
Brg Housing				

	MFG	Number	MFG	Number
Old Brgs				
New Brgs				

**Electrical Tests**

Bar to Bar \_\_\_\_\_ Field • \_\_\_\_\_ Field Test \_\_\_\_\_ Interpole \_\_\_\_\_ Thermal • \_\_\_\_\_

Megger @ \_\_\_\_\_ VDC Armature \_\_\_\_\_ Megohms Shunt Fld \_\_\_\_\_ Megohm  
 (Before) Series Fld \_\_\_\_\_ Megohms Interpoles \_\_\_\_\_ Megohm

Megger @ \_\_\_\_\_ VDC Armature \_\_\_\_\_ Megohms Shunt Fld \_\_\_\_\_ Megohm  
 (After cleaning) Series Fld \_\_\_\_\_ Megohms Interpoles \_\_\_\_\_ Megohm

**Final No Load Test Run** RUN ON Resilient ( ) Rigid ( ) MOUNTING

Vibration	(in IPS)	Horizontal	Vertical	Axial
overall	NDE			
overall	DE			
pk 1xshaft	NDE			
pk 1xshaft	DE			

Arm Volts \_\_\_\_\_ Arm Amps \_\_\_\_\_  
 Field Volts \_\_\_\_\_ Field Amps \_\_\_\_\_  
 RPM \_\_\_\_\_  
 Runtime \_\_\_\_\_

Comments \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

## Appendix C

### AC Motor Repair Information Sheet

# Quad Graphics AC Motor Repair Information Sheet

Plant _____	Master Component Name _____	(i.e. Press M-70)
Date _____	Specific Component Name _____	(i.e. Tec Turn Blower)
Sent to _____	Removed because of _____	
P.O. _____	Quoted Price \$ _____	JOB NO. _____

#### Name Plate Data

MFG _____	Model _____	S/N _____
HP _____	Frame _____	TYPE _____
RPM _____	Voltage _____	SF _____
ENCL. _____	Amps _____	

**Incoming No-Load Test Run**      RUN ON    Resilient ( )      Rigid ( )    MOUNTING

Megger @ \_\_\_\_\_ VDC      \_\_\_\_\_ Megohms

	(in IPS)	Vibration		
		Horizontal	Vertical	Axial
overall	NDE			
overall	DE			
pk 1x shaft	NDE			
pk 1x shaft	DE			

Phase	A		B	C
	A	A-B	B-C	C
Amps				
Volts				
RPM	_____			
Runtime	_____			

#### Mechanical Inspection Results

Condition of:      Windings \_\_\_\_\_      Leads \_\_\_\_\_      Rotor \_\_\_\_\_

Other \_\_\_\_\_

Item	DE	Tolerance -inches	NDE	Tolerance -inches
Shaft TIR				
Shaft Diameter				
Brg Journal				
Brg Housing				
	Manf.	Number	Manf.	Number
Old Brgs				
New Brgs				

#### Electrical Tests

Surge Test

Megger @ \_\_\_\_\_ VDC      \_\_\_\_\_ Megohms

**Final No Load Test Run**      RUN ON    Resilient ( )      Rigid ( )    MOUNTING

Vibration overall overall pk 1x shaft pk 1x shaft	(in IPS)	Horizontal	Vertical	Axial
	NDE			
	DE			
	NDE			
	DE			

Phase Amps Volts	A	A-B	B B-C	C C	A

RPM \_\_\_\_\_

Runtime \_\_\_\_\_

Comments

---



---



---



---



---