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Guide to Adhesively Mounting Accelerometers

Technical Paper 312

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Guide to adhesively mounting accelerometers

Purpose

This technical paper identifies and clarifies issues regarding adhesive mounting of accelerometers. Endevco application engineers have responded to many inquiries on this subject and therefore thought it important to provide a general guide on adhesively mounting accelerometers. This information should enable the test engineer or technician to make a better decision on the type of adhesive to use for a particular application.

Background

Test engineers and technicians are frequently asked to attach accelerometers without altering the mounting surface, i.e.,to avoid tapping holes into surfaces for a stud/screw mount. Examples include composite/ laminate surface materials, a mounting surface with insufficient structural thickness, very small surface areas with weak structural integrity, and multiple mount points where accelerometer roaming may be random. In these situations adhesive mounting of accelerometers may be required.

Test personnel are also given the task of deciding what type of adhesive is appropriate for a given circumstance. Since the natural frequency of an accelerometer, when mounted, is dependent on the stiffness of the coupling method, choosing the correct adhesive should not be just a passing thought. Some of the following issues that must be considered are: weight of the accelerometer, required frequency bandwidth of intended measurement, amplitude anticipated and temperature at the measurement point. The information presented here is restricted to sinusoidal and random vibration testing, as opposed to high-g shock testing. Currently engineers and technicians use various types of adhesives for mounting accelerometers.

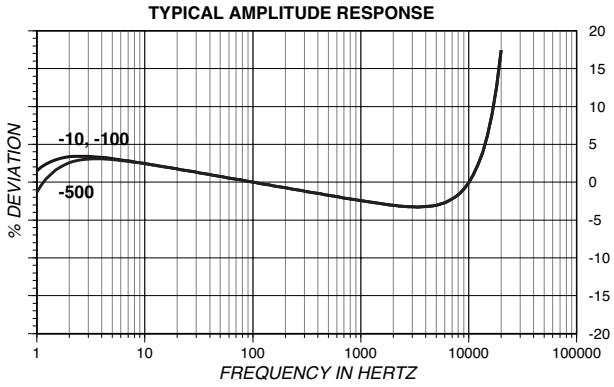
These include cyanoacrylate instant adhesive, magnets, double-sided tape, petro-wax and hot glue.The key question is which adhesive to use, and when its use is effective. This paper should help answer that question.

Sinusoidal vibration tests have been performed on two typical accelerometers that are likely to be adhesively mounted: Model 751-100 and 2226C. Adhesives used were cyanoacrylate, double-sided tape, petro-wax, hot glue and a magnetic mount. These tests were performed inside a temperature-controlled chamber. Testing was initiated at room temperature to verify the accelerometers' response before moving to other temperatures. Temperature inside the oven was monitored with a thermocouple to verify the temperature at the accelerometer.

Mounting recommendations

When adhesively mounting accelerometers, the amount (thickness) of adhesive may play a critical role in achieving good frequency response. A thin film or minimal amount of adhesive promotes higher transmissibility and hence a broader frequency response. Prior to mounting accelerometers, clean the mating surfaces with a hydrocarbon solvent such as Loctite™ X-NMS. For the most part, cyanoacrylate, double-sided tape or petro-wax may be used, resulting in a uniform thickness that will provide good results. Hot glue, on the other hand, requires more attention in its application. This is due to the limited time for application before glue hardens. However, convenience may dictate that hot melt is the best adhesive to use in particular applications.

Two models, model 751-100 and model 2226C, were considered to be most representative of the general purpose accelerometers. The Endevco model 751-100 weighs 7.8 grams and has a flat frequency response (±5% deviation from reference freq.) of 1-15 kHz when stud mounted on a high frequency shaker. The Endevco model 2226C weighs 2.8 grams and has a flat frequency response of 1-5 kHz when mounted with cyanoacrylate on a high frequency shaker (Fig. 1).



751-100

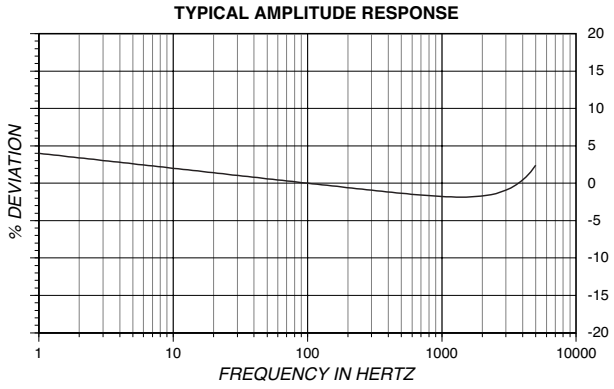


Figure 1

Specific assessment of each adhesive mounting method

Cyanoacrylate

Tests performed at Endevco indicate that for an accelerometer weighing ≤ 10 grams, cyanoacrylate has the highest merit. For the 751-100 and 2226C accelerometers, cyanoacrylate was the best adhesive to use between -18°C and +121°C. Cyanoacrylate is also usable at temperatures above +121°C (up to +177°C) since it does not fail completely at +121°C. Cyanoacrylates are liquid monomers that polymerize forming a hard plastic. This plastic adheres to metal, rubber, glass and various plastics. The thinner the layer of cyanoacrylate, the quicker the cure time. Generally, for accelerometers with aluminum or stainless steel outer cases, a methyl-based cyanoacrylate is recommended which bonds metal and glass well. When it is uncertain whether cyanoacrylates are compatible with a particular surface material, separately test a sample piece to be sure.

Advantages

- Room temperature cure
- Fast cure time(practically instant)
- Broad frequency response and good temperature range

Disadvantage

- Need for a solvent (Loctite™ X-NMS or equiv.) to break glue bond down before removing accelerometer
- Removal is time consuming
- Difficult to set on rough surfaces

Petro-wax

Petro-wax is an excellent adhesive at lower temperatures. Like cyanoacrylate, the flat frequency response of petro-wax increases with a decrease in temperature.

Recommendation

When using petro-wax it should be noted that the maximum bonding strength of the wax, when used on smooth steel surfaces, is about 15 psi. This allows up to approximately 20 g-pk vibrations with ≤ 100 gram accelerometer mounted on a 5/8" diameter area of wax. The amount of wax used should be limited to a thickness of ≤ 1/8" and preferably ≤ 1/10". To determine the resonant frequency of any accelerometer with a wax-mount configuration, see equation 1.

$$fn = 3.13 \sqrt{\frac{AE}{tW}}$$

where fn = mounted natural frequency in Hz

A = area of wax under accelerometer base in square inches
t = thickness of wax in inches
E = modulus of elasticity of wax in psi *
W = weight of accelerometer in pounds

*estimated to be 5x104 psi. The value of the modulus may change with time as wax hardens.

Equation 1

Advantages

› Ease of use
› Convenient storage (small container in pocket without spillage etc.)
› Quick application with no cure time
› Easily removed from mounting surfaces (no solvents required)

Disadvantages

› Limited upper temperature range
› Limited amplitude range
› Reduced upper frequency usage

Blanchard Wax 7036

Another adhesive is Stronghold 7036 Blanchard Wax. This is useful for mounting adhesive-mount type accelerometers to a stud adaptor such as the Endevco type 2988. There are various reasons to convert an adhesive mount accelerometer to a stud mount unit and one such reason is for obtaining repeatable results during calibration.

Blanchard Wax provides excellent transmissibility and holds-up well under continuous high levels of vibration. The maximum useable temperature is about 160°F (70°C). The wax starts to soften above 160°F thus reducing the frequency response.

The preferred method of adhesive application is to heat the adapter stud on a hot plate bringing the stud temperature to approximately 400°F (200°C). Attach the accelerometer while the wax is soft and allow harden.

Blanchard Wax provides an almost permanent mount, but is easily removed using acetone. There is no noticeable residue after clean-up.

Double-sided tape

Double-sided tape has a fairly large temperature range, similar to cyanoacrylate instant adhesives, -18°C to +93°C, for the model 751-100. The 751-100 has a flat response to 4 kHz @ +93°C.

Advantages

› Ease of application and removal
› Broad temperature range

Disadvantages

› Limited amplitude range
› Some limitations with top connector or high profile style accelerometers due to cable motion

Hot Glue

Hot glue mounting is appropriate for temperatures below +93°C to -18°C. Above +93°C, hot glue loses its stiffness and frequency response is adversely affected. Hot glue requires more attention than other adhesive mounting methods, particularly when trying to optimize for higher frequency applications. For applications ‹2 kHz this should not be a problem. Like most other adhesives, the flat frequency response range of hot-glue

increases with a decrease in testing temperature. This method has become popular because it is compatible with most materials, and the accelerometer is easily removed. With cordless glue guns, similar to the glue gun in Endevco's model 31849(DAAK) adhesive kit, hard to reach areas are more accessible.

Advantages

- Convenience
- Ready supply of adhesive (glue sticks)
- Quick cure time and easy removal

Disadvantage

- Very rapid cure time which must be taken into consideration to ensure good adhesion and proper frequency response. This implies that the user should be prepared to mount accelerometer as soon as glue is applied to mounting surface. Use at temperatures ›93°C is not advised.

Magnet

Magnetic mounting of an accelerometer is convenient and easily accomplished, however this method reduces the usable bandwidth. Magnets are not affected by environmental changes, however magnet mounting drastically reduces the resonant frequency. Certain surface materials also render this mounting method ineffective. For the Model 751-100, the flat frequency range decreases from 15 kHz stud-mounted to 3.4 kHz magnetically mounted. Therefore, magnetic mounts should be used only at lower frequencies. Heavier accelerometers, ≥ 50 grams in weight, may be a candidate for magnetic mounting. These accelerometers generally have a high sensitivity and a narrow bandwidth. Since this is the case, the reduced resonance caused by the magnetic mount may be negligible. It should be noted that the additional weight of the magnet may approach the weight of the accelerometer. When this is the case, a review of mass loading concerns should be taken to prevent errors in the measurement.

Advantages

- Ease of use
- Broad temperature range
- Good holding strength
- Size Variability

Disadvantages

- Reduced bandwidth
- Necessity for caution when applying accelerometer/magnet to mounting surface.

Caution

Damage and or destruction of the accelerometer is possible if user "slaps" accelerometer/magnet to a flat, hard mounting surface. High-frequency spikes could cause catastrophic damage to the accelerometer if this occurs. Apply accelerometer/magnet from outer edge and roll cautiously down onto mounting surface.

General note:

1. Do not use an adhesive at or near its maximum temperature limit, for a prolonged period of time. The adhesive itself may deteriorate and have a lower tensile strength.

2. When an accelerometer has been designed for adhesive mounting, all performance limitations have already been considered.

Conclusion

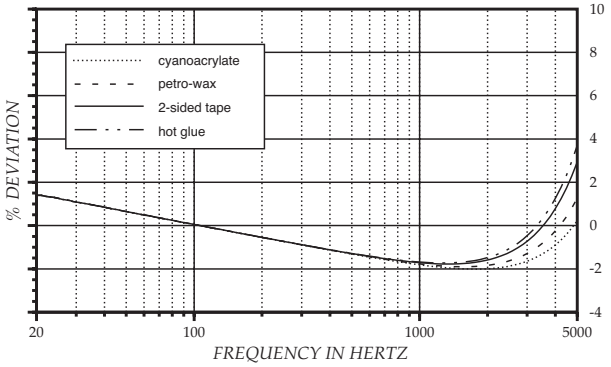
When the test engineer or test technician is required to mount accelerometers with adhesives rather than with hard studs, certain issues must be addressed and reviewed before choosing an adhesive. Cyanoacrylate instant adhesives have the widest frequency range and the broadest temperature limits of the adhesive-mount options. From -18°C to +121°C there is no significant change in the response curves. At low temperatures, ‹+54°C, petro-wax is the next best alternative to cyanoacrylate adhesives. This method is convenient and quick to use. Use a thin film of wax, if possible, to increase usable bandwidth. For temperatures up to +93°C, double-sided tape may be an appropriate

adhesive method. It should be noted that double-sided tape may have different attributes with accelerometers of similar weight at low temperatures, therefore caution should be exercised when using this form of adhesive mounting. Hot glue is a viable alternative, for temperatures ‹+93°C, if cyanoacrylate and double-sided tape methods have been ruled out. Hot-glue must be used quickly to avoid cooling and inconsistent mounting which may affect the frequency response of accelerometer.

Since magnets profoundly affect the high-end frequency response of the accelerometer, magnetic mounting should be used only for lower frequencies. Temperature does not affect magnetic mounts.

Response curves are included within this paper showing the effect of different mounting method.

751-100 (100℉)



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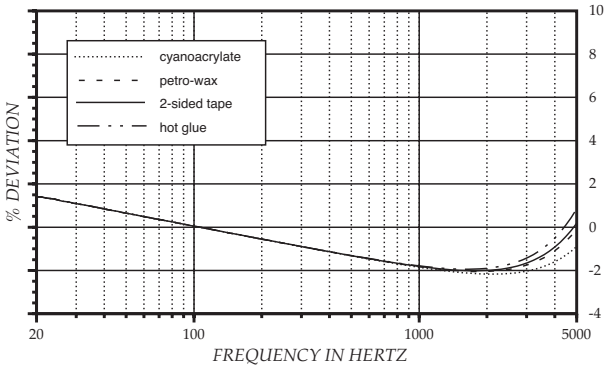

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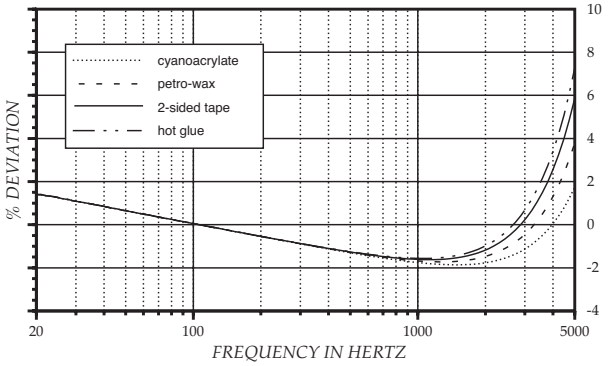

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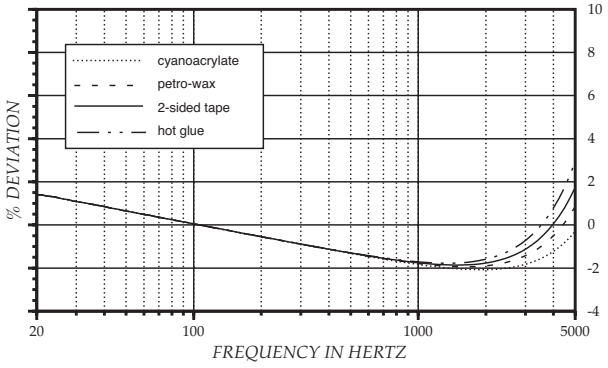

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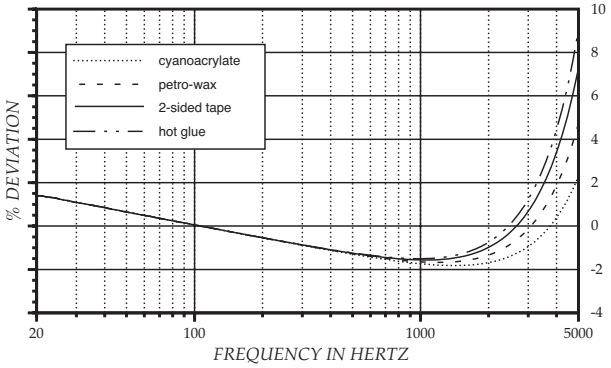

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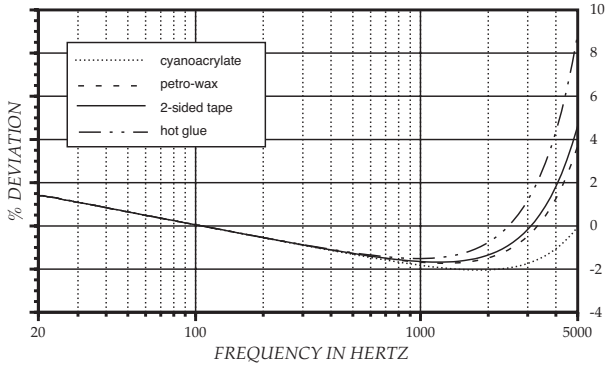

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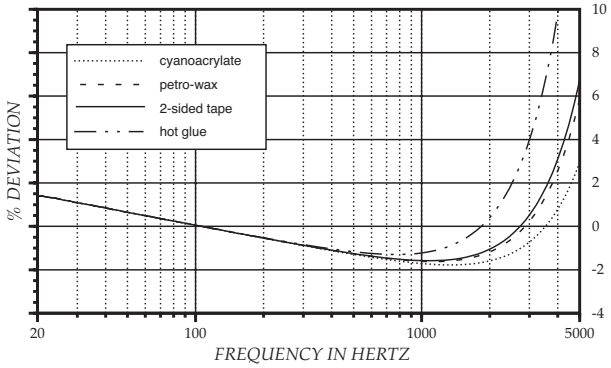
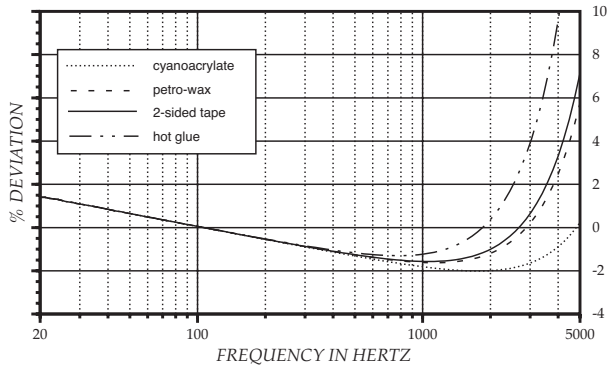


751-100 (200 ºF)



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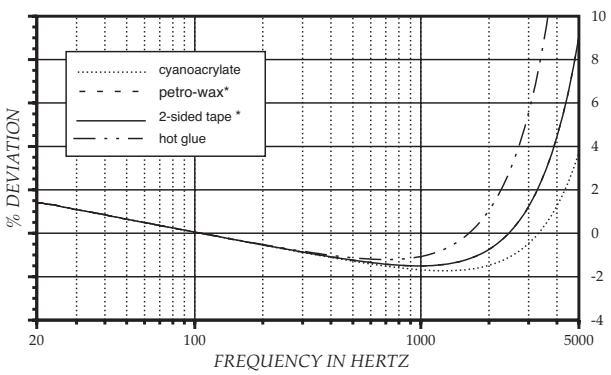
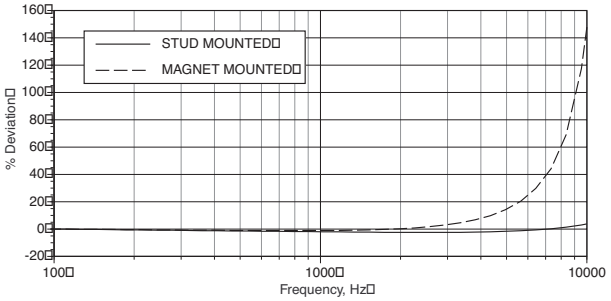
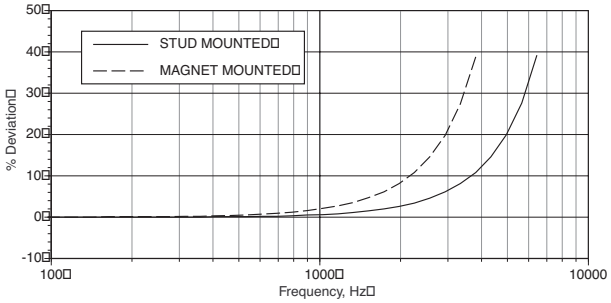


* petro-wax and 2-sided tape have same response at +200ºF, therefore curves overlap





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