



AEROSPACE RECOMMENDED PRACTICE

ARP6068™**REV. A**

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Superseding ARP6068

Gas Turbine Engine Test Facility Vibration Measurement

RATIONALE

ARP6068 has been reviewed to include a chapter about measurement of vibrations in engines equipped with FADEC systems.

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1. SCOPE

The test procedure per the applicable Engine Manual does require a vibration check for the low/intermediate and high speed rotor systems.

Release of an engine with high vibrations can result in:

- On-wing vibration complaints, with subsequent troubleshooting
- Rotor system failures
- Premature engine removals

Limits are provided for transient conditions and steady state data points.

Troubleshooting recommendations are limited to verification of the proper signal input and tracking.

This practice provides recommendations for:

- Correct cable and transmitter installation and connections
- Calibration
- Recorded data interpretation and data analysis

2. RELATED PUBLICATIONS

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

AIR5026 Test Cell Instrumentation

2.2 Other Publications

Bently, D.E., and Hatch, C.T. (2002). *Fundamentals of rotating machinery diagnostics* (B. Grissom, Ed.). ASME Press. <https://doi.org/10.1115/1.801FRM>.

Vance, J.M. (1991). *Rotordynamics of turbomachinery*. John Wiley & Sons, Inc.

Ehrich, F.F. (2004). *Handbook of rotordynamics* (3rd ed.). Krieger Publishing Company.

3. VIBRATION MEASUREMENT

3.1 General Information

In principle, the vibration of an engine under test can be measured by means of transducers which measure displacement, velocity, or acceleration. In practice, only velocity transducers, which are sometimes called vibration pickups, and accelerometers are used. Engine manufacturers specify vibration limits in units of velocity or acceleration. Even with a complex vibration signal containing many frequency components, an acceleration signal can be converted into an equivalent velocity signal by means of a single integration, or into an equivalent displacement signal by means of two integrations. These integrations reduce the sensitivity of the system to high-frequency vibrations; conversely, they increase its sensitivity to low-frequency vibrations. It is not possible to make such conversions by simple calculator multiplications, except for pure sine-wave signals of known frequency. Measurements made with narrowband filters (see 3.6.2) are an exception, as the output of a narrowband filter approximates a sine wave. Complex vibration signals require actual integrations. Although in theory it would be possible to convert a velocity signal to an equivalent acceleration signal by means of a differentiation, this is not done in practice because differentiation enhances high-frequency noise.

3.2 Accelerometers

An accelerometer contains a seismic mass mounted on a piezoelectric element, typically quartz or a special type of ceramic material, which produces an electrical charge in proportion to the force exerted on the element. Acceleration of the accelerometer body produces a force on the seismic mass and, therefore, on the piezoelectric element, generating an electrical charge, typically of the order of tens of picocoulombs per unit of acceleration due to gravity.

This charge is a relatively weak, high-impedance signal, which, therefore, is subject to electrical noise interference. Special low-noise cable should be used between an accelerometer and the first amplifier in the system to prevent mechanical vibration of the cable from generating spurious electrical signals caused by triboelectric effects. Relative motion between mating connectors in this circuit can produce spurious signals similarly.

Great care is needed in grounding accelerometer systems. Ground loops may inject excessive noise into the circuit. The amplifier should have a differential input, able to reject large amounts of common-mode noise. Typically, the first amplifier is a charge amplifier, which accepts the electrical charge that was developed by the accelerometer and produces a low-impedance voltage output that is accurately proportional to the input charge and, therefore, to the acceleration. When using single ended microdot accelerometers, which are used and represent approximately 50% of all accelerometers in use, care must be taken to avoid creating ground loops in the wiring between the accelerometer and the amplifier. Accelerometers (as well as velocity transducers) need differential amplifiers for high common mode rejection ratio (CMRR).

Some manufacturers now offer accelerometers which contain one or more stages of amplification within the accelerometer housing. This avoids the triboelectric effects which were discussed above, permitting use of ordinary electrical cabling. In many cases, however, the amplifier will not tolerate as wide a temperature range as the accelerometer will, limiting the application of the instrument.

3.3 Velocity Transducers

A typical velocity transducer contains a magnetized seismic mass sliding on a guide rod and restrained axially by springs. When the body of the transducer is vibrated along the axis of the guide rod, the seismic mass tends to remain in a constant position, producing relative movement between the mass and the transducer body. That movement generates a voltage in an electrical coil which surrounds the magnetized seismic mass; the voltage is proportional to the velocity of movement, typically of the order of several volts per meter per second.

This relatively strong and low-impedance signal is less vulnerable to electrical noise and triboelectric effects than the weak high-impedance signal from an accelerometer. It is still desirable to avoid ground loops and to use an amplifier with a differential input stage to reject common-mode noise.

Velocity transducers (as well as accelerometers) need differential amplifiers for high CMRR.