

 <i>An SAE International Group</i>	AEROSPACE STANDARD	SAE AS8054	REV. A
		Issued 1996-05 Reaffirmed 2005-10 Cancelled 2012-05 Superseding AS8054	
Airborne Engine Vibration Monitoring (EVM) System, Guidelines for Performance Standard For			

RATIONALE

This AS was raised at the request of the Regulatory authorities to provide a minimum performance standard for airborne vibration monitoring systems. Since its creation, these systems have greatly advanced in technology and application and AIR1839, shortly to be re-issued as ARP1839 now contains much more extensive and up-to-date information concerning such installations. Recent survey of the regulatory authorities by E-32 showed no further interest or usage of AS8054.

E-32 therefore voted for its cancellation.

CANCELLATION NOTICE

This document has been declared "CANCELLED" as of May 2012. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index.

Cancelled specifications are available from SAE.

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1. SCOPE

This SAE Aerospace Standard (AS) provides guidelines for the functional, performance, qualification and acceptance testing, and documentation requirements for the components of an airborne engine vibration monitoring (EVM) system which is intended for use as a turbojet engine rotor unbalance indicating system, per FAR 25.1305 (D)(3) on transport category airplanes.

For the purpose of this document, this means a system which can provide real-time flight deck displays of engine vibration caused by rotor unbalance, throughout the flight envelope, which are suitable for:

- a. Relating to engine vibration limits (where such limits are specified)
- b. Use in ice shedding procedures
- c. Helping the flight crew to determine which engine has the higher level of vibration, following an engine damage event.

As a minimum, the functional capability for such a system shall include the ability to compute and display vibration levels specifically related to the rotational speed(s) of the engine rotor(s). Systems which can produce only broadband vibration outputs have been used in the past but they are not considered suitable for the above purposes. Some EVM systems may also generate other outputs, suitable for such functions as engine vibration trend monitoring or trim balance calculation, but these are considered to be outside the scope of the requirements for a minimum system.

This document also defines some recommended, optional, functions and features which, while they are outside the scope of minimum requirements, are nevertheless considered to be highly desirable for a practical system.

It should be noted that systems incorporating capabilities such as described above are also sometimes referred to by the abbreviation AVM. However, there are, or can be, airborne measurements taken of vibrations from sources other than the engines.

For the purpose of this document the more descriptive term, engine vibration monitor (EVM), will be used.

1.1 Purpose:

The purpose of this document is to provide guidance on the requirements for airborne EVM systems for turbojet engines on transport category airplanes.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AIR1839 A Guide to Aircraft Turbine Engine Vibration Monitoring Systems

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-HDBK-217F Change Notice 1 Reliability Prediction of Electronic Equipment

2.3 FAA Publications:

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAA/AC 21-16C	RTCA Inc. Document, RTCA/DO-160C
FAA/AC 20-115B	RTCA Inc. Document, RTCA/DO-178B
FAA/AC 20-136	Protection of Aircraft Electrical/Electronic Systems Against the Effects of Lightning
FAA/AC 25-1309.1A	System Design and Analysis
FAR 21.611	Federal Aviation Regulations, Part 21.611
FAR 25.1309	Federal Aviation Regulations, Part 25.1309

2.4 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI S2.11-1969 American Standards for the Calibration of Shock and Vibration Sensors

2.5 RTCA Publications:

Available from RTCA Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036.

RTCA/DO-160C Environmental Conditions and Test Procedures for Airborne Equipment (Radio Technical Commission for Aeronautics).

RTCA/DO-178B Software Considerations in Airborne Systems and Equipment Certification

2.6 Other Publications:

ISA-RP37.2 Guide for Specification and Test for Piezoelectric Acceleration Transducers for Aerospace Testing

ARINC 404A Air Transport Equipment Cases and Racking

ARINC 600 Air Transport Avionics Equipment Interfaces

2.7 Definitions:

The following are definitions of terminology used herein:

BROADBAND FILTER: A broadband filter is one which has fixed low pass and high pass corner frequency break points. It is designed to highly attenuate input signals with frequencies above and below the range of interest and to pass, with equal and minimal attenuation, input signals with frequencies within the range of interest. The filter characteristics of primary interest are indicated in Figure 1.

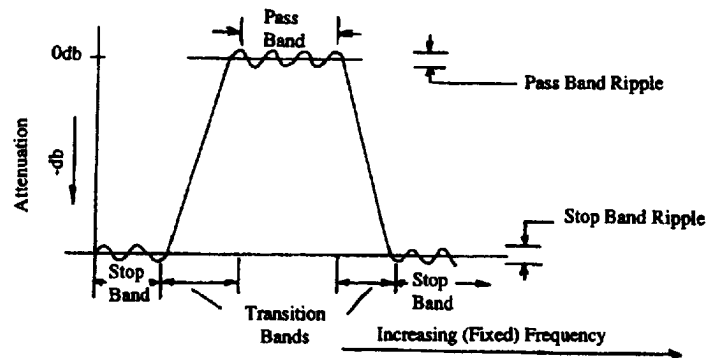


FIGURE 1 - Broadband Filter Characteristics

COMPONENT: A component is an element of a higher level unit or system. In this document the term “EVM component” specifically refers to a signal conditioner unit, a vibration sensor, a remote converter unit or a flight deck vibration display unit.

INSTALLER: The party responsible for the installation of the equipment in the aircraft and for obtaining certification for the complete system as installed.

SUPPLIER: The manufacturer and/or the manufacturer's agent supplying or quoting on the articles specified.

TRACKING FILTER: A tracking filter is a narrow bandpass filter, the center frequency of which is controlled to follow the frequency of a varying parameter of interest (in this case, the rotational frequency of an engine rotor). It is designed to highly attenuate input signals with frequencies which are not close to the present frequency of the parameter of interest and to pass, with minimal attenuation, input signals with a frequency which is close to the present frequency of the parameter of interest.

The filter characteristics of primary interest are indicated in Figure 2.

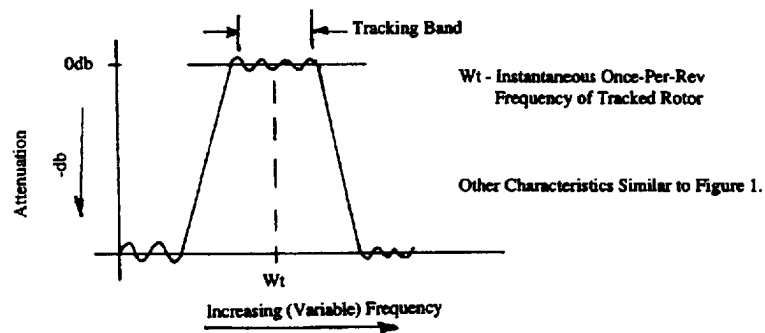


FIGURE 2 - Tracking Filter Characteristics

2.8 Abbreviations:

The following abbreviations are used herein:

AC	Alternating Current
AC	Advisory Circular
ACMS	Aircraft Condition Monitoring System
ARINC	Aeronautical Radio, Inc.
AS	Aerospace Standard
AVM	Airborne Vibration Monitor
EVM	Engine Vibration Monitor
BITE	Built-in Test-Equipment
°C	Degrees Celsius
dB	Decibels
DC	Direct Current
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
g	Acceleration Due to Gravity
Hz	Hertz
ISA	Instrument Society of America
LRU	Line Replaceable Unit
m	meters
RCU	Remote Converter Unit
RMS	Root Mean Square
RPM	Revolutions Per Minute
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automobile/Aerospace Engineering
Torr	The pressure exerted by a column of Mercury 1 mm high under the influence of 1g (Standard Gravitational Acceleration) at 0 °C.
TSO	Technical Standard Order
SPL	Sound Pressure Level
VAC	Volts (Alternating Current)
VDC	Volts (Direct Current)

3. REQUIREMENTS:

For the purpose of this document it is assumed that an EVM system consists of the following basic components:

- a. Signal conditioning unit(s) which receives inputs from engine mounted vibration sensor(s) (either directly or via a remotely mounted converter unit) and from engine tachometer(s). It processes these signals to produce outputs proportional to the level of vibration generated by engine rotor unbalance forces. The signal conditioner should be able to detect its own critical internal failure modes and provide a self-test output. An optional output for upstream system diagnosis and analysis is also recommended.
- b. Vibration sensor(s), which may include some conversion electronics, mounted in a suitable location(s) on the engine, and with the appropriate orientation(s), to measure the vibration(s) due to rotor unbalance.
- c. Remote converter unit(s) (RCU) are not used by all systems. When used, they are usually mounted as close to the sensor(s) as possible. An RCU is used to convert/amplify the low-level, direct output of the sensor(s) to a signal, which is less susceptible to noise and interference, for transmission to the signal conditioner. The RCU should be able to detect its own critical internal failure modes and provide a self-test output. An optional output for upstream system diagnosis and analysis is also recommended.
- d. Dedicated, flight deck mounted, displays for providing engine vibration information to the flight crew (unless such information is displayed by means of multifunction displays).

NOTE: While engine tachometer(s) provide necessary input(s) to the signal conditioner, they are not considered to be a part of the EVM system unless they are dedicated to that purpose. Normally the primary purpose of an engine tachometer is to provide rotor speed signals to the engine control system and other systems and to the flight deck for display. As such they are considered to be part of the engine instrumentation package.

If the same tachometers are also used for the EVM function, their characteristics and output signal quality definition, including engine and installation effects, shall be provided so that the EVM supplier may:

- a. Determine whether the tachometer characteristics are suitable for the EVM purpose and,
- b. Design the signal conditioner to properly interface with the tachometer signal(s).

The cabling and connectors that interconnect the various LRUs may, or may not, be supplied with the system but, in either case, attention should be paid to their design and characteristics. Cable lengths should be minimized and, where possible, connectors eliminated to optimize the reliability of the system.

3. (Continued):

It is recognized that the configurations for specific applications will vary. The engines being monitored may have one or more rotors. The signal conditioner may be restricted to monitoring only one engine or may be required to monitor more than one engine. The system may employ remote converter units or they may be integral with the signal conditioner, as stated above. Some systems currently in production include a unit which mounts in the forward flight deck panel and incorporates the functions of the signal conditioner, (a), and the flight deck display, (d), above. In cases such as these it is the responsibility of the supplier to select and comply with the requirements from Sections 3 and 4 as appropriate for their configuration.

It is beyond the scope of this document to cover all the possibilities, so configuration dependent requirements have been avoided except where they directly impact the required minimum performance.

The design, construction, performance, environmental capability and reliability of the EVM system and its components shall be as specified in 3.1 through 3.5.

The performance of the components, and of the EVM System as a whole, as called out in 3.1 through 3.5, shall be demonstrated under standard conditions and over the required range of environmental conditions.

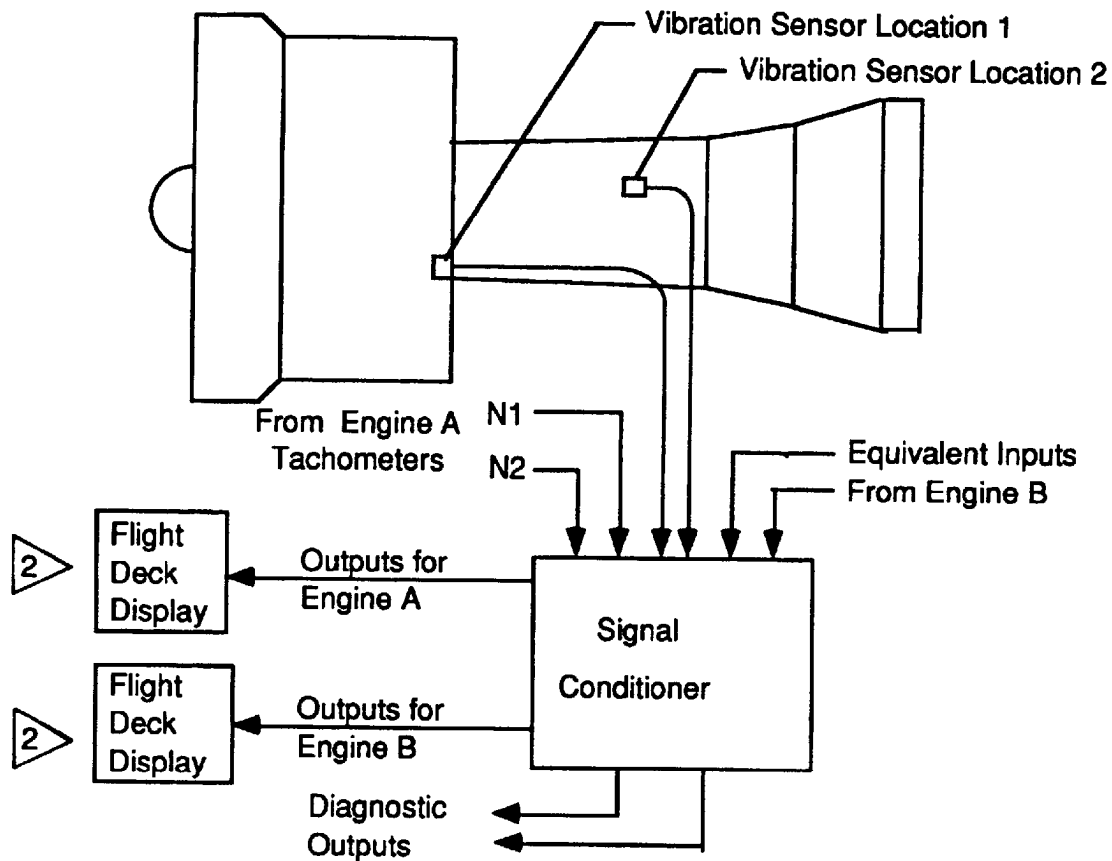
NOTE: AIR1839, covers a broader scope than this document but also contains much useful design information concerning the basic elements of a minimum system as defined herein.

Figure 3 shows a block diagram of a representative system employing signal converter/amplifiers integral with the signal conditioner unit.

3.1 General Design Requirements:

- 3.1.1 Workmanship: Workmanship shall be in accordance with the best practice of high quality aircraft equipment. Proper handling of parts and equipment shall be employed to assure freedom from physical damage such as cracks, scratches, twists, fractures, etc., and the possibility of hidden damage such as that produced by flexure of leads, stressing of soldered joints, overtightening of fasteners, etc.
- 3.1.2 Human Factors/Personnel Safety: The equipment shall be designed to adequately protect flight and maintenance personnel from injury and to minimize incorrect maintenance.
- 3.1.3 Interchangeability: Components bearing the same part number shall be interchangeable and shall not require calibration or adjustment to meet system performance requirements. Components bearing the same part number and suffix shall be identical except for changes meeting the FAR 21.611 definition of a minor change.

Components bearing different part numbers shall not be interchangeable.



- 1 Example illustrates a single signal conditioner processing two separate vibration outputs from each of two two-spool engines.
- 2 Dedicated displays shown. Shared multi-function displays may also be used.

FIGURE 3 - Typical EVM System Components



3.1.4 Dimensions and Tolerances: Where dimensions and tolerances may affect the interchangeability, operation or performance of the assembly, they shall be held or limited accordingly. Internal and external shimming shall not be used.

3.1.5 Identification

3.1.5.1 Component and/or Nameplate Marking: For each component, the following minimum information shall be legibly and permanently marked on the component, or nameplate attached thereon, in such a manner that it cannot be readily removed:

- a. Name and address (optional, included where practical) of the manufacturer
- b. The name, type, part number or model designation of the article
- c. The serial number or the date of manufacture of the article, or both
- d. AS8054 and/or TSO designation as applicable

Other information, from the list in 3.1.5.2, may also be marked on the component, or component nameplate, at the supplier's option.

All individual parts and pertinent subassemblies (first and second level) shall be marked with vendor's part number, except for those parts which do not have, and cannot be provided with, a suitable surface for markings.

3.1.5.2 Identification in the Installation Instructions: The information in 3.1.5.1 and the information below shall be provided in the Installation Instructions for each component.

- a. Country of origin
- b. Federal supplier code number
- c. Category of Approval per DO-178B
- d. Environmental Test Categories per DO-160C, Appendix A

3.1.6 Inspection Seals: Seals, embossed with the manufacturer's identification, shall be provided at strategic locations, other than those locations which are normally disassembled during replacement of line replaceable components, to indicate if disassembly has been performed after inspection.

3.1.7 Weight: The maximum weight of each component shall be specified. The weight of each component shall be kept to the minimum, consistent with good design practices to meet the operational requirements.

3.1.8 Materials: Materials shall be of a quality which relevant experience and/or tests have shown to be suitable and dependable for airborne use.

3.1.8.1 Nonmetals: Nonmetals, unless suitably protected, shall be moisture and flame resistant and self-extinguishing. Such materials shall not be capable of supporting fungus growth and shall not be adversely affected by environmental exposure as specified herein.

3.1.8.2 Flammable Materials: Flammable materials shall not be used. The materials used shall not liberate gases which can form acid or corrosive alkali. Insulation materials shall not support combustion or form current-conducting paths when subjected to electrical arcs or explosions of vapors which may be present.

3.1.9 Processes: All manufacturing processes shall be documented and be available to the installer as confidentiality permits.

3.1.10 Electrical/Electronic Design Requirements: The design, construction and performance of the EVM system shall be consistent with the reliability requirements of 3.1.12

The EVM components shall satisfy the relevant requirements of 3.1, 3.2, 3.3, 3.4, and 3.5 over the range of environmental conditions defined in RTCA DO-160C, or otherwise specified in this document, as appropriate to the airplane type and component installation.

Care must be taken to ensure that the characteristics of the individual components are compatible so that unwanted events, e.g., saturation or false indications, do not arise from environmental conditions such as steady state acceleration, low or high frequency vibration outside the range of interest and temperature changes.

3.1.10.1 Restricted Parts: No variable parts, such as potentiometers, shall be used.

3.1.10.2 Electrical Power: The system shall be designed to accept, and operate with, the electrical power characteristics defined either by the EVM manufacturer, or as required for a specific installation, including maintaining operation and indication during and after voltage transients such as will normally occur during electrical bus switching.

The maximum load of the system shall be specified.

3.1.10.3 Electrical Bonding and Grounding: The equipment grounding system shall provide for separation of AC power, DC power, chassis ground and signal ground(s). Optionally, signal ground(s) may be "referenced" to chassis ground. Wire shields shall not be used as a signal return. Conductive equipment enclosures must be capable of being bonded to aircraft structure, which may be done by dedicated faying surface contacts, bonding jumper or by wiring through an interface connector. On nonconductive enclosures, controls or metal parts which may be touched shall be bonded to ground. Case ground shall not be used for electrical power returns. Materials, surface preparation and finishes for electrical bonding surfaces shall be compatible with preservation of adequate electrical conductivity over the life of the equipment. The maximum resistance across any bonding or grounding junction shall be 10 mΩ, as manufactured.

3.1.10.4 Insulation and Dielectric Strength: These requirements are specific to each EVM component and are provided in 3.2, 3.3 and 3.4.