NOTE: The cover page of this standard has been changed for administrative reasons. There are no other changes to this document.

INCH-POUND

MIL-STD-2102A(NAVY)
18 AUGUST 1980
SUPERSEDING
MIL-STD-2102(NAVY)
20 FEBRUARY 1980

# DEPARTMENT OF DEFENSE
# TEST METHOD STANDARD

# AIRCREW ESCAPE PROPULSION SYSTEMS; VIBRATION AND SHOCK TESTS FOR


AMSC N/A

FSC 1377

DEPARTMENT OF THE NAVY
WASHINGTON, DC 20362

Aircraft Escape Propulsion Systems; Vibration and Shock Tests for MIL-STD-2102A(Navy).

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Department and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Ordnance Station, Standardization/Documentation Divison (501), Indian Head, Maryland 20640 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

## FOREWORD

This standard contains the vibration and shock tests to which aircrew escape propulsion systems (AEPS) are to be subjected.

CONTENTS

## 1. SCOPE

1.1 Scope. This standard establishes vibration and shock tests of aircrew escape propulsion systems (AEPS) to determine if the systems are constructed to withstand dynamic vibration and shock stresses expected during service use, handling, and transportation.

## 2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

| | |
|---|---|
| MIL-P-83126 | Propulsion Systems, Aircrew Escape, Design Specification for |
| MIL-A-85097 | Aircrew Escape Propulsion Systems (AEPS), Procurement Specification for |

STANDARDS

MILITARY

| | |
|---|---|
| MIL-STD-810 | Environmental Test Methods |
| MIL-STD-45662 | Calibration Systems Requirements |

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the Government procuring activity or as directed by the contracting officer.)

## 3. DEFINITIONS (Not applicable)

## 4. GENERAL REQUIREMENTS

4.1 General. Vibration and shock tests shall be conducted during the design verification (Phase II) and service release (Phase III), test phases of aircrew escape propulsion system, hereinafter referred to as AEPS, as described in MIL-P-83126. Vibration tests shall be conducted for the preproduction phase as described in MIL-A-85097.

4.1.1 Vibration test. Vibration testing is conducted to ascertain whether the AEPS is sufficiently constructed to withstand dynamic vibrational stresses expected during handling, transportation, and service use.

4.1.2 Shock test. Shock testing is conducted to ascertain whether the structural integrity and performance of the AEPS are satisfactory with respect to the mechanical shock environment expected during aircraft carrier landings.

4.2 Test sample. The number of AEPS to be vibrated and shock tested shall be in accordance with MIL-P-83126 or MIL-A-85097, as applicable.

4.3 Unit inspection. Visual and radiographic inspections in accordance with MIL-P-83126 or MIL-A-85097 shall be performed on AEPS prior and subsequent to vibration and shock testing.

4.4 Equipment. The AEPS shall be attached to an exciter table by means of a rigid fixture capable of transmitting the required input vibratory acceleration. The configuration shall be approved by the Government procuring activity and shall apply excitation to the AEPS only through the attachment fittings unless otherwise approved. Any design change of fixture shall be approved by the Government procuring activity.

4.5 Vibration. The AEPS shall not sustain damage, initiate, or subsequently fail to operate in conformance with applicable ballistic requirements after being subjected to testing in accordance with 5.5 herein.

4.6 Shock. The AEPS shall not sustain damage, initiate, or subsequently fail to operate in conformance with applicable ballistic requirements after being subjected to testing in accordance with 5.6 herein.

5. DETAILED REQUIREMENTS

5.1 Temperature conditioning. Prior to initiating a test that requires the AEPS to be at the specified temperature, each AEPS shall be conditioned for the required time interval specified by the Government procuring activity, and maintained within the required temperature tolerance for the duration of the test.

5.1.1 Temperature makeup time. If the temperature falls outside of the specified temperature limits for a period of more than five minutes, all testing shall stop and the AEPS shall be reconditioned. A reconditioning time of two minutes for every minute the AEPS spent outside the specified temperature envelope is required; however, the AEPS does not have to be reconditioned in excess of the initial conditioning time interval.

5.1.2 Test failure or malfunction. If an AEPS fails or is suspected of having failed during any part of testing, the test shall be stopped immediately and the Government procuring activity notified of the failure within 24 hours by message or by telephone followed by a message (see Appendix). The AEPS and equipment shall not be disturbed until after examination by the Government procuring activity or its authorized representative. Examination shall begin within 72 hours following notification.

5.1.2.1 Failure report. The following information shall be included in the failure report (see Appendix):

a. Approximate time of failure
b. Location and type of failure
c. Extent of failure or malfunction
d. Loading at approximate time of failure
e. Photographs of failure, if visible.

5.2 Test system design criteria. Precautions shall be taken in the establishment of mechanical interfaces to minimize the introduction of undesirable responses in the test setup. Whenever possible, the test item (AEPS) shall be distributed uniformly on the vibration exciter table in order to minimize the effects of unbalanced loads. Vibration amplitudes and frequencies shall be measured by techniques that will not significantly affect the AEPS's input control or response. The input control sensing device(s) shall be rigidly attached to the vibration table, or if the intermediate structure is used, as near as possible to the attachment point(s) of the AEPS. The following design criteria are applicable to the test system:

a. The minimum first natural resonance frequency of the fixture (all orientations) shall be no less than the maximum frequency of 2000 hertz (Hz). It is the contractor's responsibility that this goal be met as closely as physically possible.

b. Fixture material and design shall offer good damping characteristics (fo rexample, magnesium, aluminum).

c. Welded joints shall be used whenever possible, and no spot welding shall be allowed. Butt welds shall be the only welds to be used.

d. The type of vibration fixture-to-AEPS mounting bolts and the vibration fixture are to be approved by the Government procuring activity prior to their use. The bolts are to have drilled heads for the installation of lockwires.

e. The fastener system shall be designed so that sufficient bolts, tightened to specific torque values, are used to prevent separation or loosening of the fixture from the exciter table during testing. A tightening torque of all mounting bolts shall be specified. At each

opportunity during vibration, the lockwires are to be visually inspected to ensure the bolts have not loosened.

f. Bolts shall not be loaded in shear for vibration where possible.

g. Bolts loaded in tension shall be spaced no more than three inches apart.

h. Bolt lengths shall be minimized (for example, by bolt hole counterboring) where possible and practical, without adversely impacting the rigidity of the material being joined by the bolts.

i. No shear plane shall pass through a threaded section. These loads are to be carried by bolt shanks installed in close fitting (.005 inch max clearance) bores/counterbores. Shanks are to fit in both mating parts .25 inch minimum.

j. It may be preferable to use two or three separate specialized orientation fixtures for holding the AEPS to the exciter table rather than using one fixture that can be used to orient the AEPS in three mutually perpendicular attitudes with respect to the exciter table.

k. The fixture(s) shall be designed and/or procedures shall be used to minimize stress/strain placed on the AEPS during testing at the conditioned test temperature by thermal expansion differences between the AEPS and test fixture.

5.3 Transmissibility evaluation. The vibration/shock fixture(s) shall be evaluated for transmissibility prior to vibration or shock testing.

5.3.1 Test setup. The fixture(s) shall be bolted to the exciter table in the same manner proposed for the actual AEPS tests, but without attaching the AEPS. Input accelerometers shall be placed on the exciter table near the fixture. Output accelerometers shall be placed at each fixture-to-AEPS attachment point in a manner that will simulate maximum actual input to the AEPS at each point. Tracking filters shall be used in both input and output accelerometer circuits. Approval of the test setup shall be obtained from the Government procurement activity, or its representative, prior to initiation of actual tests. Input acceleration shall simulate actual test conditions except that frequency shall be varied at a rate not to exceed 1.00 octave per minute. Output acceleration shall be plotted automatically as amplitude versus frequency on an X-Y plotter and continually monitored on an oscilloscope. If a fixture is to be oriented on the exciter table in more than one way, a transmissibility test shall be required for each different orientation. Transmissibility evaluation shall include, for each fixture configuration, all axes of input, and both vibration and shock inputs. The following guidelines shall apply to fixture acceptability. In the 0-2000 Hz frequency range, the maximum transmissibility at the test item mounting point(s) is two (2), and at any point on the fixture is three (3). The maximum transverse motion must be less than the input.

5.4 Test instrumentation. All test measurements shall be made with instruments whose accuracy conforms to the following:

a. The specified tolerance, range, or limit shall be reduced by the amount of inaccuracy of the test instrument used; all test measurements shall be made with instruments whose accuracies have been verified, within the year preceding test initiation, in accordance with MIL-STD-45662 and to the satisfaction of the Government procuring activity; calibration records of all test equipment shall be maintained for a period of at least 1 year from date of test completion and shall be made available for review to the Government procuring activity before test initiation and, if requested, afterwards (see Appendix).

b. Instrumentation (all of which shall be provided by the contractor) shall be capable of measuring acceleration within ±5.0% of measured acceleration, frequency within ±1.0% of measured frequency or ±1%Hz, whichever is greater and temperature within ±2°F of measured temperature at the temperature for which the test shall be conducted. Tolerance of required instrumentation shall be adequate to maintain required acceleration and frequencies. AEPS's temperature shall be maintained within ±5°F of the required temperature. For the shock tests, instrumentation shall also be capable of measuring time within ±0.5 milliseconds.

5.4.1 Accelerometer instrumentation. The contractor shall provide and install accelerometer instrumentation on all AEPS. Pretest and post test minimum calibration information supplied shall include:

a. Voltage sensitivity at -65° and 165° F

b. Charge sensitivity at -65° and 165° F

c. Frequency response at 20, 80, 320, 1280, and 2000 Hz (use a linearity run at testing levels for the entire frequency range).

5.4.2 Input acceleration. To measure input acceleration, a single axis control accelerometer shall be mounted on the vibration fixture as close as possible to the AEPS attachment point. The input acceleration shall be controlled, for each axis, at the attachment point at which transmissibility is the worse, as determined by the Government procuring activity's authorized representative.

5.4.3 Output acceleration. A technique shall be used to determine the most critical locations for measuring output g's. One of the AEPS at ambient temperature shall be used for this determination. Conduct vibration cycling in all three axes per paragraph 5.5; except the temperature requirement. During this cycling, maximum displacement of the AEPS components shall be determined. Based upon this information, the location of three accelerometers shall be determined. Triaxial accelerometers shall then be mounted to the AEPS.

5.4.4 Temperature history. A continuous temperature history of the exterior surface of the AEPS shall be kept during the tests. Monitoring of this temperature history shall consist of, as a minimum, a continuous temperature history of one surface area. A visual check of the temperature history shall be made at approximately 20 minute intervals.

5.4.5 FM recording equipment. All vibration data shall be recorded on FM tape at a tape speed of 15 inches/second, minimum. Tape annotation shall include, but not be limited, to the following:

a. Test item identification
b. Test temperature
c. Test direction
d. Date
e. Time
f. Tape recorder track identification
g. Tape speed (15 inches/seconds, minimum required)
h. Center frequency of FM carrier
i. Full-scale calibration for each channel
j. Description of the portion of the test being conducted at the time of the recording.

5.4.5.1 AC calibration. A full-scale AC calibration for each track of at least 1-minute duration shall be recorded at the start of each reel of magnetic tape at each frequency extreme.

5.4.5.2 Magnetic taped data. All of the magnetic taped data shall be retained by the contractor for a period of not less than one year from date of test completion. Any of these data shall be supplied to the Government procuring activity upon request (see Appendix).

5.4.5.2.1 Recordings. Recordings shall be made as follows:

a. All resonance surveys shall be recorded continuously.

b. Resonance dwells shall be recorded for one minute at the beginning of each 30-minute period and at the end of the particular resonance dwell test.

5.4.5.2.2 Additional data presentations. Additional data presentations in the form of X-Y plots ("g" peak versus frequency) shall be provided for all the recorded data channels after each resonance survey and prior to any resonance dwell test.

5.4.5.3 Photographs. Photographic documentation as required by the Government procuring activity shall be provided by the contractor (see Appendix).

5.4.5.3.1 Photographic documentation. Photographic documentation shall cover (1) each different test setup, (2) failed parts, (3) damaged parts, (4) irregularities, and (5) other requirements to be set by the Government procuring activity representative.

5.5 Vibration. Vibration tests for AEPS shall be in accordance with the requirements specified for the type aircraft in which the AEPS are installed. In addition to compliance with the applicable vibration test, the AEPS shall comply with Method 514.2 of MIL-STD-810 for those applications whereby guns are installed on the aircraft. However, if the maximum test spectrum level of the gunfire configuration is equal to or less than the Method 514.2 vibration test levels, the gunfire vibration is not required.

5.5.1 Aircraft with jet engines. Each AEPS shall be subjected to random vibration in accordance with MIL-STD-810, Method 514.2, Procedure IA, for a total of 9 hours; 3 hours in each of 3 axes. The input vibratory acceleration shall be in accordance with MIL-STD-810, Figure 514.2-2A, Curve A, with a $W_0$ factor of $0.1G^2/Hz$.

5.5.2 Propeller airplanes. Each AEPS shall be subject to resonance search and vibrated as specified hereafter.

5.5.2.1 Resonance search. Resonance searches shall be individually conducted on all AEPS in the three axes and at the maximum and minimum testing temperature. Input vibratory acceleration shall be in accordance with MIL-STD-810, using Curve H of Figure 514.2-2, or Curve M of Figure 514.2-3 for AEPS used in helicopters, as determined by the Government procuring activity. All resonances shall be as noted. During the resonance survey, a permanent continuous record of input vibratory acceleration shall be kept. This record may be made on an oscillograph, but preference is for FM tape. During the resonance search, frequency shall be varied at a rate not to exceed 0.50 octave per minute. The reasonance search shall be conducted with all axes of the output accelerometers being monitored. Based upon these nine outputs (minimum), the four resonant points (maximum) shall be selected.

5.5.2.2 Resonance. A resonance shall be defined as a frequency at which a clearly defined peak in the amplitude ratio (ratio of the output acceleration in any of the three AEPS axes to the input acceleration as measured at the excitation attachment points) exceeds a value of 1.5 to 1.

5.5.2.3 Resonant point. If the resonance survey indicates a frequency band wherein the amplitude ratio exceeds 1.5 to 1 (as contrasted to a clearly defined peak), this entire band width shall be considered one resonant point. The minimum frequency band width which shall be considered a resonant band shall be 0.33 octave. If, also within this band width, there are clearly defined amplitude peaks, the most severe of these shall be considered an additional resonant point.

5.5.2.4 Endurance vibration. Each AEPS shall be sinusoidally vibrated for 15 hours; 5 hours in each of three axes specified herein. One half hour of endurance vibration shall be performed at each resonant frequency for the maximum of four most severe resonant frequencies. The remaining vibration time shall be used for cycling. Input vibratory acceleration for each resonant frequency shall be in accordance with the acceleration and displacement of Curve H, Figure 514.2-2 of MIL-STD-810, or Curve M, Figure 514.2-3 of MIL-STD-810 for AEPS used in helicopters, as determined by the Government procuring activity. If no resonant frequencies are detected in an axis, the AEPS shall be vibrated in accordance with the aforementioned provisions of MIL-STD-810. Total vibration time for the AEPS shall be 15 hours which shall include resonant and nonresonant frequencies, as applicable. Endurance vibration of frequency bands which are classified as resonances in 5.5.2.1 shall be conducted as continuous repetitive sweeps across that entire band up in frequency and return, at a rate not to exceed 0.50 octave per minute. Only one AEPS shall be vibrated at one time during resonance dwell. However, should it be possible or necessary (or desirable from a scheduling standpoint) several AEPS may be frequency cycled simultaneously, as long as the fixture and accelerometer instrumentation on each AEPS meets the requirements specified herein and is approved by the Government procuring activity. The output g's shall be monitored every fifteen minutes on every accelerometer channel. If a significant divergence has occurred, stop the test and inspect the test set-up for an abnormality/failure.

5.6 Shock. Shock shall be transmitted to the AEPS through the attachment fittings to simulate service conditions. Each AEPS shall receive a total of 1500 shocks. The duration of each shock shall be 10 ± 2 milliseconds.

a. Fifteen g's with shock applied in both directions along the longitudinal axis of the AEPS (500 shocks each direction).

b. Fifteen g's with shock applied in a direction perpendicular to the longitudinal axis of the AEPS (500 shocks).

5.6.1 Photographic record. A photographic record of the shock wave form shall be kept. Three photographs of the wave form shall be taken for each set of AEPS shocked in each axis; one photograph of one of the first shocks in each axis; one after approximately 250 shocks in each axis, and one near the 500th shock in each axis.

5.6.2 Shock wave form. The shock shall be of essentially a square wave (rounded corners) shape. This rise and decay time will be a maximum of 2.00 milliseconds as measured between the 10 percent and 90 percent levels of the peak acceleration.

5.7 Sequence of testing. Shock testing will be conducted immediately after vibration testing in each axis.

5.8 Test documentation. A complete record and description of test equipment, methods, and results, including the results of retests must be kept to provide a proper analysis of the technical effort and results. (Formal reporting shall be done only as required by the contract or work assignment (see Appendix).) To assure a proper record, the following major items of test effort shall be documented:

a. Test level and frequency distribution
b. Place and time of test
c. Temperature and other test conditions
d. Measurement techniques and instrumentation
e. Methods of inspection
f. Duration of vibration testing
g. Any visual defects.

6. NOTES

6.1 Safety precautions. The safety precautions requirements of the "Contractors" Safety Manual for Ammunition, Explosives, and Related Dangerous Material" (DOD 4145.26M) are applicable and should be specified in the contract as required by the Defense Acquisition Regulation (DAR) 1-323. NOTE: When this standard is used as part of the description of work to be accomplished by a Government activity, the safety precaution requirements of "Ammunition and Explosives Ashore" (OP 5) should be made applicable.

6.2 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

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# APPENDIX

## DATA REQUIREMENTS

10. Data requirements. When this document is used in a procurement which incorporates a DD Form 1423 and invokes the provisions of Defense Acquisition Regulation (DAR) 7-104.9(n), the data requirements identified below will be developed or specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Data Item Requirements List (DD Form 1423) incorporated into the contract. When the provisions of DAR 7-104.9(n) are not invoked, the data specified below will be delivered by the contractor in accordance with the contract requirements. Deliverable data required by this document is cited in the following paragraphs of the standard:

| Paragraph | Data Requirement | Applicable DID |
|---|---|---|
| 5.1.2 | Flash report | DI-T-1905 |
| 5.1.2.1 | Failure report | DI-R-4805 |
| 5.4 | Calibration-Maintenance Test Data | UDI-T-20340 |
| 5.4.5.2 | Magnetic taped data | - |
| 5.4.5.3 | Still photographs | DI-A-5019 |
| 5.8 | Test documentation | - |

(Copies of data item descriptions required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

# STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE: MIL-STD-2102A(NAVY), Aircrew Escape Propulsion Systems; Vibration and Shock Tests For

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

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☐ YES ☐ NO *(If "Yes", in what way?)*

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