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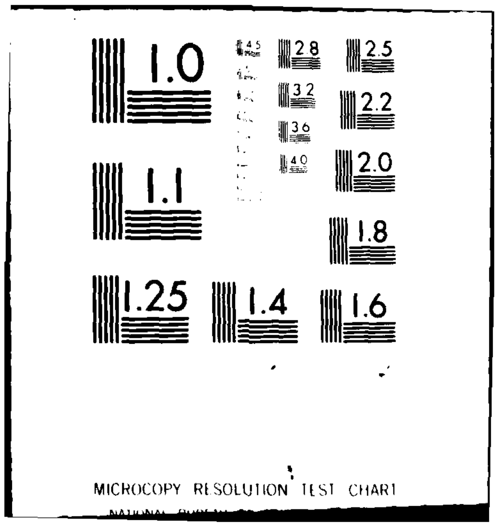
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# VIBRATION TEST LEVEL CRITERIA FOR AIRCRAFT EQUIPMENT


Preston S. Hall

Environmental Control Branch
Vehicle Equipment Division


December 1980

TECHNICAL REPORT AFWAL-TR-80-3119

Final Report for Period 6 November 1978 to 30 September 1979



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This technical report has been reviewed and is approved for publication.

Preston Scott Hall
PRESTON S. HALL
Combined Environments Test Group
Environmental Control Branch

FOR THE COMMANDER

Ambrose B. Nutt
AMBROSE B. NUTT
Director
Vehicle Equipment Division

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This study details inhouse efforts that recommend vibration test level criteria for reliability of aircraft equipment. The study assesses the impact of current vibration test level criteria on the resultant reliability statistics of aircraft equipment. Problems of profiling mission vibration environmental stresses as compared to other environmental stresses are analyzed. An analysis of the readily available tools to determine the vibration stresses is also conducted. A comparison is made of various vibration exposure times and levels for a number of equipment under multiple tests. The resulting reliability

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under the multiple tests is compared to field reliability data for the equipment studied.

# FOREWORD

This report was prepared by the Combined Environments Test Group of the Environmental Control Branch, Vehicle Equipment Division, Air Force Wright Aeronautical Laboratories (AFWAL/FIEE), Wright-Patterson Air Force Base, Ohio. This report contains the results of an inhouse research program to investigate the methods for formulating vibration test conditions used in MIL-STD-781 and Combined Environment Reliability Testing (CERT) and recommending future vibration test level criteria for aircraft equipment.

This work unit was conducted from 6 November 1978 to 30 September 1979 under work unit 24020423 with Preston S. Hall as project engineer.

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# SECTION I

# INTRODUCTION

This report focuses on the methodologies used to formulate the vibration conditions used during each test sequence of the Combined Environment Reliability Test (CERT) and to assess the impact of the resultant reliability statistics. Section II points out the problems of mission profiling vibration environmental stresses as compared to other environmental stresses. This is followed by a description of the general approach to vibration test condition formulation utilized for each of the three test sequences of the CERT program.

The purpose of the CERT Evaluation Program, conducted by the Air Force Wright Aeronautical Laboratories (AFWAL), is to evaluate the effectiveness of CERT for early identification of deficiencies and to provide insight into how the equipment will perform in operational service (Reference 1). In this program, up to ten different equipment items will be exposed to up to three different levels of environmental simulation; namely, Full CERT, CERT Without Altitude, and MIL-STD-781C Appendix B (Reference 2). This program is to determine the degree of correlation between these three different test sequences and the actual field reliability in terms of failure rates and modes. Environment mission profiles simulated by Full CERT include altitude, cooling air temperature, cooling airflow, cooling air humidity, random vibration, input voltages, and on/off cycling. All environments of the mission profiles are developed from either actual field data or by use of computerized models based on expected aircraft parameters. The environmental profiles for the MIL-STD-781C tests are in accordance with the standardized profiles of Appendix B of said standard.

Each of these test sequences utilized different methodologies for the establishment of test conditions. MIL-STD-781C Appendix B was the most completely defined in terms of methodology of determining test conditions, while Full CERT and CERT Without Altitude made use of many readily available tools such as analytical models, measured flight test data, or engineering judgments.

## SECTION II

## RELIABILITY TESTING VIBRATION CRITERIA BACKGROUND

After considerable concern was expressed regarding the reliability of avionics equipment which was used in high performance aircraft, an investigation was conducted (Reference 3) to determine how many avionics field failures were environmentally induced and to define the significant environmental parameters affecting avionics reliability. The evidence was conclusive that environmental conditions are responsible for 52% of the avionics field failures, with 90% of environment related failures attributed to temperature, altitude, humidity, and vibration (Reference 3).

Current reliability test procedures do not expose avionics equipment to realistic environmental stresses, thus contributing to the poor correlation between field and laboratory failure rates and modes. AFWAL has conducted a number of reliability tests using the flight profile concept, designed around basic aircraft missions, as a straightforward approach to identify failure modes and rates on avionics equipment in the laboratory comparable with field experience. During the ongoing CERT Evaluation Program, each engineer responsible for a test in the program individually developed the flight profiles. In many cases, flight profiles were developed using measured data, analytical data, or a composite of both. Regardless of the data source used, each engineer attempted to develop profiles that were representative of the flight conditions that a piece of avionics would see in service.

As mentioned previously, the flight profiles representative of aircraft missions (combat, low altitude bombing, training, reconnaissance, etc.) form the foundation for the environments to which the avionics will be exposed. The result is a very tailorable test with parameters traceable to characteristic circumstances. The major environmental stresses that are used in the CERT Evaluation Program are temperature, humidity, altitude, and vibration. Each environmental stress, with the exception of vibration, would have a time-varying profile that was directly related to the flight profile. Due to the limitations of vibration controllers, vibration profiles had to be structured from multiple vibration spectra representing various phases of the mission flight profile; for example, takeoff, cruise, combat, and landing (Figure 1). The resulting vibration spectra require two parameters, amplitude and frequency, to define a unique vibration stress (Figure 2). During the CERT Evaluation Program, each test engineer selected one of three techniques to generate the vibration spectra.

Since the CERT Evaluation Program was structured to compare the present MIL-STD-781 methods with the CERT concept, the conventional means for generating vibration spectra as outlined in MIL-STD-781C Appendix B was one technique used throughout the program. The criteria used in the specification are very straightforward with just two spectra shapes (Figure 3) and two equations expressing the levels for the spectra. The equations are related to the aerodynamic or acoustic induced vibrations and the only information required is Mach number, altitude, and equipment location (Table 1). The Mach number and altitude values obtained from the mission flight profiles would be related to a specific portion of the profile instead of every instant of time. A maximum of four vibration levels will be determined by: (1) takeoff, (2) maximum aerodynamic pressure [q max] [high speed dash], (3) minimum aerodynamic pressure [q min] [cruise], and (4) average aerodynamic pressure [q avg] [combination of climb, dive, combat, etc., phases] (Reference 4).

The CERT concept of testing used two techniques of generating vibration spectra for the evaluation program. Since CERT places an emphasis on realism, flight data were often used to generate vibration spectra. Various sources of data are available for obtaining flight time histories of vibration, which can be matched very closely to characteristic mission flight profiles. The disadvantage of flight data is that data may not always be available for a specific equipment

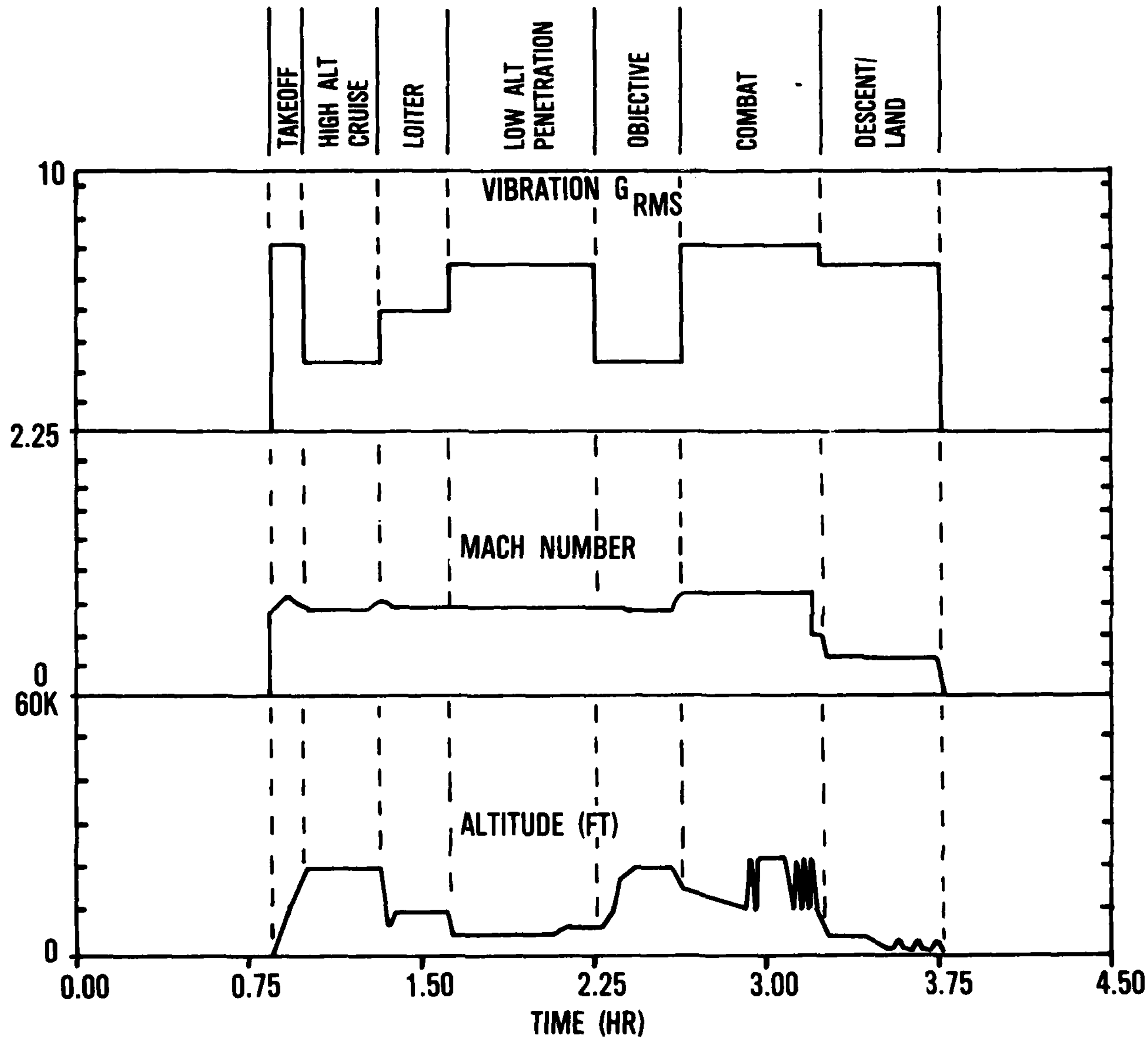



Figure 1. Typical Mission Flight Profile

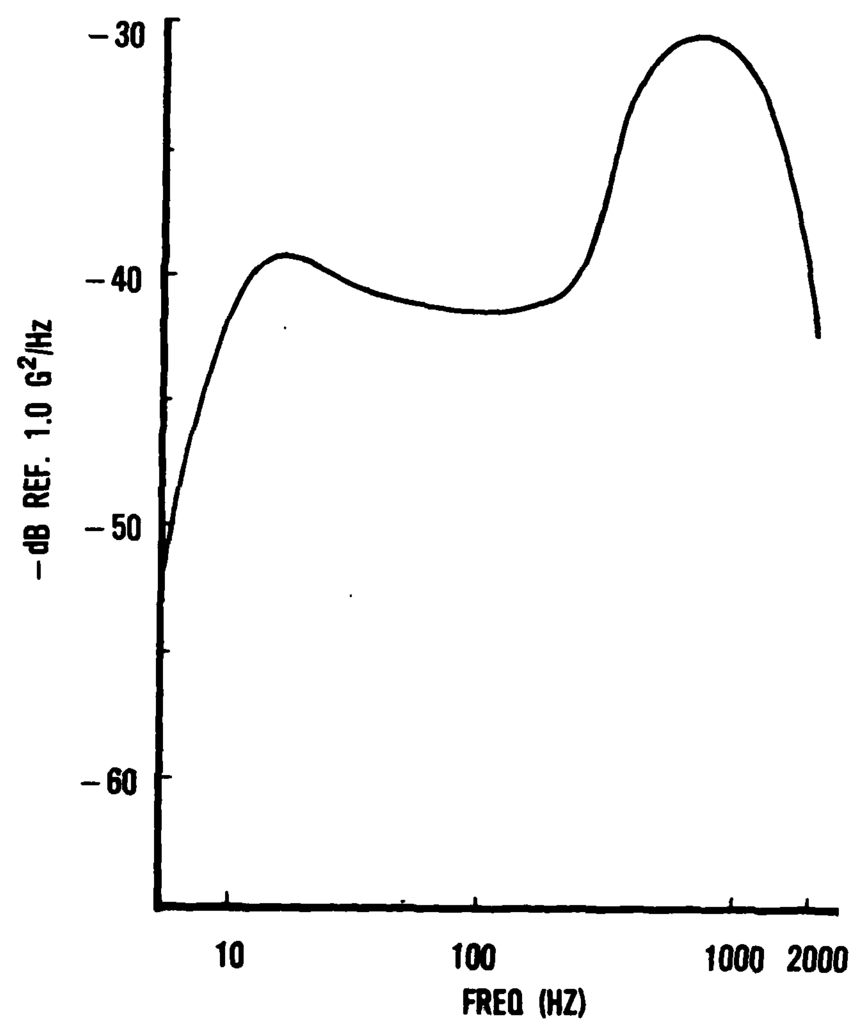
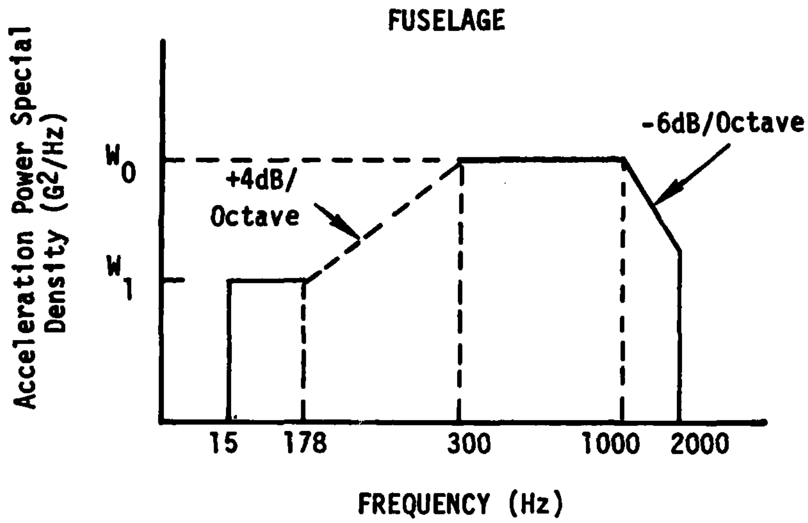



Figure 2. Random Vibration Spectrum - Avionics Bay Radio Location



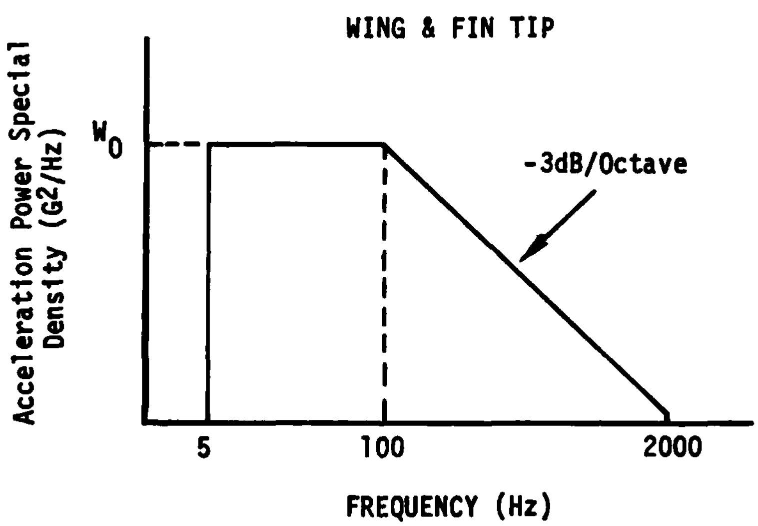




Figure 3. Jet Aircraft-Random Vibration Test Envelope

TABLE 1

MIL-STD-781C JET AIRCRAFT-RANDOM VIBRATION TEST CRITERIA

Aerodynamic Induced Vibration

$W_0 = K(q)^2$ q = Dynamic Pressure (when q > 1200 psf use 1200)

$W_1 = W_0 - 3$ dB

| K | Equipment location |
|---|---|
| $.67 \times 10^{-8}$ | Equipment attached to structure adjacent to external surfaces that are smooth, free from discontinuities. |
| $.34 \times 10^{-8}$ | Cockpit equipment and equipment in compartments and on shelves adjacent to external surfaces that are smooth, free from discontinuities. |
| $3.5 \times 10^{-8}$ | Equipment attached to structure adjacent to or immediately aft of surfaces having discontinuities (that is, cavities, chins, blade antennas, and so forth). |
| $1.75 \times 10^{-8}$ | Equipment in compartments adjacent to or immediately aft of surfaces having discontinuities (that is, cavities, chins, speed brakes, and so forth). |

SPECIAL CASE CONDITIONS

Fighter Bomber

| Condition equipment location | $W_0$ |
|---|---|
| Take off/attached to or in compartments adjacent to structure directly exposed to engine exhaust Aft of engine exhaust plane (1 minute) | .7 |
| Cruise/(same as above) | .175 |
| Take off/in engine compartment or adjacent to engine Forward of engine exhaust plane (1 minute) | .1 |
| Cruise/(same as above) | .025 |
| Take off, landing, maneuvers/wing and fin tips decelleration (speed brake) (1 minute) | .1 |
| High q (> 1000 psf)/wing & fin tips | .02 |
| Cruise/wing & fin tips | .01 |
| Take off/all other locations (1 minute) | .002 |

location. Also, this technique may not be useful to generate vibration spectra for equipment to be used in new aircraft for which no flight data exist.

Another technique of generating vibration spectra used in the CERT program is analytical prediction. The vibration prediction technique most commonly used was a computerized generation of vibration spectra that was developed by AFWAL/FIEE (Reference 5). The vibration spectra resulting from this technique are a very close approximation of flight data and relate to specific aircraft, maneuvers, and equipment locations. The prediction technique requires the availability of a computer, the prediction software, and aircraft parameters: distance of the avionic specimen from the aircraft nose, distance of specimen from skin, equipment weight, fuselage diameter, skin thickness, skin material, and mounting configuration for the location of the avionic specimen, along with specific Mach number-altitude combinations and straight-and-level or buffet turn maneuvers. At present, computer software has the capability to predict levels for only five fighter aircraft. In order for this technique to be used on aircraft other than the five preprogrammed, it is necessary to supplement the program with additional information regarding fuselage bending modes and transfer functions describing the primary and secondary structures of the aircraft in question.

The commonality of all these methods of vibration spectra generation is that all are dependent upon Mach number and altitude combinations. The spectra vary in shape and amplitude depending upon which technique is used. The methods used in the CERT concept generally resulted in more stylized spectra shapes, which seemed to satisfy the desire to achieve a degree of realism. The ability to time vary the spectra in direct relation to the time varying Mach number and altitude values of a mission flight profile is at present technically impossible due to the limitation of the state-of-the-art for vibration controllers. With all these considerations kept in mind, the issue of concern is: What is required of test criteria to identify realistic failure rates and failure modes in the laboratory?

## SECTION III

## VIBRATION SPECTRA GENERATION

Before an engineer can determine the vibration spectra to be used for either MIL-STD-781 tests or CERT, he must first examine the various mission/environmental profiles that are possible for the aircraft/avionic combination. Figure 4 shows a typical logic flow diagram a test engineer may use in establishing the test profiles for a piece of avionics in a specific aircraft. An individual aircraft type is designed to operate within a specific flight envelope and to fly specifically determined mission profiles. These design flight envelopes and mission profiles should be utilized when formulating the environmental profiles for a test. A number of mission profiles may be possible for one aircraft type, but statistically only two may be representative of the aircraft's major life. After the aircraft mission profiles have been determined for testing, the environmental profiles shall be generated and shall vary according to the aircraft mission profile. As pointed out earlier, the thermal, humidity, and altitude test environment profiles can have a one-to-one time varying relationship with the aircraft mission profile just as in flight. However, aircraft mission profiles must be analyzed by individual flight phases such as takeoff, climb, mission objective, descent, and landing to generate a number of vibration spectra which would make up the environmental vibration profile to which the test specimen is exposed sequentially. After the test engineer has determined what flight phases significantly impact the test, he must determine the maximum, minimum, or average conditions and Mach number-altitude combinations necessary to generate the vibration spectra. The test engineer then makes another judgment as to whether he wants multiple vibration spectra or a composite of several for the aircraft mission profile.

After determining the vibration spectra required to give a representation of vibration stresses, the engineer must give consideration to test equipment limitations. There exists a number of ways to control vibration inputs, all of which have their limitations. The devices to control

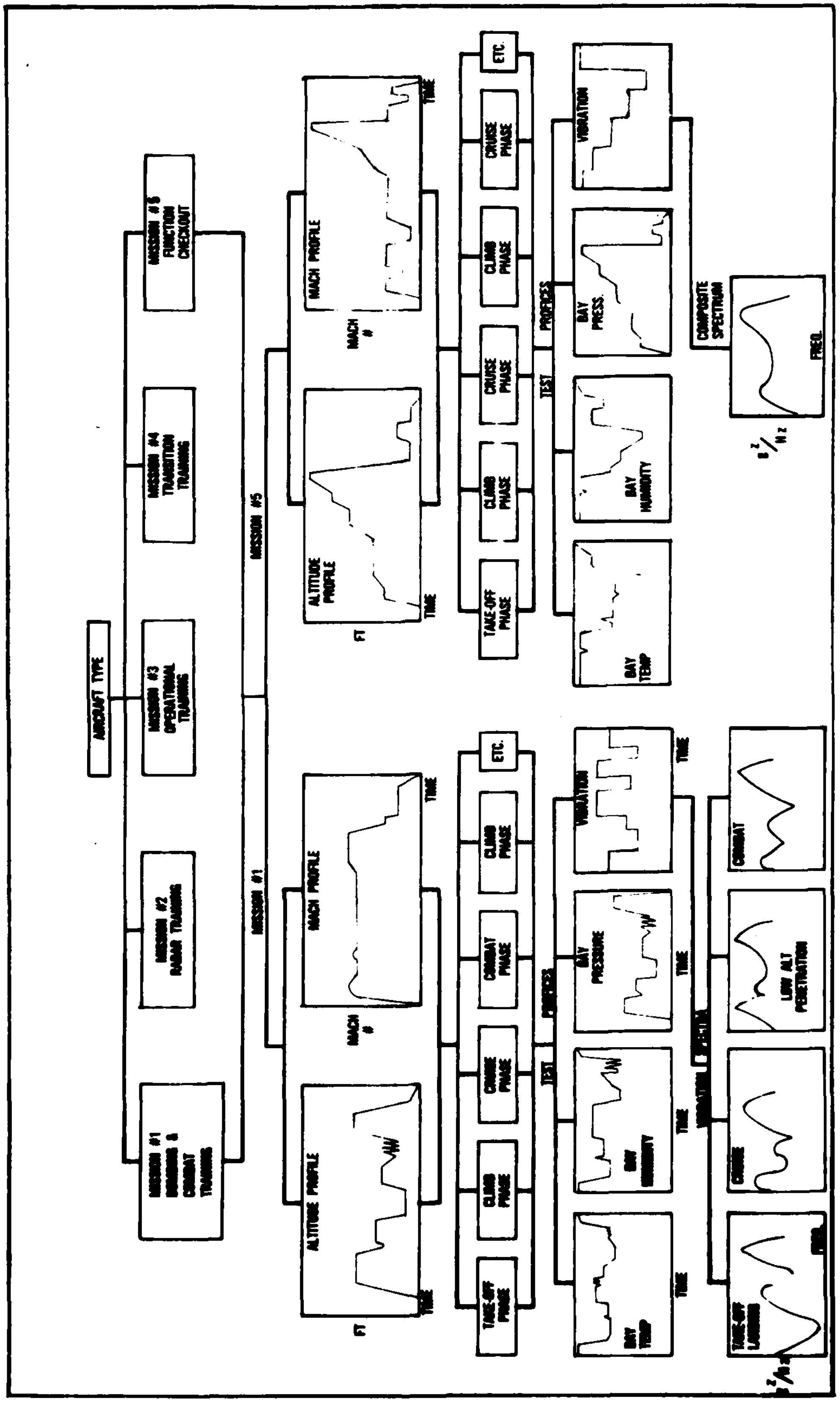



Figure 4. Test Profile Generation Logic Diagram

vibration range from simple audio recording equipment to extensive digital computer controllers (Reference 6).

The minimum level of a vibration spectrum is of concern for any vibration system. With both analog and digital controllers there exists a noise floor or a level of vibration that is so low that the controller's signal to noise capability is exceeded. The manufacturer establishes a cut-off level for a controller relative to its characteristic noise floor in order to assure good controllability. For some cases in the CERT Evaluation Program, the levels of vibration derived from flight data and analytical methods have been below the cut-off level of the controllers. A judgment must be made to either eliminate vibration exposure during these periods of the vibration profiles or choose some minimum spectrum level that the controller could handle for the total mission.

Economics is another concern if vibration requirements impose the use of more sophisticated vibration control equipment. The developer of a piece of avionics may find it economically impossible to purchase a sophisticated digital system in order to achieve the vibration requirements. The analog controller is fine for vibration spectrum control; however, the major difference between it and digital systems is that only one spectrum shape per mission simulation can be effectively controlled. Considerable time is required to establish a spectrum and there is no convenient method of storing multiple spectra that may be introduced at various times to represent different phases of a vibration profile. Early tests during the CERT Evaluation Program used analog systems, as digital controllers were not available. A single vibration spectrum was used throughout the test and the mean time between failures (MTBF) was in good correlation with field MTBF data (Reference 7).

Under MIL-STD-781 procedures for establishing vibration spectra, a number of the engineering decisions are eliminated and equipment limitations are nonexistent in the majority of cases. By definition, the engineer is still required to give consideration to the various mission/environmental profiles that are possible for the aircraft/avionic combination to be tested. However, when design flight envelopes and specifically designated flight mission profiles are not available, the generalized mission profiles listed in MIL-STD-781C, Appendix B are to be used for development of environmental profiles.

With regard to vibration spectra generation, MIL-STD-781C, Appendix B has only two spectrum shapes and the level is dependent upon Mach number-altitude combinations obtained from actual profile data or given values in Appendix B (Tables 2, 3, and 4) (Reference 4). A constant value also must be determined from a choice of four values relating to equipment location. If the level for particular phase of the vibration profile is less than 0.001 $g^2$/Hz, vibration exposure is not required.

The criteria in MIL-STD-781 give the test engineer the advantage of determining numbers of missions, flight phases, and vibration spectra for new avionics on new aircraft for which there are no mission/environmental data. The criteria also allow the use of analog equipment to control the vibration spectra since only one shape exists and levels are easily changed. Problems with control of extremely low levels are eliminated, since the minimum cut-off level in the test criteria is well above the capability of most controllers.

With the introduction of a cut-off level for vibration under MIL-STD-781C criteria, the possibility exists that the test specimen may not be exposed to vibration during considerable portions of the tests. With the CERT concept of testing, vibration is continuous during the flight portion of a mission as long as it is within controller capabilities. As previously mentioned, the number, shape, and levels of vibration spectra used in the CERT portion of the evaluation program varied for a number of reasons, but the exposure time is continuous, or nearly so.

The project engineer for the AN/APX-76 test in the evaluation program examined the differences between MIL-STD-781C and CERT vibration in both time and levels (Reference 8). Figure 5 shows the difference

TABLE 2

TYPICAL MISSION PROFILE - AIR SUPERIORITY FIGHTER

| Flight Mode | Test Phase* | % Time | Altitude (1000 ft) | Mach Number | q (psf) |
|---|---|---|---|---|---|
| Ground Runup (no AB) | A,F | 4 | 0 to 0.5 | 0 | - |
| (with AB) | | 1 | | | |
| Takeoff | B,G | 5 | 0.5 to 1 | 0 to 0.4 | - |
| Climb (to 40,000 ft) | B,G | 8 | to 40 | 0.6 | 245 |
| Cruise (500 ft) | C,H | 6 | .5 | 0.8 | 900 |
| (20,000 ft) | | 5 | 20 | 0.9 | 550 |
| (40,000 ft) | | 40 | 40 | 0.9 | 225 |
| Acceleration | C,H | 4 | 40 to 50 | 1.7 | 620 |
| Combat (500 ft) | C,H | 1 | .5 | 0.85 | 900 |
| (5000 ft) | | 1 | 5 | 0.9 | 1000 |
| (10,000-40,000 ft) | | 2 | 10 to 40 | 2.0 | 1800 |
| (50,000 ft) | | 3 | 50 | 2.5 | 1180 |
| Descent | D,I | 8 | 40 to 3 | 0.8 | 445 |
| Loiter | D,I | 8 | 3 | 0.4 | 200 |
| Landing | D,I | 5 | 3 to 0.5 | | |

*See Figure B-3 of MIL-STD-781C, Appendix B

TABLE 3

TYPICAL MISSION PROFILE - INTERDICTION FIGHTER

| Flight Mode | Test Phase* | % Time | Altitude (1000 ft) | Mach Number | q (psf) |
|---|---|---|---|---|---|
| Ground Runup (no AB) | A,F | 4 | 0.5 | 0 | - |
| (with AB) | | 1 | 0.5 | 0 | - |
| Takeoff | B,G | 4 | 0.5 to 1 | to 0.4 | - |
| Climb (to 35,000 ft) | B,G | 5 | to 35 | .6 | 245 |
| Cruise (500 ft) | C,H | 27 | .5 | 0.8 | 900 |
| | | 32 | 35 | 0.9 | 280 |
| Acceleration | C,H | 3 | 35 to 50 | 1.7 | 620 |
| Combat (500 ft) | C,H | 2 | .5 | 0.85 | 900 |
| (10,000-35,000 ft) | | 1 | 10 to 35 | 2.0 | 1800 |
| (50,000 ft) | | 4 | 50 | 2.5 | 1180 |
| Descent | D,I | 6 | 40 to 3 | 0.8 | 445 |
| Loiter | D,I | 7 | 3 | 0.4 | 200 |
| Landing | D,I | 4 | 3 to 0.5 | | |

*See Figure B-3 of MIL-STD-781C, Appendix B

TABLE 4

TYPICAL MISSION PROFILE-TRANSPORT/CARGO AIRCRAFT

| Flight Mode | Test* Phase | % Time | Airspeed Knots** | q (psf) |
|---|---|---|---|---|
| Ground Runup | A,F | 5 | - | - |
| Takeoff/Climb | B,G | 5 | to 260 | 200 |
| Cruise High Altitude 36K | C,H | 70 | 240 | 210 |
| Medium Altitude 22K | | 5 | 250 | 225 |
| Low Altitude 1K | | 10 | 350 | 400 |
| Descent/Land | D,I | 5 | 140 | 100 |

*See Figure B-1 of MIL-STD-781C, Appendix B
**Knots Equivalent Airspeed

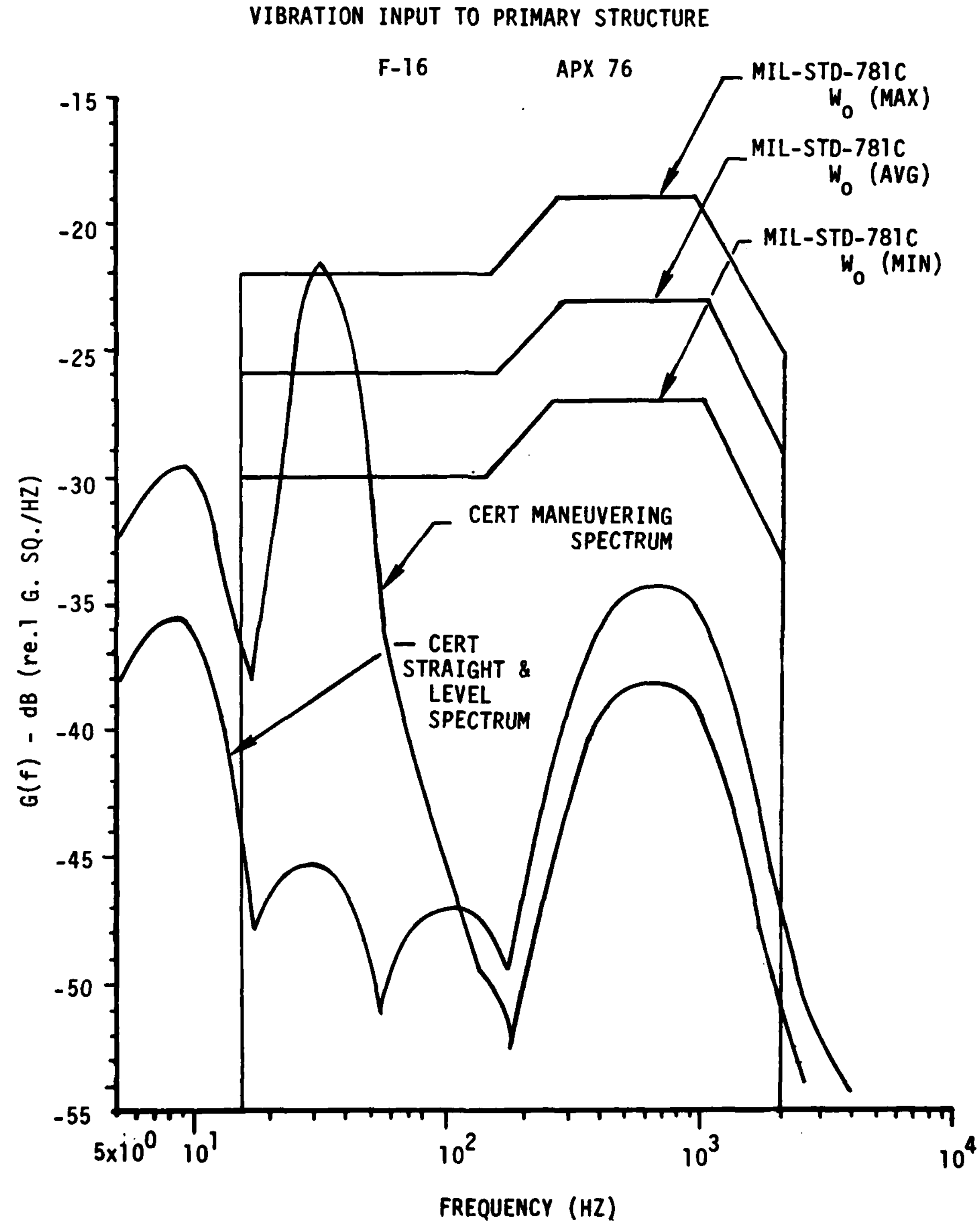



**Figure 5. Vibration Input to Primary Structure**

in the two test concepts' spectra. During CERT, the straight-and-level vibration spectrum was applied 63 percent of the time to the equipment under test and the maneuvering spectrum was applied 18% of the time, for a total of 81%. In a MIL-STD-781C, Appendix B test, no vibration would be applied 70% of the time, $W_{o(max)}$ 2% of the time, $W_{o(min)}$ 8% of the time, and $W_{o(avg)}$ 20% of the time, for a total of 30% of a mission having vibration. The MIL-STD-781C, Appendix B vibration levels are significantly greater than those used during CERT. As a matter of fact, the CERT straight-and-level spectrum is below the level specified in MIL-STD-781C, Appendix B, where random vibration need not be applied.

Table 5 lists equipment tested in the CERT Evaluation Program, and it is apparent in the majority of the cases that CERT revealed a better correlation of failure rates to field data than MIL-STD-781C. For the few cases where MIL-STD-781C failure rates were much greater than field (APX-76 and APX-101), it was determined that the failures were attributed to unrealistic environmental extremes of temperature and humidity. Table 5 points out the vast difference in vibration exposure time the avionics experienced for a total mission for both MIL-STD-781C and CERT. Of these tests, all equipment items were exposed to levels for CERT that were equal to, and in most cases less than, the minimum level for MIL-STD-781C. The levels for CERT were derived primarily by the Flight Dynamics Laboratory computer predictive technique and was checked against flight data when available. The aircraft application varied and also may be found in Table 5.

After the original three test sequences in the evaluation program had been completed on the AN/APX-101 to A-10 conditions, an additional series of test cycles was to be conducted to FULL CERT criteria with the exception of vibration. Instead of using the highly stylized computer-predicted vibration spectra, the test was to use MIL-STD-781C, Appendix B spectra, but the cut-off level exclusion was eliminated. This would provide for vibration to be continuous throughout the test,

TABLE 5

EQUIPMENT TEST/FAILURE RATE CORRELATION, PERCENT OF VIBRATION EXPOSURE, AND LEVEL

| A/C | Equipment | FIELD | MIL-STD-781C | | | FULL CERT | | |
|---|---|---|---|---|---|---|---|---|
| | | MTBF | MTBF | % of Vib Exp Time Over Total Mission | Overall Vib Level (g's RMS) | MTBF | % of Vib Exp Time Over Total Mission | Overall Vib Level (g's RMS) |
| F-15 | AN/APX-76 | 133 | 57 | 63.0 | 1.33 | 200 | 100.0 | 0.44 |
| A-7 | AN/ASN-90 | 156 | 338 | 80.0 | 1.17 | 101 | 100.0 | 1.49* |
| F-15 | AN/APX-101 | 273 | 42 | 2.0 | 1.33 | 252 | 100.0 | 0.073 |
| F-111 | AN/ARC-109 | 95 | 348 | 0.3 | 1.66 | 85 | 100.0 | 0.37 |
| F-5 | AN/ARN-84 | 170 | 188 | 22.0 | 1.93 | 157 | 100.0 | 0.55 |

*Composite spectrum. All other levels are based on straight-and-level or cruise conditions.

but the levels would never go below 0.001 $g^2$/Hz. This level was found to be greater than the predicted stylized levels and measured data. The intent of using the simplistic vibration criteria, along with the other realistic environmental profiles, was an attempt to evaluate the need for stylized vibration profiles and the effect of vibration exposure time.

# SECTION IV

# ANALYSIS

The CERT Evaluation Program, to date, has tested six pieces of avionics. Each test has utilized at least two, and sometimes all three, methods of generating vibration spectra previously mentioned. For all avionics tested data were available from previous tests to MIL-STD-781, field reliability (AFM 66-1), and flight data was also available. The data from the evaluation program showed that testing by MIL-STD-781C results in large deviations of test MTBF data compared to field data, while testing with CERT results in MTBF data approximate to the field data.

The obvious difference with regard to vibration between MIL-STD-781C and CERT is the exposure time. An examination of test/field MTBF data correlation showed a higher level of correlation under CERT than MIL-STD-781C for equipment/test combinations with continuous vibration. This does not imply that vibration alone is responsible for equipment failures. What this does indicate is that some synergistic effect from combined thermal and vibration cycling is responsible for the realistic determination of failure rates and modes.

From available literature examined (Reference 9), it was found that the presence of very low amplitude vibration for a long period of time does have a significant impact on equipment life (Figure 6). Even though these data are for a single environmental condition which is much less complex than combined environments, they still suggest the importance of vibration-caused failures over a long period of time, even at low amplitudes.

At this time, testing of the APX-101 to A-10 conditions is continuing with over 1000 hours of ON time. Although tests have already been conducted on this equipment to Full CERT and MIL-STD-781C, Appendix B,

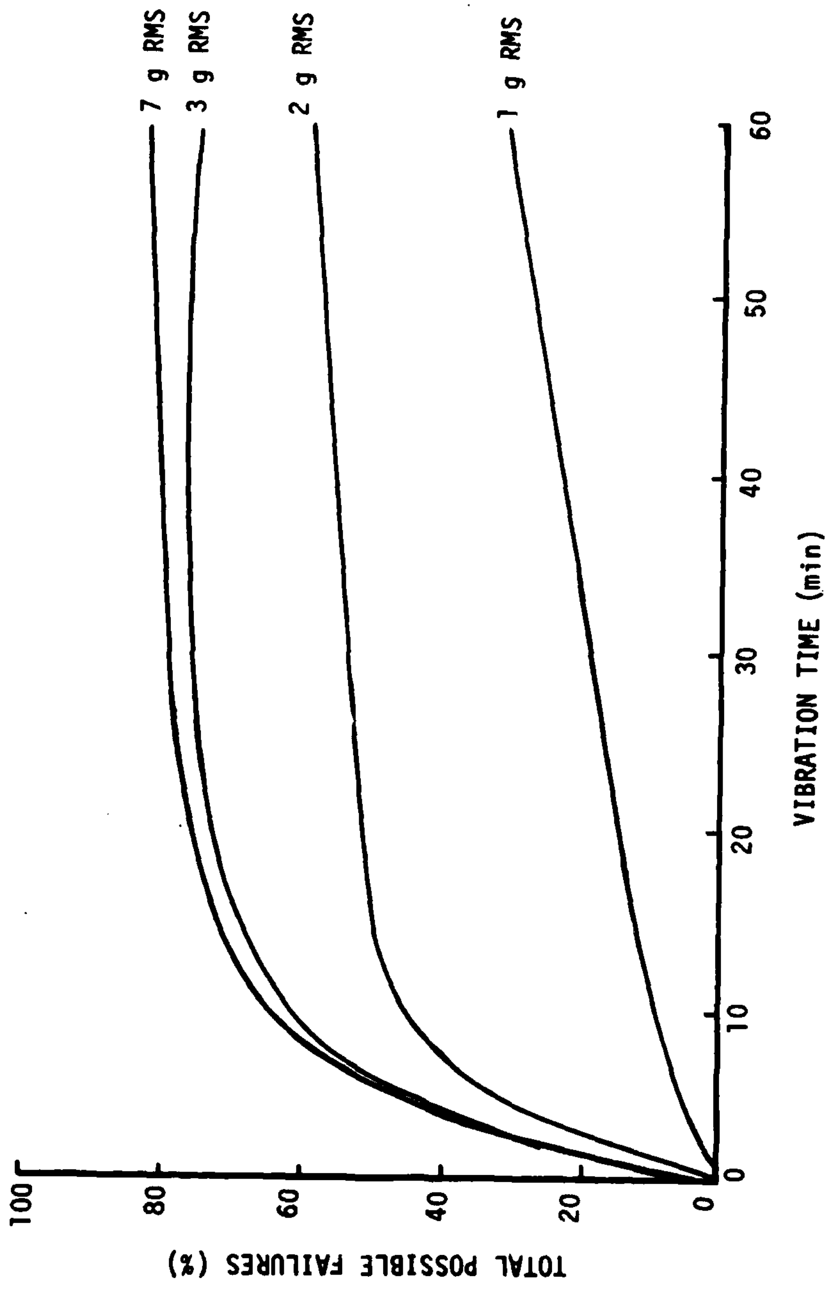



Figure 6. Random Vibration Faults

it is now being tested to Full CERT again but with MIL-STD-781C, Appendix B vibration spectra in lieu of the highly stylized spectra. In cases where the vibration level was calculated to be below the standard's cut-off level, vibration was to be continuous over that range at the cut-off level. Although the level may be higher than actual field conditions, and if the findings in the referenced literature (Reference 9) are true even in combined environment cases, the failures may propogate at a faster rate and then level off. It was indeed found in the modified CERT that the only two failures to date were discovered in the first test cycle.

Although these data are not enough to give overwhelming support to the vibration issue, they also do not refute the claim for simpler test criteria. What is implied, though, is that the payoff from using the MIL-STD-781C vibration spectrum for CERT may be less expensive testing, increased ease of implementation, and better test results over present MIL-STD-781C criteria. The test results still must have additional data to increase confidence of the preliminary results.

Considerable savings in testing would be the result if laboratories and manufacturers did not have to obtain additional peripheral test equipment and software to generate highly sophisticated tailored vibration spectra. Finally, since the random vibration spectra in MIL-STD-781C are commonly used and accepted, continued use of some form of these spectra may result in less confusion for future test concepts.

# SECTION V

# CONCLUSIONS AND RECOMMENDATIONS

From the tests run to date for the CERT Evaluation Program, it is apparent that continuous vibration throughout the test mission may contribute to a strong degree the good correlation between field and laboratory MTBF of internally carried aircraft equipment. With the variance in engineering judgments made in the generation of vibration spectra (numbers, shapes, and levels), it appears that highly stylized vibration spectra may not be technically or economically necessary to achieve realistic results.

By continuing the CERT concept of testing with MIL-STD-781C vibration spectra, it is felt that CERT would be more widely accepted for economic and simplicity reasons. The stipulation in MIL-STD-781C criteria with no vibration exposure for levels calculated below 0.001 $g^2$/Hz should be eliminated. Instead, vibration exposure should continue at 0.001 $g^2$/Hz until a phase in the mission profile requires a higher level. The need for highly sophisticated vibration controllers, digital computers for spectra generation, and extensive software/programming would not be required to perform the vibration portion of a reliability test. With a simplistic and yet technically correct approach to generating vibration spectra for a reliability test, the resulting data are trackable and confidence increased for procurement buys of avionics equipment.

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