MIL-HDBK-340 (USAF)
NOTICE 1
31 July 1989

MILITARY HANDBOOK

APPLICATION GUIDELINES FOR MIL–STD-1540B; TEST REQUIREMENTS FOR SPACE VEHICLES

TO ALL HOLDERS OF MIL-HDBK-340 (USAF)

1. THE FOLLOWING PAGES OF MIL-HDBK-340 (USAF) HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
69	31 July 1989	69	01 July 1985
70	31 July 1989	70	01 July 1985
71	31 July 1989	71	01 July 1985
72	31 July 1989	72	01 July 1985
77	31 July 1989	77	01 July 1985
78	31 July 1989	78	01 July 1985

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-HDBK-340 (USAF) will verify that page changes indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

Custodian:
Air Force - 19

Preparing Activity:
Air Force - 19
(Project Number 1810-F041)
Doc 1808b Arch 1301b

FSC 1810

DISTRIBUTION STATEMENT A: Approved for public released distribution unlimited.

8.1.2 Rationale for Space Vehicle Test Baseline Requirements. Environmental qualification tests are a formal demonstration that a production vehicle (or prototype) is adequate to successfully sustain specified environmental design levels. These tests are mainly performed to determine if there are factors that may have been overlooked during design, analysis, or manufacturing. Additionally, the environments used during these tests are the design levels that are more severe than those predicted to occur during flight in order to account for variabilities in subsequent production articles and other uncertainties. Qualification test requirements, therefore, incorporate margins which are added to the range of environmental extremes and stresses expected to occur in service. Before qualification testing, the space vehicle should have been subjected to the same controls, inspections, alignments, and tests imposed on flight vehicles. This includes completion of the environmental acceptance tests.

The environmental tests required for space vehicle qualification are EMC, acoustics (vibration for certain configurations), pyrotechnic shock, thermal balance, thermal vacuum, and pressure test of fluid subsystems before and after the pyrotechnic shock and acoustic tests. Functional tests are required before and after each environmental test. Thermal cycling at ambient pressure is an optional test but becomes a required test if thermal cycling is imposed for space vehicle acceptance testing.

For certain configurations, random vibration may replace acoustic testing as one of the required tests. In general, these situations arise when the space vehicle is of small size and has a high density. For such a small compact vehicle, acoustic noise may not adequately excite vibratory responses, due to insufficient surface area over which the acoustic pressures may act, and due to a frequency mismatch between the excitation and the natural vibration frequencies related to the dimensions of the space vehicle. In such a case, vibration testing is used to generate a more realistic response in the test specimen.

Environmental acceptance tests are conducted on space vehicles to demonstrate flightworthiness and to disclose quality deficiencies in the flight article. Acceptance tests are intended to satisfy these goals by subjecting the space vehicle to the maximum environmental exposures expected in service. The test program is comprised of a series of tests; some are required tests, while others are optional. Required vehicle-level acceptance tests include thermal vacuum, acoustic (or vibration for certain configurations), pressure test of fluid subsystems, and functional tests before and after each environmental test. Augmenting the required tests are those optional tests which are considered appropriate in accordance with the goals and characteristics of a given space vehicle program. Among the optional acceptance tests are EMC, pyrotechnic shock, and thermal cycling. If thermal cycling is performed, the thermal vacuum testing requirements for the space vehicle are reduced, and the number of thermal cycles specified for the thermal vacuum test may be reduced from four to one.

8.1.3 Guidance for Use of Space Vehicle Test Baseline Requirements. The suggested sequence of environmental tests is based on three considerations: preserving the sequence or concurrent nature of the service environments, assuring that potential failures will be detected as early as possible with the least cost and schedule impact, and assuring detection of dynamically induced intermittents. Therefore, dynamic tests, which simulate the launch and ascent environment and are generally of short duration with limited performance testing, should precede thermal vacuum tests, which simulate long duration orbital environments where greater opportunity is afforded for more extensive diagnostic testing. The dynamic tests provide an opportunity for the detection of dynamically induced intermittents not usually detected in post-dynamic functional tests. However, in recognition of program-peculiar requirements, such as the buildup sequence and logistic considerations, the order of testing in MIL-STD-1540B is only a suggested rather than a required sequence. However, the sequencing used should recognize that the thermal vacuum test offers an opportunity of performing a completely integrated orbital performance check and should be run towards the end of the test sequence.

In order to minimize changes to test setups and instrumentation, the acceptance test exposures required for the qualification article may be integrated with the qualification test program by performing the acceptance level test just prior to the qualification level test. For example, in conducting the space vehicle acoustic qualification test, the acceptance level acoustic environment would be imposed for its prescribed duration before imposition of the full qualification acoustic environment. By conducting the acceptance test just before the applicable qualification test exposure, a secondary objective of validating the environmental acceptance test program is accomplished.

The thermal cycling test, which may be imposed at the space vehicle level, has proved to be extremely useful and cost-effective in disclosing latent defects. Thermal cycling tests are also useful for periodic testing of vehicles in storage to assure that they remain flight-ready.

The mechanical and electrical functional tests are extremely important elements in the test baselines. The functional tests are conducted prior to and after each of the environmental tests. They should be designed to verify that performance of the components and of the space vehicle meets the specification requirements, that the components and the space vehicle are compatible with ground support equipment, and that all software used is validated, such as in computer-assisted commanding and data processing. In addition, the electrical functional tests should include negative logic testing to verify lockout, to assure that no function other than the intended function was performed, and to verify that the signal was not present other than when programmed. To the extent practicable, the functional tests should also be designed so that a data base of critical parameters can be established for trend analysis. This is accomplished by measuring the same critical parameters in all of the functional tests conducted before, during, and after each of the baseline environmental tests. During these tests, the maximum use of telemetry should be employed for data acquisition, problem identification, and problem isolation. This can assist in mechanizing the data base for trend analysis and provides training for on-orbit flight support.

The trend data and the final ambient functional test conducted prior to shipment of the space vehicle to the launch base provide the data to be used as success criteria during launch base testing. For this reason, the vehicle level functional tests should be designed so that they can be duplicated, as nearly as possible, at the launch base.

It is extremely important that functional tests be conducted before and after each environmental test. These functional tests provide the criteria for judging successful survival of the space vehicle in a given test environment. It is also important to perform functional tests of space vehicle subsystems while the environment is being imposed. This is especially important for the thermal balance or thermal vacuum tests, since the space vehicle is expected to be fully operational under these conditions. It is considered appropriate during acoustic or random vibration acceptance tests to have the vehicle in an operating mode representative of launch and ascent. The launch and ascent time period usually involves a minimum level of functional performance with many subsystems inoperative. It is probable that any undetected dynamically induced fault which was not detected in the post-test functional test would be found during the thermal test which requires full subsystem performance monitoring. This again is rationale for performing dynamic tests before thermal environmental acceptance testing. For qualification and protoflight space vehicles; however, dynamic tests should be performed on fully functional space vehicles with their performance monitored for intermittent. Many design related defects such as improper mounting, inadequate clearances or electrical intermittents, which otherwise escape detection by pre- and post-test functional checks, reveal themselves during dynamic environmental qualification or protoflight testing.

Practical limitations frequently restrict the extent of operation of space vehicle subsystems during the relatively brief acoustic test. In recognizing this problem MIL-STD-1540B permits extended functional testing with subsystems operating and monitored, but conducted at a level 6 dB lower than the required test level, after the required environmental exposure has been satisfied.

For small compact spacecraft, acoustic testing will not provide adequate environmental simulation, and random vibration should supplant the acoustic test. MIL-STD-1540B directs that vibration testing be considered for vehicles of compact shape and weight less than 180 kilograms (approximately 400 pounds) . For a launch vehicle such as the STS, which produces considerable acoustic noise in the low frequency range below 100 Hz, the wavelengths of the dominant frequencies are longer than 10" feet. If a small heavy cylindric space vehicle, 4 feet in diameter and 3 feet long, were tested in a representative acoustic environment, the resulting vibration response of the vehicle might fall short of simulating actual conditions in the low frequency range. In such an instance, random vibration testing could become the preferred mode of testing. If there is insistence on an acoustic test mode, it may become necessary to include the interfacing structure with the space vehicle test specimen to achieve adequate simulation. This could include cradles which hold the space vehicle or associated upper stage, or even a portion of the launch vehicle. The proportions of the test article should correlate with those of the environmental frequency range of interest. Where either test may be appropriate, equivalent vibration and acoustic criteria should be derived by analysis or empirical observations to provide corresponding criteria. In addition to considering fidelity of simulation, a number of practical issues are involved in this matter. Random vibration equipment capabilities are limited in terms of displacement, force output, and frequency range. An acoustic chamber which simulates the ascent acoustic environment from 25 to 10,000 Hz can usually accommodate relatively large vehicles, regardless of their weight. However, a random vibration test facility imposes weight limitations based upon vehicle plus fixture weight because of its force limitations. In addition, mechanical vibration exciters have difficulty generating frequencies above 2000 Hz. Also, a very real danger exists of anomalous behavior of the vibration exciter such as sudden shutdowns, runaways, and line transients. When the space vehicle is intimately attached to a vibration exciter of significant force capability, much damage can be inflicted unless careful attention is devoted to safeguards. The decision to perform either acoustic or random vibration tests involves much engineering judgment. Situations may arise in which some combination of acoustic and vibration tests provides the best parameters shall be provided to detect intermittent failures. Functional tests are required before and after the environmental exposure.

8.2.1.2 Rationale for Qualification Acoustic Tests. Acoustic qualification tests are a formal demonstration that a production space vehicle can successfully sustain the specified acoustic design levels. The space vehicle acoustic qualification test also serves as a source for accurate vibration data which may be used to compare with component qualification test requirements as well as forming a reference for evaluating vibration levels encountered during acoustic acceptance testing of subsequent vehicles.

8.2.1.3 Guidance for Qualification Acoustic Test A critical element in the space vehicle acoustic qualification test is the instrumentation used to measure the acoustic levels and the vibration response of the equipment subjected to the acoustic inputs. The quantity of instrumentation required may vary widely from program to program due mainly to the size and complexity of the test vehicle; however, sufficient vibration data should be obtained such that every component may be evaluated. For large vehicles, it would not be unusual to have in excess of 100 accelerometer measurements. Where large numbers of measurements are not feasible and when each component cannot be instrumented, emphasis should be placed on those components which have exhibited poor component level qualification history or which are known to have less than 6 dB qualification margins. It may be feasible to choose locations which are representative of several component mountings . In general, measurements should be made on primary or secondary structure at component attachment points. Measurement on the component attachment flanges or lugs is acceptable only when there is no room on the adjacent structure.

In general, triaxial measurements should be taken; however, a single axis may be taken when it is known to be the higher response axis or is the axis of maximum component sensitivity. The data acquisition system should have the capability of acquiring accurate data from 20 to at least 2000 Hz.

8.2.2 Acoustic Acceptante Tests

8.2.2.1 Standard Criteria. Contents of Paragraph 7.1.3 of MIL-STD-1540B (requirements for space vehicle acceptance acoustic test) are as follows:

7.1.3 Acoustic Test, Space Vehicle Acceptance

7.1.3.1 Purpose. This test simulates the acoustic and vibration environment imposed on a space vehicle in flight in order to detect material and workmanship defects that might not be detected in a static test condition.

7.1.3.2 Test Description. Same as 6.2.3.2.

7.1.3.3 Test Levels and Duration. The acoustic spectrum shall represent the maximum predicted flight environment as defined in 3.20. The overall sound pressure level for acceptance testing shall not be less than 138 dB. The exposure time at full acceptance test level shall equal or exceed the maximum expected flight exposure time, but the test time shall not be less than 1 minute. Operating time should be divided approximately equally between redundant circuits. Where insufficient time is available at the full test level to test all redundant circuits, all functions, and all modes, extended testing at a level 6 dB lower shall be conducted as necessary to complete functional testing.

7.1.3.4 Supplementary Requirements. During the acoustic acceptance test all electrical and electronic components which are operating during the launch, ascent, or reentry phase shall be electrically energized and sequenced through operational modes to the maximum extent possible. Continuous monitoring of several perceptive parameters shall be provided to detect intermittent failures. Functional tests are required before and after the environmental exposure.

8.2.2.2 Rationale for Acceptance Acoustic Tests. Acoustic acceptance tests are conducted on space vehicles to demonstrate flightworthiness and to disclose quality deficiencies by subjecting each flight article to the maximum acoustic exposure expected in service. The space vehicle acoustic acceptance test also serves as a source for vibration data which may be used to compare with component expected flight levels, component acceptance test levels, space vehicle qualification levels, and as a diagnostic aid in the event of component malfunction or failure.

8.2.2.3 Guidance for Acceptance Acoustic Tests An important element in the space vehicle acoustic acceptance test is the instrumentation used to measure the acoustic levels and the vibration response of the equipment subjected to the acoustic inputs. The quantity of instrumentation is governed by the size and complexity of the test vehicle. Particular attention should be given to those components critical to the flight mission, and whose qualification test margin is less than 6 dB or which have a poor vibration test history. Single-axis measurements may be made in lieu of triaxial, when that axis has been shown to be the higher response axis or is the axis of maximum component sensitivity. A total of 12 measurements is considered nominal. In some instances, the accelerometer and some of its wiring may be left in place for flight, if its removal would require partial disassembly and thus cause additional testing. In general, accelerometer locations should duplicate those used in the qualification testing.