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BACKGROUND STUDY AND SELECTION CRITERIA ANALYSIS OF MIL-STD-810C : ENVIRONMENTAL TEST METHODS

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INTERIM TECHNICAL REPORT

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of study was to determine the rationale for the inclusion of each of the thirteen climatic tests in MIL-STD-810C; determine the rationale and utility of test procedures; and provide guidance for the selection of tests, including when a test should or should not be used.

Investigation took two forms: research of other environmental test standards and documents, and interviews with people in Department of Defense and industry. Members of the Tri-Service and Industry Environmental Study Group, responsible for

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revision to the Standard, were also contacted.

Major conclusions regarding individual tests included: lack of coordination among tests which include temperature; lack of coordination and guidance among single-and multiple-factor tests; lack of guidance for corrective action following test failure; and, inadequacy of test guidance.

Major conclusions dealing with overall testing included lack of a means of reflecting in present procedures the impact of differences in environmental requirements factors such as stage of testing in the acquisition process, use environment, and type of equipment; and, lack of consistency in applying test limits.

Recommendations included need to address factors impacting on environmental test specification development; need for coordination, correlation, and test selection criteria; and need for combined factors test sequencing. A major recommendation was the need to develop guidance in the form of a logical, step-by-step approach which will ensure that the developer or planner will consider all factors and aspects bearing on the development of environmental test specifications and plans for his equipment.

SUMMARY

The purpose of this study effort was to determine the rationale for the inclusion of each of the thirteen climatic tests in MIL-STD-810C, Environmental Test Methods; determine the utility of the test procedures; and provide guidance for the selection of tests, including when a test should or should not be used.

The investigation took two forms. One was an intensive background study which involved research of other environmental test standards and related documents. The other was the conduct of selective interviews, either through visits or by telephone, with people in the Department of Defense and industry, and obtain from them comments and suggestions to aid in the study. In particular, members of the Tri-Service and Industry Environmental Study Group, which is responsible for the revision to the Standard, were contacted for their advice and suggestions for further research.

Each of the climatic tests was analyzed to determine its rationale and present utility. Discussion concentrated on weak points in the existing procedures, which included the areas of coordination among tests, correlation of results of tests, limits among tests involving like environmental factors, and guidance in several key areas. Conclusions were drawn from the analysis, and were followed by recommendations.

General discussion and recommendations on overall testing were based on comments by the respondents and analysis of individual tests where a problem concerned more than one test. This overview addressed factors which impact on environmental test specification development, need for coordination, correlation, and test selection criteria, need for combined factors test sequencing, and need for coordination in implementing new guidance for environmental test developments.

Major conclusions dealing with individual tests include:

- Lack of coordination among tests which include temperature: Temperature-Altitude, Temperature-Humidity-Altitude, Humidity, Low Temperature, High Temperature, Temperature Shock.
- Lack of coordination among single-factor and multiple-factor tests.
- Lack of guidance for sequential testing among single-factor and multiple-factor tests.
- Lack of guidance for corrective action following a test failure.

- Inadequacy of test guidance, including the decision whether to apply or not to apply the test.

- Lack of consistency in the application of test limits, mainly for tests involving high temperature.

- Need to eliminate several tests as being more quality-control oriented in their present construction than useful for environmental testing: Salt Fog and Leakage Tests.

Additional major conclusions dealing with overall tests include:

- Lack of a means of reflecting in present procedures the impact of differences in environmental requirements factors such as stage of testing in the acquisition process, use environment, and type of equipment.

- Need for central coordination of test guidance formulation during the present update process of the Standard.

- Need for central direction for application of new format guidance for climatic test procedures.

- Need for a new guidance format for developing environmental test specifications and plans.

Significant recommendations were advanced in consonance with the conclusions. A major recommendation was the need to develop guidance in the form of a logical, step-by-step approach which will ensure that the developer or planner will consider all factors and aspects bearing on the development of environmental test specifications and plans for his equipment.

An additional recommendation was to consider the development of one test, perhaps with a sequence of procedures, involving temperature, as a means of combining like tests and ensuring consistency in the application of test temperature limits.

Comments made by the respondents in the investigative interviews tend to support the conclusions drawn from this study, i.e., the present Standard lacks guidance, consistency, updated test procedures, and overall utility. Steps need to be taken to upgrade the guidance for applying environmental tests.

PREFACE

This project coincides with current efforts by the Tri-Service and Industry Environmental Study Group to revise MIL-STD-810C. Members of that Group were helpful in providing assistance to the authors.

The authors would also like to acknowledge the generous and timely assistance given by the Project Sponsor, Dr. Thomas E. Niedringhaus, and Mr. Harry S. McPhilimy, both of the Environmental Effects Group, Engineer Topographic Laboratories.

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SECTION 1 - INTRODUCTION

1.1 PURPOSE

ManTech of New Jersey Corporation was contracted by the Environmental Effects Group (ETL-GS-A), Engineer Topographic Laboratories, Corps of Engineers, Fort Belvoir, Virginia to perform a background study and selection criteria analysis of MIL-STD-810C, Environmental Test Methods.

The specific purposes of this study were:

a. Determine the background, or rationale for inclusion, of each of the natural environmental tests of MIL-STD-810C.

b. Determine the present utility of each test method. More specifically, ascertain the purposes for which each test should be used and also the purposes for which each test should not be applied.

This study is an interim report covering the first phase of a two-phase effort. The second phase will involve the development of a method to provide guidance to the user of MIL-STD-810. The method initially considered is a logic tree approach that will lead the user step-by-step through the application of MIL-STD-810 to his materiel development problem.

The natural environmental tests which are the subject of this investigation, are listed below:

Method 500.1 - Low Pressure (Altitude)

Method 501.1 - High Temperature

Method 502.1 - Low Temperature

Method 503.1 - Temperature Shock

Method 504.1 - Temperature-Altitude

Method 505.1 - Solar Radiation (Sunshine)

Method 506.1 - Rain

Method 507.1 - Humidity

Method 508.1 - Fungus

Method 509.1 - Salt Fog

Method 510.1 - Dust (Fine Sand)

Method 512.1 - Leakage (Immersion)

Method 518.1 - Temperature-Humidity-Altitude

1.2 BACKGROUND

The aim of these studies, as stated in the contract, was to provide better guidance to specification writers and test engineers in the selection of tests to which their equipment should be subjected. Because of the high cost of testing, it is important to know not only which tests to use, but also which tests should not be used.

This study is intended as a contribution to an overall Department of Defense (DoD) and industry effort to revise MIL-STD-810C and issue a succeeding MIL-STD-810D. This revision effort is being undertaken by a Tri-Service and industry (steering) group of engineers headed by Mr. David L. Earls of the Preparing Activity for the Standard, the U.S. Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio.

Various members of the steering group have been assigned specific environmental tests to review and revise as necessary, including revision of test guidance. The timetable for the submission of those portions of the Standard for which they are responsible is such that this report may be a timely input to their deliberations.

1.3 APPROACH

The ManTech team was guided in its approach by the suggestions contained in the contract and offered by the project sponsors at the Environmental Effects Group.

The approach to conducting this study involved the following phases:

a. Investigative interviews, both in person and by telephone, with members of the steering group and with other Service, industry, and governmental representatives suggested by the group or identified by the ManTech team. These interviews immediately followed commencement of contract effort.

b. Research, conducted throughout the study duration.

c. Analysis, commencing midway through the investigative phase and continuing through the report development phase.

d. Report development, commencing at the beginning of the sixth month of study effort and continuing to the end of the contract period.

SECTION 2 - RESULTS OF INVESTIGATION AND ANALYSIS

2.1 INVESTIGATION

2.1.1 GENERAL

In accordance with our approach to the project effort, visits and telephone interviews were conducted from February 1978 through mid May 1978 with people from all branches of the Department of Defense (DoD), other government agencies, laboratories and defense industries. The following table is a breakdown of these visits and telephone interviews:

Type of Agency	No. of Activities	No. of People Interviewed
Army	14	25
Navy	10	15
Air Force	4	4
Other Government	4	4
Industry, Including Labs	6	22

This breakdown does not reflect the attendance of one team member and the consultant to the annual meeting of the Institute for Environmental Sciences (IES) in Fort Worth, Texas in April 1978, and the many people interviewed there. The consultant also interviewed eight people in Los Angeles during a Reliability and Maintainability Seminar, including some who were chairmen of various IES environmental committees.

2.1.2 SUMMARY OF INVESTIGATIONS

Appendix A contains the significant comments compiled during the visits and telephone interviews. The interviews are presented in chronological order, and contain the name and activity of the respondents.

Table 2-1 is a further condensation of the remarks contained in Appendix A. Significant comments were arranged in topical groupings for clarity, with source and frequency of comment indicated in columnar form.

2.2 ANALYSIS

2.2.1 GENERAL

Background research was conducted throughout the six-month contract period. A bibliography, contained at the end of this report, summarizes the research material. This research, together with the main thrust of the comments obtained during the interviews, provided direction to the project team in conducting its analysis of the rationale and utility of MIL-STD-810C (hereafter called 'Standard').

TABLE 2-1. TYPE AND FREQUENCY OF COMMENTS MADE BY RESPONDENTS.

COMMENT	ARMY	NAVY	AIR FORCE	IND/ OTHER	TOTAL
A. TEST MANAGEMENT					
1. Cost Impact					
Cost influences management decisions on scope of testing and test limits; cost of testing is low compared to cost of equipments under test; costs increase for overtesting to unnecessary limits, or repetitive testing; special interests of development people drive design (and test) costs upward.	5	0	1	2	8
2. Test Specification					
Management - Get management back into the test spec decision process; test design and specs need a formal decision process; RFPs generally give no latitude in test specs. Provision for flexible response from contractors needed; inconsistencies noted in spec approval process; PM offices too short of people to screen test specs adequately; too much layering between spec writer and approval authority.	0	0	4	5	9
Development - Test specs lack detail due to lack of guidance in 810; spec writing procedure is vague; test specs tend to be prescribed using previously developed specs; weapon specs are used as disguised MIL-SPECS; government agencies generally "beef up" specs; 810 tests are used as a starting point for own spec development; 810 is used too much as a specification, instead of a guidance document; source of empirical data for each 810 test method should be made available to all test planners; 810 guidance should include a risk analysis approach; equipment identification is a critical factor, and may be a problem especially for human-related equipments; standard packaging and mounting must be taken into account in test specs and planning; important to properly define equipment class, as being critical to application of 810 procedures.	3	6	1	4	14
3. Acquisition Stage					
Tests as now shown may need restriction of limits and duration during development stage; scope and extent of testing may have to be adjusted to recognize compromises in design; tests differ according to stage of equipment development, important to define this; get environmental test planning into the acquisition process at the early stages; 810 doesn't differentiate among development stages in citing procedures and conditions for testing; 810 should be used primarily for development testing; 810 is ill suited for acceptance testing.	2	8	1	1	12

TABLE 2-1. TYPE AND FREQUENCY OF COMMENTS MADE BY RESPONDENTS.

COMMENT	ARMY	NAVY	AIR FORCE	IND/ OTHER	TOTAL
4. Test Waivers Number of waivers indicates degree of severity of test specifications; a waiver is usually granted in the event of a test failure; cost is a consideration in granting waivers in the event of test failure; too many waivers are granted during the development stage.	3	2	0	2	7
B. TEST APPLICATION					
1. Rationale Present test rationale is inadequate; intent of tests is not clear; tests are not realistic.	3	1	0	0	4
Comments on individual tests: fungus test rationale inadequate; shock test: data in 810 based on hammer table - now have aerodynamic shaking - 810 curve doesn't fit new methods; vibration test is sinusoidal only - no random test; fungus test was successful when performed at Fort Huachuca; need for salt fog test questioned; 810C vibration test levels lower than were in 810B; humidity test procedures unsatisfactory.	6	0	0	4	10
2. Utility Guidance lacking on corrective action following failure; guidance needed for both simulation tests and exaggerated tests; hard (fixed) numbers should not be prescribed in addressing test guidance; need guidance for testing at other than extreme values; 810 procedures should be response oriented rather than fixed, i.e., they must be flexible to permit a wide range of limits selection; need to infuse notions of synergistic and sequential environmental effects into new guidance; vagueness in 810 test procedures: "generally accepted", "shall be no evidence of..."; compromises have left 810 incomplete; tests are too stringent or inflexible; tests do not take into account advances in equipment technology; present tests too vague about whether equipment operation is required during testing; clash noted between 210B and 810C limits; 810 contains unrealistic test requirements; most equipments today can pass the 810 tests easily. Tests have not kept pace with technology; test procedures were transferred bodily from 810B to 810C, thus errors were perpetuated; concern with details of test procedures that lead to non-repeatability of test results. Conditions can't be met or measured with sufficient accuracy.	8	4	3	8	23

TABLE 2-1. TYPE AND FREQUENCY OF COMMENTS MADE BY RESPONDENTS.

COMMENT	ARMY	NAVY	AIR FORCE	IND/ OTHER	TOTAL
On realism: Combined testing is the key to better simulation of the real environment; realism is the key word in environmental testing; "worst case" is not always the extreme value the equipment will see; lab tests can only approximate the real world; environmental test planners need more knowledge on realism of the use environment.	6	2	2	3	13
3. Guidance					
Environmental profile should be constructed before making test decisions; equipment should be designed to the mission profile; caution urged in accelerated testing. Results not linear in all cases when stress levels are raised; test planners should look for "limiting element" of a system, then test to that limit; performance monitoring during tests needs to be improved; need more guidance in general for all tests; spec writers need more guidance; need tailoring matrix or checklist; source of empirical data for each test method should be made available to all test planners; new guidance should incorporate a logical, step-by-step approach to test selection and planning; guidance should recognize different needs of test planners, according to type of equipment to be tested and stage of development; 810 guidance should be coordinated with design requirements.	18	13	9	10	50
TOTAL - ALL COMMENTS	54	36	21	39	150

Significant comments were also received from the members of the Tri-Service and Industry Group involved in the revision of the Standard. This group recommended additional sources of expertise for obtaining constructive comment.

2.2.2 DEFINITIONS

In order to place the guidance and procedures in the present version of the Standard in the proper perspective, it is important to understand the meaning of the words "rationale" and "utility". From Webster's New World Dictionary:

Rationale - the fundamental reasons, or rational basis, for something.

Utility - the quality or property of being useful; usefulness.

The fundamental reason for performing a test in the Standard is to determine whether the objective equipment can withstand certain environmental conditions without manifesting any of several phenomena which would indicate failure or an undesirable physical condition. For example, in the rain test, if blowing rain penetrates a protective cover, a failure would be indicated. If the rain penetrates, it can cause corrosion. The reason, or rationale, for conducting the test is that blowing rain can cause corrosion to equipment if permitted to penetrate the protective surface.

A test in the Standard is regarded as having "utility" if its application will lead to a determination that the equipment can or cannot withstand exposure to a certain environmental condition. The test also has utility if its guidance and procedures are structured in such a way as to make the test relatively easy to implement. However, the test must also be able to produce the desired conditions and lead to a clear determination of results in order to be useful. It is quite possible that a majority of users may assume that a test has utility, and at the same time the test may be in error procedurally or in its parameters. In this case, the test has little or no utility at all.

2.2.3 ANALYSIS OF INDIVIDUAL TESTS

Each test is analyzed from the standpoint of both rationale and utility. In many cases, the rationale is well documented; therefore, it is stated briefly using excerpts from the "Effects" paragraph of the Standard or from other well-known references such as Junker. The utility is portrayed as "Present Utility", with statements reflecting the present use of the test and a brief description of the test procedures.

The argumentative portion of the analysis is presented in the "Discussion" for each test. Comments include presumed errors in limits, limitations of the test itself, lack of coordination or correlation with other tests, inapplicability of the test for environmental testing, missing back-up data deemed essential to test planning, and conflict among tests. Where comments pertain to more than one test, they are addressed in subsection 2.3 which follows.

Table 2-2 profiles, in matrix form, the type of comments made in the Discussion portion of each test analysis presented in Section 3.

The Discussion portion in Section 3 is followed by conclusions which logically follow the supporting comment. Recommendations follow the conclusions immediately, and are numbered in consonance with the conclusion. When more than one recommendation is made for each conclusion, alphabetical characters are used.

2.3 GENERAL DISCUSSION AND RECOMMENDATIONS

2.3.1 GENERAL

The following paragraphs discuss areas uncovered during the investigation which were not specifically required in the contract effort, but which are believed to be pertinent to the provision of guidance for environmental test specification preparation, test planning, and test selection. These areas are discussed in the paragraphs below, and are followed by recommendations.

Also discussed are those areas in the individual test analyses which involved more than one test. Comments in these areas include combined testing, sequential testing, relationship between single and multiple-factor tests, and synergisms. Recommendations follow each discussion area.

2.3.2 ENVIRONMENTAL TEST SELECTION FACTORS

Test selection factors are those factors which bear on the type of test to be given to the equipment in question, the particular procedures to be followed in each test, and the test parameter values to be imposed. These factors are:

a. Type of Equipment
b. Use Environment
c. Stage of Testing

2.3.2.1 Type of Equipment

Configuration and modes of operation requirements in the design of military equipment present different aspects that impact on requirements for environmental testing. Requirements

TABLE 2-2. CRITIQUE OF MIL-STD-810C CLIMATIC METHODS

	AMBIGUOUS			UNDER-COORDINATED	UNDERCORRELATED		INADEQUATE FOR EVALUATING INTERACTION EFFECTS OF:			INADEQUATE FOR SEPARATION OF EFFECTS OF:			RATIONALE FOR PARTICULARIZED PROCEDURE(S)		
	FAILURE CRITERIA	TEST PARAMETERS	GUIDANCE/ PURPOSE	WITH OTHER 810C METHODS	WITH NATURAL CONDITIONS	WITH OTHER 810C METHODS	SINGLE ENVIRONMENT	COMBINED ENVIRONMENTS	SYNERGISMS	SINGLE ENVIRONMENT	COMBINED ENVIRONMENTS	SYNERGISMS	NOT PROVIDED	EXPLICIT BUT INADEQUATE	IMPLIED BUT INADEQUATE
METHOD 500.1 LOW PRESSURE (ALTITUDE)		x	x	x	x		x	x	x	x	x	x	x		
METHOD 501.1 HIGH TEMPERATURE		x	x	x	x	x	x	x	x	x	x	x		x	
METHOD 502.1 LOW TEMPERATURE			x	x	x	x	x	x	x	x	x	x	x		
METHOD 503.1 TEMPERATURE SHOCK		x	x		x										x
METHOD 504.1 TEMPERATURE ALTITUDE			x	x	x	x	x	x	x	x	x	x		x	
METHOD 505.1 SOLAR RADIATION (SUNSHINE)	x		x	x	x	x	x	x		x					
METHOD 506.1 RAIN	x		x	x		x								x	
METHOD 507.1 HUMIDITY	x	x	x	x	x	x	x	x	x	x	x	x		x	x
METHOD 508.1 FUNGUS	x			x	x	x	x	x		x	x		x		
METHOD 509.1 SALT FOG			x		x		x	x		x	x		x		
METHOD 510.1 DUST (FINE SAND)		x			x										x
METHOD 512.1 LEAKAGE (IMMERSION)		x	x	x		x									
METHOD 518.1 TEMPERATURE-HUMIDITY-ALTITUDE		x	x	x	x	x	x	x	x	x	x	x	x		
FREQUENCY (OUT OF 13 METHODS)	4	7	11	10	11	9	9	9	6	9	8	6	5	4	3

for electrical and electronic equipment can be different from those for mechanical equipment. The Standard presently contains little or no guidance as to how the type of equipment impacts on the test specification. The specification writer and test planner need guidance in selecting environmental test methods and specific procedures which consider the distinct nature of their particular equipment.

RECOMMENDATION 1: Guidance be developed which will indicate the effect of the type of equipment on the development of the test specification.

2.3.2.2 Use Environment

Use environments are those environments to which the equipment is expected to be subjected during its service life. Procedures in the Standard should be sufficiently flexible to accommodate the limits and durations of exposure to the environmental conditions associated with the particular use environment. The severity of exposure is also determined by the orientation of the equipment in its use environment.

RECOMMENDATION 2: Guidance be developed which will indicate the effect of the use environment, and specific orientation in that environment, on the development of the test specification.

2.3.2.3 Stage of Testing

The acquisition of weapon systems and related equipment is a process encompassing three distinct stages: design, development and production. These phases should be reflected in environmental testing as regards provisions for test selection and severity of parameters. Guidance should be available to define environmental conditions that will impact on attainment of the technical objectives of each phase. Environmental test requirements should be tailored to meet the needs of the particular stage of acquisition.

RECOMMENDATION 3: Guidance be provided relating the test specification to the stage of the acquisition process.

2.3.3 SELECTION AMONG SINGLE- AND MULTIPLE-FACTOR TESTS

There are two combined tests in MIL-STD-810C, the Temperature-Altitude Test and the Temperature-Humidity-Altitude Test, Methods 504 and 518. In these tests, multiple environmental factors are controlled and tested simultaneously. In addition, the Humidity Test is really a combined High Temperature-Humidity Test.

Thus, there is an overlap among the purposes, procedures and results of these tests and the corresponding single-factor tests, the Low Pressure, High Temperature and Low Temperature

Tests (Methods 500-502). Further, there is an overlapping of effects, and in some cases synergistic effects, among the tests mentioned above and the Temperature Shock, Solar Radiation, Rain, Fungus and Leakage Tests (Methods 503, 505, 506, 508 and 512). In addition, many of these tests contain more than one procedure.

Yet guidance relating to the coordination and sequencing of these tests, and the correlation of test results, is almost entirely lacking. Where there is guidance, it is not documented.

Specification of the multiple-factor tests should be coordinated with the corresponding single-factor tests. For example, if a piece of equipment passes a multiple-factor test, it does not have to undergo single-factor tests of the same severity. However, if the item fails the multiple-factor test, it may have to undergo separate single-factor tests in order to determine the failure mode. On the other hand, if a piece of equipment passes all the single-factor tests, it normally must still undergo the combined-factor tests, to test for synergistic effects.

RECOMMENDATION 4: Guidance be developed to coordinate specification of the multiple-factor tests with the corresponding single-factor tests.

In some tests with multiple procedures, the procedures and applications given are very similar. Further, as shown in the profile of temperature cycles in Figure 2-1, there is a similarity of some of the temperature maximums in the High Temperature, Humidity and Temperature-Humidity-Altitude Tests (Methods 501, 507 and 518). The rates of temperature change are also similar, as shown in the figure, although the total rises in temperature are not. Addition of the other procedures of Methods 501 and 507 to this figure would enhance the similarity in temperature maximums. The foregoing points to the possibility that in some cases procedures could be combined, or even tests, and guidance be developed to enable the test planner to specify the test parameter values. Cyclic variations would of course have to be investigated if certain procedures were considered for combining.

RECOMMENDATION 5: Guidance be developed to help a test planner choose from among multiple procedures in those tests that contain more than one.

There is a recommended test sequence (Table I, MIL-STD-810C) for various types of equipment, but no guidance or documentation relating to the reasons for the sequence. Thus, there is no way for a test planner to know whether sequential tests should be scheduled close together (to allow for sequential effects) or far apart, or whether he is justified in changing the order for any reason. In addition, there is no guidance as to whether

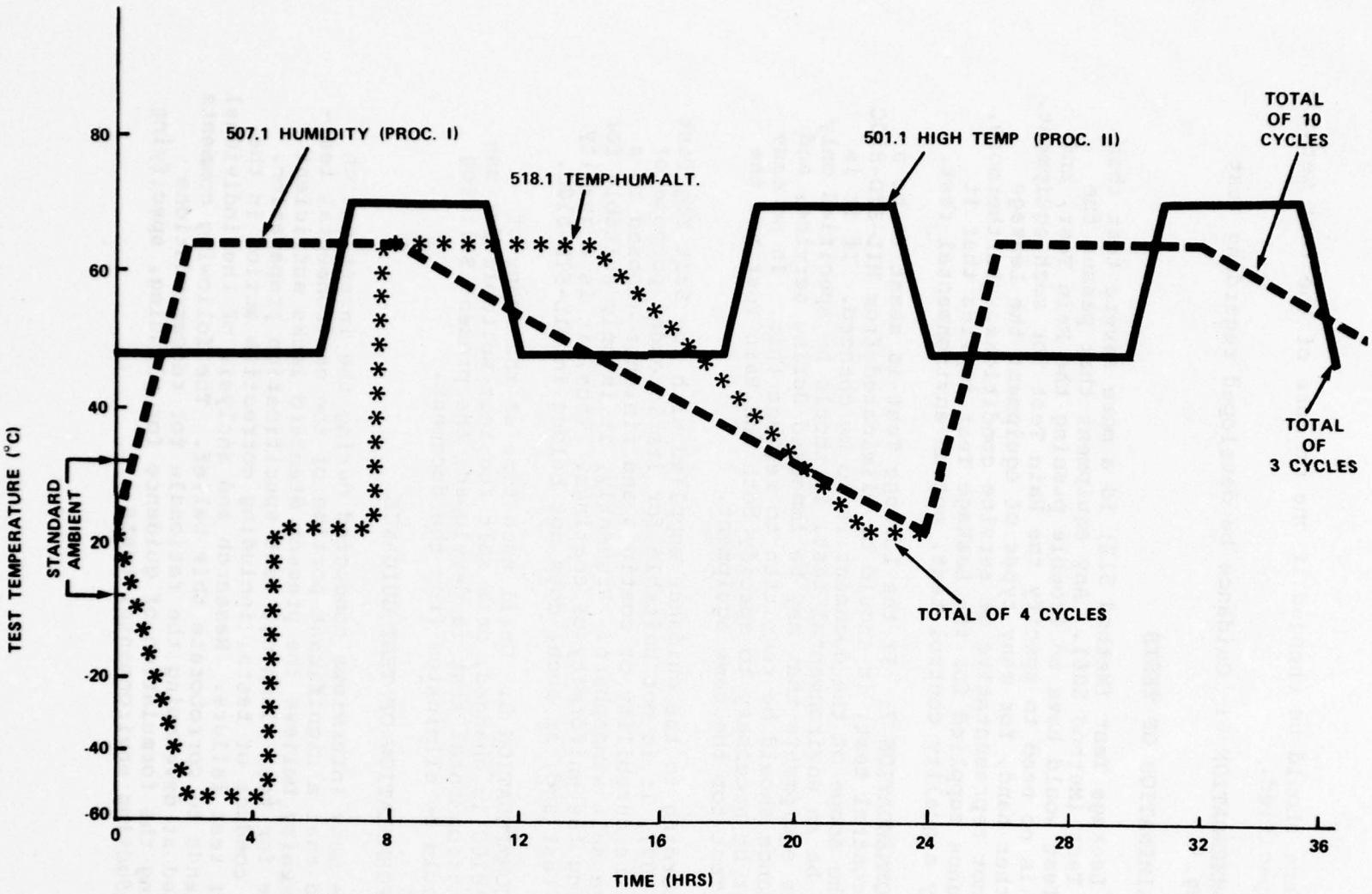

Figure 2-1. Comparison of Temperature Cycles from MIL-STD-810C Test Methods 501.1, 507.1, and 518.1

the sequence should be changed if one or more of the test methods are not specified.

RECOMMENDATION 6: Guidance be developed regarding test sequencing.

2.3.4 ELIMINATION OF TESTS

The Leakage Test (Method 512) is a more severe test than the Rain Test (Method 506). Any equipment that passes the Leakage Test would have no trouble passing the Rain Test, and so there is no need to specify the Rain Test for such equipment. On the other hand, for many types of equipment the Leakage Test is not representative of service conditions. Furthermore, the guidance supplied for the Leakage Test implies that it is really a quality control test, not an environmental test.

RECOMMENDATION 7: If the Leakage Test is meant to be a quality control test, it should be eliminated from MIL-STD-810C unless the scope of the document is to be changed. If it is meant to be an environmental test, it should be specified only for those equipments that may be immersed during service, and the guidance should be rewritten to reflect this. In no case should it be necessary to specify both the Rain Test and the Leakage Test for the same equipment.

According to the guidance supplied with the Salt Fog Test (Method 509), it is not suitable for its intended purpose of testing the durability of coatings and finishes exposed to a corrosive salt atmosphere. Presently, it is only suitable for evaluating the uniformity of coatings. Thus, it is a quality control test and, as such, does not belong in MIL-STD-810C.

RECOMMENDATION 8: Until such time as the scope of MIL-STD-810C is changed, or a salt fog test suitable for use as an environmental test is developed, the present Salt Fog Test should be eliminated from the document.

2.3.5 FORMULATION OF TEST GUIDANCE

The many interviews conducted during the investigation revealed that a significant portion of the environmental testing community believe the present Standard lacks sufficient guidance for test planning, test specification preparation, and the conduct of tests, including corrective action in the event of test failure. Research and analysis of the individual tests tends to corroborate this belief. The following comments are aimed at developing the rationale for recommendations regarding the formulation of guidance for planning, specifying and conducting environmental tests.

2.3.5.1 Test Update Coordination

The present Tri-Service and Industry Group effort aimed at revising the Standard has various individuals performing updating of each climatic test. This process makes coordination of test procedures guidance difficult, since most of the group members are well separated geographically. The overall analysis of the aggregate tests will presumably not take place until they are all updated and submitted to the Preparing Activity (PA). It is felt that this analysis will take place too late in the update phase to reflect a continuity in guidance among the various test methods. Further, our analysis indicates that in several areas it may be desirable to eliminate some tests, combine others, and change some limits and procedures to provide consistency among tests.

RECOMMENDATION 9: Like tests, or tests that contain a common environmental factor, should be coordinated in their update through one agency or office, for the purpose of providing consistency among test procedures, limits and guidance.

2.3.5.2 Guidance Format Change Process

There is generally a common format for guidance and procedures in the existing Standard. However, if it is decided that a new guidance format will be provided, the process of changing from present to future guidance should be coordinated through one agency or office, preferably that of the PA.

RECOMMENDATION 10: A new guidance format, if directed, should be constructed concurrently with the test procedures update process. It can be performed separately, but inputs would be needed from those who are currently updating test procedures. One central agency or office should construct, or supervise the construction of, the new guidance format.

2.3.5.3 New Guidance Format

The preceding discussion and recommendations in this section have repeatedly cited the need for additional and more definitive guidance in selecting and sequencing tests, and defining test parameter values. A framework should be provided within which the factors such as type of equipment and stage of testing can impact the process of test specification development. Respondents during the investigation have, by their comments, underscored the need for this guidance.

A logical, step-by-step approach to environmental test specification development and test planning is needed to ensure that all factors bearing on the test process are considered. This approach should be structured so that when the process is complete, the test developer will have defined the test specification with the assurance that he has considered every necessary aspect.

RECOMMENDATION 11: Guidance be developed in the form of a logical, step-by-step procedure by which the test planner can consider all factors bearing on the development of a test specification or plan.

SECTION 3 - INVESTIGATION AND ANALYSIS OF CLIMATIC TESTS

3.1 LOW PRESSURE (ALTITUDE) TEST, METHOD 500.1

3.1.1 PURPOSE

The altitude test is conducted to determine the effects of reduced pressure on equipment, which may be encountered during air shipment, transportation or operational use at high ground elevations.

3.1.2 RATIONALE

Some of the deleterious effects that low pressure may cause are:

- Leakage of fluids from sealed enclosures
- Rupture of pressurized containers
- Evaporation of lubricants
- Galling or cold welding
- Arcing or corona in electrical or electronic equipment
- Decreased efficiency of convective cooling
- Outgassing of materials
- Changes in aerodynamic characteristics of flight vehicles.

3.1.3 PRESENT UTILITY

The test method is suitable for equipment designed for installation or operation at high ground elevation, and equipment that is to be air-shipped in cargo aircraft, the cargo compartments of which are pressurized to an altitude no higher than 15,000 ft. It is not suitable for equipment to be installed in or on aircraft, missiles or space vehicles.

There is a single test procedure which specifies a pressure corresponding to aircraft cargo compartments. Temperature and humidity are kept at ambient. In addition, equipment that could damage an aircraft from failure due to cargo compartment depressurization is tested at an altitude corresponding to that at which transport aircraft fly.

3.1.4 DISCUSSION

The test conditions specify a pressure of 429.1 mm of Hg (16.9 in of Hg), corresponding to an altitude of 15,000 ft.

Modern cargo aircraft in military service, and those commercial aircraft which could be pressed into service during emergencies, maintain equivalent altitudes of 8,000 to 10,000 ft in their cargo compartments. The altitude test for air-shipped equipment should specify an altitude equal to that found in the lowest pressure cargo compartment to be used, plus a safety factor.

Maximum ground elevations experienced in the field may be in the vicinity of 10,000 ft. For equipment to be installed or operated at a ground elevation of 15,000 ft, as stated in the standard, the pressure specified is not sufficient. According to MIL-STD-210B, the lowest atmospheric pressure recorded at 15,000 ft is 14.8 in Hg (375.9 mm Hg), and the extreme low pressures corresponding to risk factors of 1%, 5%, 10% and 20% are 15.0 in Hg (381 mm Hg), 15.2 in Hg (386.1 mm Hg), 15.4 in Hg (391.1 mm Hg) and 15.6 in Hg (396.2 mm Hg), respectively. For such equipment, a pressure should be specified equal to some extreme value found at the highest ground elevation used, not a nominal value.

There is no coordination with the Temperature-Altitude Test (Method 504) or Temperature-Humidity-Altitude Test (Method 518), i.e., no guidance as to when one, two or all three should be specified.

The general argument in favor of combined-factor testing is that it more closely simulates actual field conditions and thus can predict field service failure modes.

The counter-argument is usually that if a piece of equipment fails a combined test, it is not known which factor causes the failure. However, it is possible (and highly desirable) to design a test program that starts with single-factor tests and works up to combined-factor tests to track failures. It is necessary to predict field failures caused by synergistic effects as well as individual factors.

Even though one of the low pressure effects mentioned is decreased efficiency of convective cooling (Method 500.1, Paragraph 1.1), no extreme temperature conditions are specified.

The special procedure for equipment whose failure by sudden cargo compartment depressurization could damage the aircraft is inadequate:

- The procedure does not specify (or allow) any pressure loss more rapid than 2000 ft/min.
- The procedure does not simulate other effects resulting from rapid depressurization, i.e., rapid cooling.

3.1.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The test conditions do not appear to reflect actual conditions found in present-day transport aircraft or high ground service elevations.

Recommendation 1: Guidance be developed to more closely tie the test conditions to field conditions, i.e., the specified pressure should reflect the extreme values to be found in aircraft cargo compartments or high ground elevations, not just the nominal values.

Conclusion 2: There is no coordination or correlation between the Altitude Test (Method 500) with the multiple-factor tests incorporating altitude - the Temperature-Altitude Test and the Temperature-Humidity-Altitude Test (Methods 504 and 518).

Recommendation 2: Guidance be developed to coordinate the Altitude Test with the combined-factor tests (Temperature-Altitude, Method 504, and Temperature-Humidity-Altitude, Method 518).

Conclusion 3: The test procedure for equipment whose failure by sudden depressurization could damage aircraft is inadequate.

Recommendation 3: An explosive decompression test be developed for those equipments whose failure could cause aircraft damage.

3.2 HIGH TEMPERATURE TEST, METHOD 501.1

3.2.1 PURPOSE

The high temperature test is conducted to determine the resistance of equipment to high temperatures that may be encountered under operational conditions, or during storage or transportation.

3.2.2 RATIONALE

High temperatures have deleterious effects. The characteristic permanent set which is imposed during normal operating conditions upon packings, gaskets and other synthetic rubber parts in aircraft hydraulic and pneumatic systems is severely aggravated by temperatures above 54°C (130°F). The most severe trouble encountered with present synthetic rubber seals is the extraction of the plasticizer during exposure to heat by vaporization and leaching. Binding of parts may occur in equipment of complex construction, generally a result of using dissimilar metals and the close tolerances which must be maintained between moving parts to ensure accuracy. Fuel and hydraulic valves or similar units may bind or lose an effective seal if constructed of dissimilar metals. For example, a steel valve core seated in an aluminum housing would lose an effective seal. Bearing difficulties are usually the result of differential contraction and expansion of materials or loss of lubrication. A bronze bushing on a steel shaft, subjected to high temperatures, may experience differential contraction and expansion, resulting in excessive clearance. Ball and roller bearings are not seriously affected by differential contraction and expansion; however, all lubricated surfaces may be left dry and without protection because of considerable change in properties of the lubricant resulting from evaporation at high temperatures. Synthetic rubber, plastic, and plywood tend to discolor, crack, bulge, check and craze; closure and sealing strips become gummy and stick to contacting parts. The operating lifetime of electronic equipment is shortened by exposure to high temperatures.

3.2.3 PRESENT UTILITY

The test is suitable for equipment exposed to temperatures up to 71°C (160°F). This range covers normal field and storage conditions found anywhere on the Earth's surface. It does not cover conditions found at altitudes commonly traversed by transport and other aircraft. It also may not cover certain other special situations, for example, equipment mounted near heat-producing equipment. In addition, temperatures higher than 71°C (160°F) have been measured inside parked aircraft exposed to sunshine.

There are two test procedures, one for high temperature storage and the other for cyclic high temperature storage and operation.

3.2.4 DISCUSSION

The test procedure makes it inconvenient to specify a temperature other than 71°C (160°F) for the test. Guidance should be developed to permit the test planner to specify the high temperature values to be used, based on the mission profile of the equipment to be tested.

There is no correlation or coordination between the high temperature test and the multiple-factor tests which include high temperature, i.e., the Temperature-Altitude Test (Method 504), the Temperature-Humidity-Altitude Test (Method 518), and the Humidity Test (Method 507). Guidance should be developed to enable a test planner to decide which of those tests to specify, or whether more than one is desirable. It may be possible to start out with multiple-factor tests and only specify single-factor tests in case of failure, in order to track down the failure modes. Conversely, it may prove desirable to start out with single-factor tests and work up to multiple-factor tests as equipment design matures and improves.

High temperature combines and reacts with other environments as follows:

- With low pressure - sputtering, outgassing
- With high humidity - accelerated fungus growth
- With solar radiation - increased temperature
- With salt fog - accelerated corrosion.

Unlike the Low Temperature Test (Method 502), which specifies a single procedure for storage and operation, the High Temperature Test specifies two procedures. It is possible that a single procedure would provide adequate results. In addition, there is no guidance as to whether to use one or both procedures.

3.2.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The High Temperature Test (Method 501) procedure specifies a single temperature and leaves little room for informed judgment.

Recommendation 1: The test planner be encouraged to specify the high temperature used, and guidance be developed to aid him in deciding what temperature to use.

Conclusion 2: There is no correlation between the High Temperature Test (Method 501) and the multiple-factor tests incorporating high temperature - the Temperature-Altitude, Temperature-Humidity-Altitude, and Humidity Tests (Methods 504, 507 and 518).

Recommendation 2: Guidance be written so that a test planner can correlate and coordinate specifications of these tests and/or analysis of their results.

Conclusion 3: Synergistic effects resulting from high temperature combined with some other factors are not considered.

Recommendation 3: Investigations be undertaken to determine these effects and recommend any necessary changes in procedures.

Conclusion 4: There is no guidance pertaining to the two distinct procedures.

Recommendation 4: Guidance be developed so that a test planner can decide whether to choose Procedure I, Procedure II, or both.

Recommendation 5: An investigation be undertaken to decide whether two procedures are necessary or if adequate results can be obtained with a single combined procedure.

3.3 LOW TEMPERATURE TEST, METHOD 502.1

3.3.1 PURPOSE

The low temperature test is conducted to determine the effects of low temperatures on equipment under operational conditions, or during storage or transportation.

3.3.2 RATIONALE

Some of the deleterious effects of low temperatures are: congealing of lubricants and other liquids such as fuel; loss of resiliency and consequent cracking of normally pliable materials such as rubber, gaskets, canvas and leather; increased brittleness of metals and plastics; and, structural damage and moisture problems caused by ice and snow.

3.3.3 PRESENT UTILITY

The test is suitable for equipment exposed to temperatures down to -57°C (-70°F), the present lower limit of the test. It may not be suitable for equipment exposed to lower temperatures - temperatures down to -62°C (-80°F) have been recorded in Canada and Alaska, below -62°C (-80°F) in Greenland, and below -68°C (-90°F) in Siberia. The world record low temperature is -88°C (-127°F), in Antarctica. In addition, temperatures lower than -57°C (-70°F) are found at commonly traversed altitudes - a temperature of -62°C (-80°F) is specified in the Temperature-Altitude Test (Method 504).

There is a single test procedure, which includes steps simulating storage and operation.

3.3.4 DISCUSSION

The test procedure makes it inconvenient to specify a temperature other than -57°C (-70°F) for the test. Guidance should be written to let the test planner specify the low temperature used, based on the mission profile of the equipment to be tested.

Equipment which comes in contact with or contains cryogenic components may be exposed to temperatures far below that specified in the test. Special test procedures and test chambers may be needed for such equipment.

There is no correlation or coordination between the low temperature test and the multiple-factor tests which include low temperature - the Temperature-Altitude Test (Method 504) and the Temperature-Humidity-Altitude Test (Method 518). Guidance should be developed to enable a test planner to decide which of these tests to specify, or whether more than one is desirable. It may be possible to start out with multiple-factor

tests and only specify single-factor tests in case of failure, in order to track down the failure modes. Conversely, it may prove desirable to start out with single-factor tests and work up to multiple-factor tests as equipment design matures and improves.

Synergistic effects may occur when low temperature is combined with other factors. The combination of low pressure and low temperature can result in increased leakage through seals and gaskets. Low temperature can increase the penetration of sand and dust. Absolute humidity decreases with temperature, but relative humidity increases, and is usually close to 100% at extremely low temperatures. This may induce moisture and frost on exterior and interior surfaces.

Unlike the High Temperature Test (Method 501), which specifies two procedures (one for long-term storage and one for cyclical storage and operation), the low temperature test only specifies one. It is possible that there should be similar procedures for the low temperature test.

3.3.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The Low Temperature Test (Method 502) procedure specifies a single temperature and leaves little room for informed judgment.

Recommendation 1A: The test planner be encouraged to specify the low temperature used, and guidance be developed to aid him in deciding what temperature to use.

Recommendation 1B: A study be undertaken to decide if special test procedures and/or test chambers are necessary for equipment which contains or comes in contact with cryogenic components.

Conclusion 2: There is no correlation between the Low Temperature Test (Method 502) and the multiple-factor test incorporating low temperature - the Temperature-Altitude and Temperature-Humidity-Altitude Tests (Methods 504 and 518).

Recommendation 2: Guidance be written so that a test planner can correlate and coordinate specification of these tests and/or analysis of their results.

Conclusion 3: Synergistic effects resulting from low temperature combined with some other factors are not considered.

Recommendation 3: Investigations be undertaken to determine these effects and recommend any necessary changes in procedures.

Recommendation 4: An investigation be undertaken to determine whether a single storage-operation procedure or two procedures (one for storage and one for operation, as in the High Temperature Test) is preferable.

3.4 TEMPERATURE SHOCK TEST, METHOD 503.1

3.4.1 PURPOSE

The temperature shock test is conducted to determine the effects on equipment of sudden changes in temperature of the surrounding atmosphere during service life.

3.4.2 RATIONALE

A rapid change in ambient temperature may cause malfunctions as a result of rapid differential contraction and expansion of dissimilar materials such as metals or plastics, or as a result of the large thermal gradient induced.

3.4.3 PRESENT UTILITY

The test is applicable to any item of equipment which can undergo a large temperature change in a short period of time. Examples of situations where this may occur are:

- Movement of material from temperate storage conditions to extreme outdoor conditions.
- Rapid movement of equipment from transport aircraft to desert or tropic field conditions, or vice versa.
- Heating of equipment during start-up in arctic field conditions.
- Heating of exterior-mounted aircraft equipment (due to friction) immediately after takeoff from arctic airfields.
- Air drop of equipment.

3.4.4 DISCUSSION

The test procedure specifies a temperature change from $-57^{o}C$ to $71^{o}C$ ($-70^{o}F$ to $160^{o}F$), a traverse of $128^{o}C$ ($230^{o}F$) within five minutes.

The test makes no provision for a temperature shock of smaller magnitude than $128^{o}C$ ($230^{o}F$). If the mission profile of the equipment shows that the extreme temperatures to which it will be exposed form a smaller range, then the temperature shock test should be limited to that range.

The test procedure should also make provision for limited temperature shock ranges of temperate-to-low-temperature and temperate-to-high-temperature, for use with test items that will never be subjected to larger shocks.

MIL-STD-210B has no extremes listed for temperature shock. The National Weather Service has published data showing the following extreme ambient temperature changes:

Rise of 27°C (49°F) in two minutes

Rise of 46°C (83°F) in twelve hours

Fall of 26°C (47°F) in fifteen minutes

Fall of 47°C (84°F) in twelve hours

Rise of 32°C (54°F) followed by fall of 32°C (54°F), within two hours.

3.4.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The Temperature Shock Test (Method 503) makes no provision for varying the upper and lower limits of the temperature shock range.

Recommendation 1: Provision be made for letting the temperature limits be set by the test planner, and guidance be developed to help him.

3.5 TEMPERATURE-ALTITUDE TEST, METHOD 504.1

3.5.1 PURPOSE

The temperature-altitude test is conducted to determine the ability of equipment to withstand simultaneous exposure to ambient conditions of high or low temperature and low pressure.

3.5.2 RATIONALE

The effects of such simultaneous exposure include those resulting from exposure to each of the individual factors of the test (see High Temperature, Low Temperature and Altitude Tests, Methods 501, 502, 500). The combination of low temperature and low pressure may cause failure in a pressurized system as a result of greater pressure differential combined with contraction of seals or material around seals. The combination of high temperature and low pressure may cause failure in equipment dependent on a convection cooling system since the efficiency of such systems is reduced in less dense air.

3.5.3 PRESENT UTILITY

The test is suitable for any equipment mounted or transported in aircraft at altitudes up to 100,000 ft. The test may also be suitable for equipment to be operated at high ground elevations under extreme conditions.

For the test, equipment is placed in one of eight categories, depending on the altitude for which the equipment is specified. The temperature conditions for the test are dependent on the category. The procedure includes both operating and non-operating steps at a variety of temperature-altitude combinations.

3.5.4 DISCUSSION

There is no coordination or correlation among this multiple-factor test, the test incorporating those factors singly (Altitude, High Temperature and Low Temperature; Methods 500, 501 and 502) and the multiple-factor Temperature-Humidity-Altitude Test (Method 518). Guidance should be developed through which a test planner can decide which of these tests to specify and in what order.

It may be possible to start out with multiple-factor tests and only specify single-factor tests in case of failure, in order to track down the failure modes. Conversely, it may prove desirable to start out with single-factor tests and work up to multiple-factor tests as equipment design matures and improves.

Guidance is particularly needed to coordinate the Temperature-Altitude Test with the Temperature-Humidity-Altitude Test. One of the important deleterious effects in the Temperature-Altitude Test is frost and moisture condensation on equipment surfaces as the temperature drops. The amount of such frost and moisture is highly dependent on humidity, yet humidity is left almost uncontrolled in this test.

The special procedure for equipment whose failure by sudden depressurization could damage the aircraft is inadequate:

- The procedure does not specify (or allow) any pressure loss more rapid than the maximum attainable by the chamber.
- The procedure does not simulate other effects resulting from rapid depressurization, i.e., rapid cooling.
- The procedure is limited to equipments in Categories 1 and 2 only.

The rate of pressure loss should be specified according to realistic conditions of rapid depressurization experienced in present day aircraft. Representative tables should be provided.

The test procedure (Paragraph 3.1) specifies that the temperature change may not exceed 1°C (1.8°F) per second for airborne equipment. This rate is larger than the rate specified in the Temperature Shock Test. Thus, if this rate is actually attained, there may be no need for the Temperature Shock Test. On the other hand, since there is no specification for recording the temperature change rate, there may be undesired failure modes or non-repeatability of results. The temperature change rate should be more closely specified, and the test and its guidance be coordinated with the Temperature Shock Test.

3.5.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: There is no coordination or correlation among the Temperature-Altitude Test (Method 504) or the Altitude, High Temperature, Low Temperature or Temperature-Humidity-Altitude Test (Methods 500, 501, 502, or 518).

Recommendation 1A: Guidance be developed through which a test planner can decide which of these tests to specify and in what order.

Recommendation 1B: Guidance be developed to correlate results from these tests, and to help a test planner decide how results from any of these tests affect the decision to specify or not to specify any others.

Conclusion 2: Humidity may affect the results of the Temperature-Altitude Test (Method 504), yet humidity is left almost uncontrolled during the test.

Recommendation 2: Humidity be specified during the test. If this recommendation is followed, an investigation then be undertaken to decide if the Temperature-Humidity-Altitude Test (Method 518) is necessary.

Conclusion 3: The special procedure for equipment whose failure by sudden depressurization could damage the aircraft is inadequate.

Recommendation 3: An adequate procedure with supporting guidance be developed.

Conclusion 4: The rate of temperature change in the Temperature-Altitude Test (Method 504) is not controlled closely enough, and is allowed to reach a value larger than that in the Temperature Shock Test (Method 503).

Recommendation 4: The rate of temperature change be more closely controlled. If a large value is desired, the Temperature-Altitude Test be coordinated and correlated with the Temperature Shock Test.

3.6 SOLAR RADIATION (SUNSHINE) TEST, METHOD 505.1

3.6.1 PURPOSE

The sunshine test is conducted to determine the effect on equipment exposed to solar radiation energy in the Earth's lower atmosphere.

3.6.2 RATIONALE

Solar radiation generally has two deleterious effects on equipment: photochemical effects and heat effects. The photochemical effects of sunshine may cause fading of colors, deterioration of paints, plastic, fabrics and natural rubber. The heat effects can raise internal temperatures of equipment to values far above ambient. The same effect can be found, for example, on equipment stored, even for a short time, on blacktop pavement in the sun. Sunshine can also produce compound effects as a result of the heating and photochemical effects working together. Heating causes acceleration in any photochemical effect which might be present.

3.6.3 PRESENT UTILITY

The test is suitable for any item of equipment which may be exposed to sunshine during service at the Earth's surface or in the lower atmosphere.

There are two test procedures, one an accelerated steady state nonoperating test which is meant to test for long-term storage conditions, and the other a cycling temperature and solar radiation test, meant to simulate extreme field conditions.

In both procedures, the spectral distribution of the radiation source is specified.

3.6.4 DISCUSSION

The heating effect of solar radiation cannot be duplicated by a simple high temperature or oven test. The reason is that sunshine produces temperature gradients in equipment, while an oven test produces a steady-state temperature.

Procedure II in the Standard (Paragraph 3.2) is represented as an accelerated test, but the conditions specified are representative merely of the most extreme conditions found in field service.

The specification of spectral distribution does not reflect current capabilities of artificial radiation sources.

3.6.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: Procedure II of the Solar Radiation Test (Method 505) is an extreme field-service condition test, not an accelerated test.

Recommendation 1A: The guidance for the test be rewritten to reflect this fact.

Recommendation 1B: If an accelerated cycling operating test is desired, investigation be made to determine if such a test can be developed.

Conclusion 2: The spectral distribution applicable to both test procedures does not reflect current capabilities of artificial radiation sources.

Recommendation 2: Upgrade the present spectral distribution specification.

3.7 RAIN TEST, METHOD 506.1

3.7.1 PURPOSE

The rain test is conducted to determine the effectiveness of protective covers, cases and gasketing to shield equipment from rain under operational conditions, and during storage and transportation.

3.7.2 RATIONALE

Protective covers, cases and gasketing are designed to shield equipment or its vital parts from the deleterious effects of rainwater penetrations. Moisture can cause malfunction of electrical or electronic equipment by short-circuiting. Leaked-in water frozen inside equipment may cause delayed deterioration and malfunction by swelling or cracking of parts. High humidity resulting from rain leakage can cause corrosion and support fungal growth.

3.7.3 PRESENT UTILITY

The test is suitable for all equipment installed, operated or stored unsheltered. It is not suitable for determining the effects of rain erosion. There are two procedures, one to simulate the effects of blowing very heavy variable rainfall, and one to simulate steady-state moderately heavy rainfall on the top and sides of a piece of equipment.

3.7.4 DISCUSSION

The test procedure does not specify if the presence of water inside a protective case constitutes failure. Thus, it does not quite meet its stated purpose, namely to determine its effectiveness in such cases. The procedure states that at the conclusion of exposure to rain, the case or cover should be opened if possible (emphasis added), and the item inspected. This procedure will not detect moisture (or predict a consequent failure) inside a sealed but not waterproof cover, unless there is immediate loss of operability.

The test may not be suitable to predict a failure mode caused by frozen rain inside equipment.

There is no coordination with the Humidity or Fungus Tests (Methods 507 and 508), even though the rain test can produce more moisture inside equipment and consequent higher risk of long-term failure due to corrosion or fungal growth.

Additionally, there is no coordination with the Immersion Test (Method 512) which is a more severe test, although it may not have the same utility.

At present there is no test for rain erosion. Rainfall contains acid in varying amounts, especially in Central Europe. The effect of acid rainfall should be simulated as part of a rain erosion test.

3.7.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: Failure criteria in the Rain Test (Method 506) are inadequate.

Recommendation 1: Specific failure criteria be developed, corresponding to all of the deleterious effects mentioned in the Rationale section.

Conclusion 2: There is no coordination or correlation among the Rain Test (Method 507) and the Humidity, Fungus or Immersion Tests (Methods 507, 508 or 512).

Recommendation 2: Guidance be developed to coordinate the test with the Humidity, Fungus and Immersion Tests.

Conclusion 3: Two separate procedures may not be necessary.

Recommendation 3: It may be possible to combine the two procedures into one.

Conclusion 4: There is no test procedure for rain erosion.

Recommendation 4: A rain erosion test be developed, specifically including the effects of acidic rainfall.

3.8 HUMIDITY TEST, METHOD 507.1

3.8.1 PURPOSE

The purpose of the humidity test is to determine the resistance of equipment to the effects of exposure to a warm, highly humid atmosphere such as that encountered in tropical operations and storage.

3.8.2 RATIONALE

Some of the deleterious effects of humidity on equipments are:

- Corrosion of metals
- Swelling of hygroscopic materials
- Loss of physical strength
- General deterioration and changes in mechanical properties of materials
- Degradation of electrical and thermal properties of materials
- Condensation inside and on equipment, with all the associated problems of water, as detailed in the sections on the Rain and Immersion Tests.

3.8.3 PRESENT UTILITY

The test is suitable for any equipment which may be exposed to long-term high humidity during its service life.

There are five procedures, the first for airborne electronic equipment, the second for ground and airborne electronic equipment, the third for ground and airborne sealed electronic equipment (not hermetically sealed), the fourth for ground fire control and shipboard equipment, and the fifth for ammunition.

All five procedures specify exaggerated conditions of high relative humidity and cycling high temperatures, designed to accelerate the degrading effects of humid air.

The procedures specify the humidity, temperature cycle, duration and number of cycles, and physical properties, including pH of the water used to obtain the humidity. The five procedures differ in the values assigned to these parameters.

3.8.4 DISCUSSION

Procedure I specifies temperature cycling between 30°C and 65°C (86°F and 149°F) in a 24-hour period, the test duration being 10 cycles or 240 hours. The humidity is maintained in the range of 90 to 98% during the periods of temperature rise and constancy, and at least 85% while the temperature is falling.

Procedure II specifies five 48-hour cycles, for the same total length test. The first half of each cycle has a similar temperature cycle, with the same limits, while the second half has temperature kept almost constant at 30°C (86°F), with a short dip to 20°C (68°F). The humidity conditions are the same as in Procedure I.

Procedure III starts out with the same five 48-hour cycles as Procedure II (except that the humidity must always stay in the range of 90 to 98%), followed by 480 hours at 30°C (86°F) at the same humidity.

Procedure IV specifies temperature cycling between 30°C and 60°C (86°F and 140°F) in a 24-hour period, the test duration being five cycles or 120 hours. The humidity must be at least 95% during the hours of temperature constancy, and need not be controlled at other times.

Procedure V specifies temperature cycling between 21°C and 40.5°C (70°F and 105°F) in a 24-hour period, the test duration being 20 cycles or 480 hours. The humidity must be in the range of 90 to 95% at all times.

As can be seen, Procedures I, II and III are very similar. They also have overlapping applicability, i.e., all geared for electronic equipment. In addition, there is no guidance to help a test planner decide which of the three to choose, which is most severe, or which would give results most useful to him.

The three procedures should be combined into one, with temperature and humidity levels and durations and cycle length and number left up to the test planner. Guidance should be developed to help a test planner make these judgments. The guidance should include information relating equipment deterioration in the test at various levels of temperature and humidity to what would be expected in the field.

The conditions in Procedure IV are less exaggerated than in the first three procedures. The maximum temperature and dewpoint are lower and the test duration is shorter. There is no guidance as to how the deterioration produced by these conditions relates either to that produced by field conditions or that produced by the first three procedures.

The conditions in Procedure V are not exaggerated - they are representative of extreme field conditions. However, the test duration is longer than those of Procedures I & II. Again, there is no guidance as to how deterioration produced by these conditions relates to any other procedure or test.

The conditions in the Fungus Test (Method 508) specify high humidity, moderately high temperature and long duration, so that the Fungus Test can be considered a humidity test. There is no guidance as to correlation or coordination between the Fungus Test and any procedure of the Humidity Test.

The water used to produce the humidity is specified to have a pH between 6.0 and 7.2. This value is open to question, since distilled water may have a pH as low as 5.0, and water condensing from the atmosphere in a jungle area would probably contain dissolved gases which would affect the pH. A strict control of pH is necessary for uniform test results, but investigation should be made to determine whether the presently specified values are correct.

There is no correlation or coordination between the Humidity Test and the Temperature-Humidity-Altitude Test (Method 518). Guidance should be developed to enable a test planner to decide which of these tests to specify, or whether both are desirable. It may be possible to start out with multiple-factor tests and only specify single-factor tests in case of failure, in order to track down the failure modes. Conversely, it may prove desirable to start out with single-factor tests and work up to multiple-factor tests as equipment design matures and improves.

3.8.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The first three procedures of the Humidity Test (Method 507) are similar and have overlapping applicability.

Recommendation 1: The first three procedures be combined into one, with temperature and humidity levels and durations, and cycle length and number left up to the test planner. In addition, guidance be developed to help a test planner make these judgments.

Conclusion 2: The conditions in Procedure IV are less exaggerated than those in the first three procedures, yet there is no guidance as to how to judge deterioration produced by this test.

Recommendation 2: Guidance be developed to help a test planner decide how deterioration produced by Procedure IV relates to that produced by field conditions and that produced by the first three procedures.

Conclusion 3: Procedure V is not an exaggerated test - it is a test simulating extreme field conditions, yet the guidance implies that it is an exaggerated test.

Recommendation 3: Guidance be developed to specify this test as a simulation test, and to relate its results to those produced by the other procedures and field conditions.

Conclusion 4: There is no coordination or correlation between the Humidity Test (Method 507) and the Fungus Test (Method 508), which has similar high humidity conditions.

Recommendation 4: Guidance be developed coordinating and correlating these two test methods. This guidance include the development of humidity failure criteria for the Fungus Test.

Conclusion 5: The range of the pH value for water specified in the Humidity Test (Method 507) is open to question.

Recommendation 5: Investigation be made to determine the optimum range of pH values.

Conclusion 6: There is no correlation or coordination between the Humidity Test (Method 507) and the Temperature-Altitude-Humidity Test (Method 518).

Recommendation 6: Guidance be developed so that a test planner can correlate and coordinate specification of these tests and/or analysis of their results.

3.9 FUNGUS TEST, METHOD 508.1

3.9.1 PURPOSE

The purpose of the fungus test is to determine the resistance of equipment to fungi such as that encountered during tropical operations and storage.

3.9.2 RATIONALE

Fungi attack organic materials, and thus may adversely affect textiles, plastics, leather, rubber, wood, paper, paints, varnishes, electrical insulation, and certain optical and electronic parts and coatings. Byproducts of fungal metabolism may cause corrosion or deterioration of equipment. The physical presence of fungal growth may cause electrical failure due to short-circuit. Fungal growth may be supported by dirt and impurities on a surface even though the surface material itself may not support such growth.

Even where fungal growth does not affect operation of a piece of equipment, it may affect the usability of the item. For example, as a result of the odor and general appearance of the growth, personnel may be reluctant to use the item.

3.9.3 PRESENT UTILITY

The fungus test is suitable for all equipment which may be used, stored or transported through regions which may support fungal growth.

The test procedure specifies the preparation of the culture, mineral salt solution, and control items, and the method by which the control and test items shall be inoculated and incubated.

3.9.4 DISCUSSION

The fungus test criteria do not specify what constitutes failure. There are three problems to consider in defining failure criteria: the direct effect of fungal growth on equipment operation, the subjective human factors effects, and the corrosion effects of high humidity.

A possible definition of failure might be a determination that fungal growth impedes equipment use in an unacceptable way, taking into account both functional operation and human factors. For example, if in the opinion of human factors engineers, fungal growth on an item would tend to make personnel reluctant to use it, the item would fail the test.

Since the fungus test is also a humidity test, consideration should be given to devising humidity failure criteria for this test, and separating the two types of failure. Thus,

an item, after undergoing this test, may pass for fungus and fail for humidity, and only need to be redesigned and/or retested for humidity.

As a test of humidity effects, the fungus test is longer than the Humidity Test (Method 507), 28 days rather than 10 days, but less severe, 30°C (86°F) rather than 65°C (149°F). Tests should be run to find the relationship between the corrosive effects of humidity on various types of equipment under the two sets of conditions, and also the relationship between humidity effects under test conditions and field conditions. Following that, guidance should be written coordinating the Fungus Test and Humidity Test as tests of humidity conditions, to enable a test planner to decide whether to specify one or both tests.

The project team is aware of USATECOM's current efforts to change the fungus test procedures. This may bear on the relevance of the foregoing discussion.

3.9.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The Fungus Test (Method 508) does not specify failure criteria.

Recommendation 1: Failure criteria be developed which specifically take note of the three problem areas, namely the subjective problem of human factors, the effect of fungal growth on equipment operation, and the corrosion effects of high humidity.

Conclusion 2: The Fungus Test is also a test of high humidity conditions, but no distinction is made between failures due to humidity, failures due to fungal growth, and failures due to the combined effect of both.

Recommendation 2A: Failure criteria be developed for this test as a humidity test, and a distinction be made between pieces of equipment that fail the test because of humidity and those that fail because of fungal growth, or failure because of both humidity and fungal growth.

Recommendation 2B: Tests be run correlating the corrosive effects of humidity on equipment under field conditions, by the Fungus Test (Method 508) and the Humidity Test (Method 507). Following that, guidance be developed coordinating the Fungus Test and Humidity Test as tests of high humidity conditions.

Recommendation 2C: All these recommendations be considered, and possibly modified, with respect to any changes to Method 508 proposed by USATECOM.

3.10 SALT FOG TEST, METHOD 509.1

3.10.1 PURPOSE

The purpose of the salt fog test is to determine the resistance of equipment to the effects of salt atmosphere exposures during operations and storage.

3.10.2 RATIONALE

The two major deleterious effects of salt fog on equipment are corrosion of metals and coatings, and clogging or binding of moving parts. A salt atmosphere has dielectric properties different from those of an ordinary atmosphere, and thus may affect the operation of electrical and electronic equipment.

3.10.3 PRESENT UTILITY

The test is suitable for any equipment exposed to salt fog conditions in service. The test conditions are aggravated - the moisture and salt conditions specified are more severe that those found in service. The purpose of these exaggerated conditions is to accelerate the deleterious effects of the salt atmosphere.

The test procedure specifies the salt solution, atomizing equipment, and method by which the atomized solution shall be injected into the test chamber.

The test can be used for evaluating the uniformity of protective coatings of different lots of the same product. It can also be used to detect the presence of free iron contaminating an equipment surface made of another metal.

3.10.4 DISCUSSION

Unlike the other tests in the Standard, the test guidance has a number of limitations and deficiencies listed. The deficiencies are:

- There is no evidence of a relationship between salt fog corrosion and corrosion due to other media,
- The salt fog used in this test does not have the same effect as a marine atmosphere,
- Passing this test does not prove that an item will withstand other corrosive conditions,
- The test is unreliable for comparing the corrosion resistance of different materials or coating conditions, or for predicting their comparative service life.

There is a partial contradiction in the guidance for the salt fog test contained in the Standard. Paragraph 1.1, Application, states that the test is valuable for determining the durability of coatings and finishes exposed to a corrosive salt atmosphere. However, paragraph 1.1.1.1(d), Deficiencies, states that the test is generally unreliable for comparing the corrosion resistance of different materials or coating conditions. If the latter is true, it is difficult to see how the former can be true. In fact, after reading through the limitations, it seems that the test's only useful purpose lies in the evaluation of uniformity of coatings. This makes the salt fog test a useful quality control test, but not a useful environmental test.

Data is needed on the correlation between marine atmosphere corrosion and corrosion due to the salt fog either of this test or of a redesigned test.

There is no provision in the test procedure for evaluating the effects of a salt atmosphere on electrical and electronic equipment, other than the purely mechanical effects of clogging or binding of moving parts, e.g., a radar or fire control antenna mounted topside on a ship.

3.10.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The deficiencies of the Salt Fog Test (Method 509) seem to outweigh the advantages, indicating that the test is unsuitable for its intended purpose.

Recommendation 1: The Salt Fog Test be used as a quality control test to check uniformity of coatings only.

Conclusion 2: There is no strong correlation between corrosion produced in the Salt Fog Test and corrosion produced by a marine atmosphere.

Recommendation 2: Investigation be made to establish whether the present Salt Fog Test or a redesigned test is predictive of field service marine and/or other corrosion.

Conclusion 3: The Salt Fog Test contains no provisions for evaluating the effect of a salt atmosphere on electrical or electronic equipment, other than mechanical effects.

Recommendation 3: Procedures be developed for evaluating the effects of a salt atmosphere on electrical and electronic equipment.

3.11 DUST (FINE SAND) TEST, METHOD 510.1

3.11.1 PURPOSE

The purpose of the dust test is to determine the resistance of equipment to the effects of dry dust (fine sand) blowing during operations and storage.

3.11.2 RATIONALE

Dust can foul mechanical moving parts, interfere with their lubrication, and cause them to wear out quickly; make relays inoperative; short out electrical or electronic equipment; act as a nucleus for collection of water vapor; support growth of fungus; or directly corrode external surfaces.

3.11.3 PRESENT UTILITY

The test is suitable for all equipment which may be exposed to an atmosphere laden with dry sand and dust up to 150 micrometers in size. It is not suitable for equipment that will be exposed to larger dust particles; for example, rifles, vehicles and helicopters which ordinarily encounter particles of up to 1000 micrometers.

The test procedure simulates the blowing of sand against the equipment, at two different wind speeds, 300 fpm and 1750 fpm. The equipment may be operated during the exposure to sand, if so specified, and must be operated and inspected following the exposure.

3.11.4 DISCUSSION

The test specifies the dust size, and allows no changes even if it is known that the equipment will encounter different dust and sand conditions in the field. The test should allow the test planner the option of specifying different dust or sand sizes if he can document the need for such a change.

The dust concentration specified (0.3 ± 0.2 g/ft^3) is really a range having a factor of five from bottom to top (0.1 to 0.5). It is quite conceivable for a piece of equipment to pass the test at the lower end of the range and fail at the top end or even the middle. The range should be narrowed if technologically feasible.

The test procedure does not specify the humidity inside the test chamber when the temperature is raised to 63°C (145°F) during Step 2 (Paragraph 3.1). Since there is no humidity specified, the condition reverts to the General Requirements, Paragraph 3.1, or a humidity of 50% $\pm$ 30%. This humidity level is a less severe condition than desired. It is presumed that a dry condition is desired during this step and the following one; therefore, the desired humidity should be specified.

3.11.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: No allowance is made for other dust and sand sizes than the one specified.

Recommendation 1: Allowance be made for the test planner to specify the dust and sand granular size suitable for the equipment in question, and guidance be written to aid in this decision.

Conclusion 2: The dust concentration specified (0.3 ± 0.2 g/ft^3) has too wide an allowable range.

Recommendation 2: The dust concentration have a narrower range if technologically feasible.

Conclusion 3: The humidity is not specified during Steps 2 and 3 of the test, which allows the test to be made under conditions less severe than desired.

Recommendation 3: The desired humidity be specified during Steps 2 and 3 of the test procedure.

3.12 LEAKAGE (IMMERSION) TEST, METHOD 512.1

3.12.1 PURPOSE

The purpose of the leakage (immersion) test is to determine the resistance of equipment to water leakage while being immersed in water during operations.

3.12.2 RATIONALE

Air seepage in the form of bubbles would be an indication of defective equipment or workmanship. Water seepage into the equipment can cause corrosion or contamination of lubricants between moving parts.

3.12.3 PRESENT UTILITY

The test is suitable for all items of equipment with hermetic seals or gaskets. There are three procedures currently in use: a simple immersion test (Procedure I), an immersion test with the air above the water at reduced pressure (Procedure III), and an immersion test in which the equipment is internally pressurized (Procedure IV). (Procedure II has been discontinued.) Procedure III is suitable for determining slight leakage as well as gross leakage, and is also suitable for pressurized equipment. Procedure IV is only suitable for equipment which is normally pressurized in use.

3.12.4 DISCUSSION

The test is only representative of a natural environment for exterior-mounted shipboard and amphibious equipment, and possibly personnel-carried field equipment. According to the failure criteria, however, simulation is not the purpose of the test - the item is not to be tested for operability after the test, only for evidence of leakage. Thus, the test is really a quality control test. No mention of this fact is made in the guidance given for the test.

There is no coordination with the Rain Test (Method 506). The leakage test is more severe, and a piece of equipment which passes it should have no trouble passing the rain test.

Both Procedures III and IV claim to be suitable for equipment which is normally pressurized in use. However, no guidance is given as to whether one procedure is preferable to the other for such equipment, or whether both procedures should be used.

The test conditions for Procedure IV (Paragraph 3.4.1) specify that the pressurizing gas shall be clean and dry with a dewpoint of <u>at least</u> -32°C (-25°F) (emphasis added). Since a lower dewpoint corresponds to a dryer gas, the condition should read <u>at most</u> -32°C (-25°F), or -32°C (-25°F) <u>or lower</u>.

3.12.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: The Leakage Test (Method 512) is really a quality control test, not an environmental test.

Recommendation 1: Guidance be written to reflect this fact.

Conclusion 2: There is no coordination between the Leakage Test (Method 512) and the Rain Test (Method 506), a test similar in procedure and purpose.

Recommendation 2: Guidance be written to help a test planner decide whether one test or both tests are desirable, or whether passing or failing one test obviates the need for the other.

Conclusion 3: There is no guidance for deciding among the three procedures for the Leakage Test (Method 512).

Recommendation 3: Guidance be written to help a test planner decide which, if any, of the three procedures to use, or whether more than one is desirable.

Conclusion 4: The requirement (Paragraph 3.4.1) that the pressurizing gas have a dewpoint of at least $-32^{\circ}C$ ($-25^{\circ}F$) (emphasis added) is mistaken.

Recommendation 4: The requirement be changed to read at most $-32^{\circ}C$ ($-25^{\circ}F$), or lower.

3.13 TEMPERATURE-HUMIDITY-ALTITUDE TEST, METHOD 518.1

3.13.1 PURPOSE

The purpose of the temperature-humidity-altitude test is to determine the resistance of equipment to the effects of cycling between flight conditions and ground conditions during operations and/or transportation.

3.13.2 RATIONALE

Some of the effects of such exposure will be found in the sections on the Temperature-Altitude and Humidity Tests (Methods 504 and 507). In addition there may be synergistic or sequential effects resulting from the rapid change between these environments.

3.13.3 PRESENT UTILITY

The test is a nonoperating test suitable for equipment transported by air between extreme environments.

There is a single test procedure, consisting of alternating conditions of low temperature and pressure, with conditions of high temperature and humidity. The low temperature and pressure are representative of extreme service conditions, while the high temperature and humidity combination is an exaggerated condition.

3.13.4 DISCUSSION

There is no coordination between this multiple-factor test and the other tests incorporating the same environmental factors singly or in combination (Altitude, High Temperature, Low Temperature, Temperature-Altitude or Humidity; Methods 500, 501, 502, 504, or 507). Guidance should be developed for a test planner to decide which of these tests to specify and in what order. It may be possible to start out with multiple-factor tests and only specify single-factor tests in case of failure, in order to track down the failure modes. Conversely, it may prove desirable to start out with single-factor tests and work up to multiple-factor tests as equipment design matures and improves.

There is only a single set of environmental conditions for this test, unlike the Temperature-Altitude Test (Method 504) with its eight categories of equipments, depending on use. It does not allow the test planner any leeway in setting limits according to a judgment based on the test items and their use. It would be preferable to have different sets of conditions allowable in the test, either by defining a set of equipment categories in a way similar to that of the Temperature-Altitude Test, or by developing guidance which would

enable the test planner to set his own conditions. The optimal situation would be the combining of the Temperature-Humidity-Altitude Test with the Temperature-Altitude Test. The combined test would retain the equipment categories and test procedure of the present Temperature-Altitude Test, with modifications if desired. The only changes necessary would be to specify the humidity at each step, to allow operation or nonoperation as desired in any step, and to allow repetition of all or part of the test cycle if desired.

3.13.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1: There is no coordination or correlation among the Temperature-Humidity-Altitude Test (Method 518) and the Altitude, High Temperature, Low Temperature, Temperature-Altitude or Humidity Tests (Methods 500, 501, 502, 504, or 507).

Recommendation 1: Guidance be developed through which a test planner can decide which of these tests to specify and in what order. Guidance also be developed to correlate results from these tests, and to help a test planner decide how results from any of these tests affect the decision to specify or not to specify any others.

Conclusion 2: No deviation is allowed in setting the values of the test parameters other than those specified.

Recommendation 2: Allowance be made for more than one set of values for the environmental parameters, in one of the following methods:

- Establishment of a set of equipment categories.
- Development of guidance to enable a test planner to set his own parameter values.
- Merging the Temperature-Humidity-Altitude Test with the Temperature-Altitude Test.

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APPENDIX A

SUMMARY OF INVESTIGATIONS

1. VISIT TO AFFDL/FEE, WRIGHT-PATTERSON AFB, DAYTON, OH

Mr. Hamilton traveled to Dayton, Ohio on 16 February 1978 to meet with Mr. David L. Earls of the Air Force Flight Dynamics Laboratory (Code FEE) on overall guidance for analyzing MIL-STD-810C. A series of questions were prepared beforehand to aid in the discussion. The following comments provide highlights of the meeting:

a. Mr. Earls basically agrees that 810C tests should be applied as early as possible in the developmental process. COL Ben Swett's (OUSD (R&E)) remarks on this subject are contained in the minutes of the 24-25 January 1978 meeting at Dayton regarding the 810D revision, and have been provided to the Project Officer (the Project Officer raised the question of when best to apply 810 testing).

b. He agrees that we should first touch base with the members and advisors of the Tri-Service Group, namely Mr. Slusarski at Aberdeen, Mr. Schafer at China Lake, Messrs. Martin and Broude at NAEC Lakehurst, and Mr. Gott in Washington. Also, Mr. Askin at ARADCOM if time permits.

c. He also concurs that to the degree necessary, the project team should contact Army, Air Force and Navy projects (2-3 each) and talk to PMs, PEs, spec writers and environmental test engineers. He agrees that interviews with testing laboratories and manufacturers of environmental test equipment would also be fruitful.

d. The discussion of the format for 810D occupied most of the meeting time. He is sure that the concept of a Section I for "Criteria Methods" and a Section II for the test procedures themselves is the preferred format at this time. If we can construct a standard, scientific methodology for selection of criteria, limits, specific test values and their attendant justification, it is possible that it may be added to the front of 810D as a recommended methodology. We will construct some example methods early in the project and submit them for review.

e. He feels that developing cost as a parallel to criteria limits selection and definition of risks may be too difficult. His experience reveals that test costs are difficult to obtain from contractors (some

proprietary problems owing to a contractor's risk cost versus an actual test cost). Also, the range of costs associated with a range of risk may be difficult to document. This particular approach has not been tried to his knowledge, but the acquisition of costs has, and he sees many pitfalls. However, he agrees that we should try to obtain them during our talks with testing labs and contractors.

f. He has a copy of the Statement of Work for this contract and our role has been clarified.

g. He believes we should stick to the basic tenet that 810 is for electronic equipments, and not try to obtain background or perform analysis to bring other equipments under its umbrella, e.g., micro-electronics, components, etc.

h. He introduced Mr. Hamilton to Mr. Phillip Hermes, an environmental test engineer at AFFDL. In a meeting of about two hours, Mr. Hermes provided some insight into the 810 test procedures and development of test criteria and limits.

i. He also provided the project team with additional documentation relevant to the 810 analysis.

2. TELEPHONE INTERVIEW WITH I.B. IRVING, JOHNS HOPKINS APL, LAUREL, MD

On 3 March 1978, Mr. Hamilton conducted a telephone interview with Mr. I. B. Irving of Johns Hopkins University, Applied Physics Laboratory, Laurel, Maryland. Mr. Irving often represents the Navy in matters dealing with contractor environmental testing according to contractual specifications. His comments included the following observations:

a. Check several specifications to see how many waivers have been granted to environmental test methods and limits.

b. Combined testing is the key to better simulation of the real environment.

c. Human-related equipments are built under much stricter specifications. There may be a problem in identifying when an equipment is truly human-related.

d. See how many layers there are between the spec writer and the approval authority. The more layers there are, the tighter (more extreme criteria) the specification.

3. VISIT TO TECOM, ABERDEEN, MD

Mr. Hamilton and Dr. Plotkin met with Messrs. S. Wise, J. Slusarski and R. Williamson, Methodology Division, TECOM Headquarters on 6 March 1978. A conference room was provided and almost four hours of productive talks ensued.

The ManTech team stated its work premise, and Mr. Wise gave background information on TECOM and its role in environmental testing. The TECOM people advised we obtain MIL-STD-781C (examine selectively-ignoring data) and MIL-STD-331A, which is being revised.

TECOM also advised that we not delve into the cost of testing. Costs should only be examined from the standpoint of how they influence developers/project managers in their decisions on the scope of environmental testing and test limits.

TECOM agreed that our investigation would be fruitful if we defined the interface between the user (developer) requirements and the people who will design the rationale, or guidance, for Section I of the 810 revision. More clearly, by outlining the breadth of needs of those whose function it is to invoke environmental testing requirements in contractual specifications, we will provide guidance to those who will develop the rationale of Section I. This should ensure that the resulting rationale encompasses those areas in which originators of testing requirements will be seeking advice.

TECOM believes that the present environmental test method rationale is inadequate. They cited the Fungus Test (508.1) as an example.

TECOM believes that combined testing is the "wave of the future", but it is not now documented. They believe that combined testing more nearly approximates the real environment.

4. VISIT TO ARADCOM, DOVER, NJ

Mr. Hamilton met with Mr. David Askin, Instrumentation Branch, and Mr. E. Kenneth Stewart, Product Assurance Branch of ARADCOM on 7 March 1978.

Mr. Askin gave a broad history of the development of 810, including the inclusion of the present rationale.

In discussing the point-in-time for conducting tests, i.e., early development or full production acceptance, Mr. Stewart said that tests, as shown in 810, may need shortcutting during early development article testing. This is in view of the equipment probably not being in its final production configuration. He also felt that during early development the full usage envelope for the article may not have been defined. He

gave several examples of ammunition which was developed for use in free fall canisters with corresponding low shock test limits; however, later the ammunition was designated for use in artillery rounds, which required a much higher shock test threshhold.

Mr. Askin suggested that the ManTech team familiarize themselves with MIL-STD-331A (as per TECOM the day before), and several other documents which cite 810.

He also consented to contact three Army developmental projects at ARADCOM to set the stage for telephone interviews with project personnel concerned with 810 testing.

Mr. Askin and Mr. Stewart both discussed at length the approach to providing guidance for invoking the tests, and generally agreed that we were operating in the right area to provide better definition to those who will develop the rationale. They were most helpful in referring us to documents, other interested parties, and project offices at ARADCOM.

5. VISIT TO TENNEY ENGINEERING, UNION, NJ

Dr. Plotkin met with Sy Sternbach (Executive Vice President) and George Wheeler (Chief of Quality Assurance) of Tenney Engineering, Inc., Union, NJ on 7 March 1978. Tenney Engineering manufactures environmental test chambers of all sizes, from bench top chambers of 1 or 2 ft^3 to special orders of 2,000 ft^3. Their standard models are capable of combined temperature-humidity altitude testing, and they have the capability of constructing chambers for all the environmental tests, although they haven't made many salt fog, dust or rain chambers.

Their chambers are capable of combined environmental and physical testing (vibration, acceleration, noise, shock), and are equipped for operational testing. The also have facilities for electrical and/or mechanical hookups, and glove ports.

They don't particularly delve into the specs themselves (use or misuse of 810C), only that their equipment can be used for the testing.

It was their belief that the cost of operating the chambers during tests is fairly low - the major factor in cost of testing is the cost of equipment being tested.

The cost differential between single-stage refrigeration and cascade system is not great. A typical 30-ft^3 chamber (temp/hum) costs about \$9K for -40°F, and \$10K for -112°F.

6. VISIT TO REMBASS PROJECT, FT. MONMOUTH, NJ

Dr. Plotkin met with John Quinn, Product Assurance Chief of PM REMBASS, on 8 March 1978. From Quinn's viewpoint, the

REMBASS specs are ancient history - they came from the Material Need (MN) document, which was put together by the user, TRADOC, and the PM office at the very beginning. The specs are then written using the MN, MIL-STD-810, AR 70-38, and tradition. Not very much thought is given to the details in the specs, and more guidance in 810 would be very welcome. Some of the REMBASS tests have different limits from those mentioned in 810.

7. VISIT TO FIREFINDER PROJECT (OLD MALOR), FT. MONMOUTH, NJ

Dr. Plotkin met with Frank Murphy, Project Assurance Chief of FIREFINDER, on 8 March 1978. His feeling about how the specs are written is much the same as Quinn's. He feels that the MN document should be more specific and give more guidance to spec writers, and that all the documents the spec writers use, including 810, should have more guidance. He says that deviation from the 810 format, tests and limits is too much trouble, so that most people just follow it. (Note: ROC now used vice the MN).

The spec writers he is familiar with do have guidance available from environmental engineers.

They have an example of *procedure* following test failure: the AN/TPQ-37 radar failed the 810C humidity test. The developer complained that the test was not realistic, whereupon the PM office called in an independent contractor to evaluate the test. The contractor agreed that the test was too stringent - an exaggerated test, not an accelerated test. The PM and the developer are now deciding what test to use. The outcome will probably be to use the 810C test as a storage test - with dryout allowed before operation, and then use a test based on AR 70-38 as an operational test.

8. VISIT TO CERCOM, FT. MONMOUTH, NJ

Dr. Plotkin met with Art Landberg, Chief, Airborne Communications Section, Logistics Engineering Directorate, CERCOM, on 9 March 1978.

CERCOM maintains the specs after equipment is fully developed and in the field. They are handed the spec package from the developing command and have the responsibility of making sure each new procurement meets the specs. They aren't involved in spec development (in terms of realism of testing, etc.), and are concerned only that the equipment meets the requirements.

They don't actually do the testing - they witness contractor testing.

They feel that the cost of testing is irrelevant - the large cost is that of the tested equipment which may be destroyed.

They think that 810 is too vague about whether operation is required during testing - it has led to disagreement between them and TECOM in the past.

They are not always sure about the intent of the tests.

9. VISIT TO NAEC, LAKEHURST, NJ

Dr. Plotkin met with David Broude and Alex Martin of the Engineering Specifications and Standards Division of NAVAIR, on 10 March 1978.

They feel that tailoring (as per MIL-HDBK-248) is the wave of the future - it will be necessary to have a matrix or checklist to examine for each equipment type in order to determine what tests and the severity of tests necessary.

They are also in favor of the approach taken in MIL-STD-1670; the construction of an environmental profile for equipment before making any decisions on testing.

They would like to see much more guidance included in 810. Alex Martin feels that a large introductory section with philosophy, rationale and instructions is necessary, possibly including something like a tailoring matrix.

10. MEETING AT JOINT CRUISE MISSILE PROJECT OFFICE, WASHINGTON, DC

Dr. Plotkin and Mr. Hamilton met with Mr. Jack Gott of the Cruise Missile Project on 14 March 1978.

His feeling is that the whole spec writing procedure is very vague - no guidance is given anywhere along the line down to the spec writer, who then sets everything in concrete, arbitrarily.

He feels there is a distinction between simulation tests and exaggerated or accelerated tests, and that exaggerated tests should be included. He wants both philosophies to be included in the guidance document.

On projects he has been associated with, very little time or money is available to cope with test failures, so usually a waiver is granted.

11. CONSULTANT TRIP TO RAM SYMPOSIUM, LOS ANGELES, CA

ManTech's consultant on this project, Mr. Maurice H. Simpson, visited Los Angeles to meet and talk with various key and knowledgeable members of the Technical Divisions and Climatic Committee of the Institute of Environmental Sciences (IES) who were holding a meeting during the Reliability and Maintainability Symposium (RAMS) in Los Angeles, 16-18 January 1978. The objective of the trip was to obtain inputs from the IES people for recommended type questions, places, and technical environmental testing and specifications writers to interview in connection with the background survey for the MIL-STD-810C study.

Members of the Climatic Committee of IES were contacted and consulted before, during and after the IES meeting. Specific members present were J. Stuart (Boeing Aircraft), Chairman of the Climatic Committee; Stan Baber (Boeing Aerospace), Technical Vice President of IES; Robert Hancock (Vought Corp.); and Hal Chenoweth (Rockwell International). Others present were Fred van Biene (Jet Propulsion Laboratory), President of IES; Dr. Clement Tatro (Lawrence-Livermore Laboratories); and Bob Geminder (Mechanics Research of Systems Development Corp.), Executive Vice President of IES. These latter people were made aware of ManTech's impending survey and the possibility for contacting them during the course of the survey. A working copy of a preliminary list of possible questions and names of users of MIL-STD-810C to survey was completed. This preliminary list was presented for review and amplification by the various IES people during the 17 January morning and afternoon meetings. During the afternoon and evening of 17 January, Mr. Simpson met with J. Stuart and further examined and reviewed the proposed set of questions, and places and names of people to survey. Stuart was provided with a Xerox copy of the working papers and took the information with him for further review by other members of the Climatic Committee who were not attending the RAMS meeting. He promised a response within 15 days.

Other informal contacts were made with Vic Marone and Hank Caruso of Westinghouse, Baltimore with regard to (1) ManTech's general approach to performing the survey, and (2) possibilities of various methodologies for use in analysis of information acquired and methods of presentation.

The following results were attained: (1) an input list of specific "best" persons and government agencies and industry organizations to survey, (2) type questions to ask them, and (3) background information useful to the development and assessment of the rationale behind the use of climatic methods of MIL-STD-810C.

12. VISIT TO NAVAL ORDNANCE STATION, INDIAN HEAD, MD

On 16 March 1978, Messrs. Hamilton and Plotkin visited NOS Indian Head, Maryland to discuss environmental test specifications with Messrs. Steve Brennan and Karl Linde, of Code 6111E, NAVSEA Military Standards and Specifications Office.

This office basically receives rough specifications from developing agencies and Navy laboratories, formats them in accordance with prescribed MIL-STD/SPEC procedures, and checks them for content and clarity. Both Brennan and Linde are engineers, thus, they check all specifications from an engineering standpoint backed by experience.

They feel they have no ready environmental test guidance, and would be in favor of having more available in a revised 810C.

They noted some conflicts between MIL-E-5272 and 810C. NAVSEA wants to cancel MIL-E-5272 and so does the Air Force (both on record with letters), but NAVAIR wants to retain it.

They believe the inclination of the spec originator tends to be to prescribe environmental tests and associated limits from previously developed specs.

They commented that many Navy programs use Weapons Specifications (WS) as disguised MIL-SPECs. They believe the number of WSs is almost half of the entire total of DODISS specs and standards.

13. VISIT OF HOWARD SCHAFER, NWC CHINA LAKE TO MANTECH'S ROCKVILLE OFFICE

On 17 March 1978, Mr. Howard Schafer, NWC China Lake, California visited Messrs. Hamilton and Plotkin and ManTech Corporate Vice President Norman I. Radin at ManTech's Rockville, Maryland office. Also in attendance were the project sponsors, Mr. Harry McPhilimy and Dr. Thomas Niedringhaus, Engineer Topographic Laboratories, Fort Belvoir, Virginia.

Mr. Schafer made extensive comment. The following excerpts are noteworthy:

a. MIL-STD-781C and 785 leave much to be desired.

b. The ManTech team should concentrate on talking to design people, and test and spec developers.

c. Design is a compromise process. In a similar vein, the scope and extent of environmental testing may have to be adjusted to recognize the compromises made in design.

d. The team should seek out opposing views, then meld them together.

e. The team should contact Edward H. Parker of Lockheed-Georgia and get his views on environmental testing. Also contact Cliff Ryerson of Hughes.

f. Define, for example, how the engineering development stage environmental test differs from an environmental qualification (pre-production) test, a reliability, or production acceptance test.

g. Environmental testing is a subset of reliability testing.

h. Realism is the key word in environmental testing.

i. The team should become familiar with MIL-SPEC-41065, dealing with R&M and environmental testing.

j. The team should use caution in prescribing hard (fixed) numbers in addressing guidance for environmental testing.

14. VISIT TO WESTINGHOUSE CORPORATION, BALTIMORE, MD

On 20 March 1978, Messrs. Hamilton and Plotkin visited Mr. Henry Caruso at Westinghouse Baltimore. His comments included the following points:

a. Decisions on environmental tests are generally avoided. It is easier to use a "hand-me-down", or prior specification as a basis for stipulating environmental testing parameters.

b. Get management into the decision process on the proscription of environmental tests. They have abdicated their responsibility.

c. Get a decision process back into the environmental test design and specification development.

d. He cautions of the approach taken in MIL-STD-781C. A table of minimum values is an unfortunate inclusion in this document. It affords test specification originators an "easy way out". Also, the worst case philosophy, as applied to test limits, may not identify the extreme limit the equipment will see.

e. A rationale is needed for testing at other than the extreme values presently prescribed in MIL-STDs.

f. Tailoring may imply that the contractor "is getting out of something".

g. A caution is urged in accelerated testing. The results are not linear in all cases when stress levels are raised.

h. Get environmental test planning into the acquisition process in the beginning when it can impact more readily on the design process - not two years later when it will be more expensive to go back to design to accommodate the change.

i. We need to underscore the purpose of 810C. What should it do? How can we get people to use it in test planning - and intelligently?

j. MIL-STD-810C procedures should be response oriented rather than fixed.

k. The RFP dictates the mode of response: the provision of no latitude generally results in no thought in testing by the contractor; the provision of alternatives gets the test engineer into the response process.

l. Regarding the shock test (516.1) - the data in 810C are based on the hammer table. Now, with aerodynamic shaking, the curve in 810C doesn't fit.

m. The procedures in 810C are too hard and fast. Some are based on old thoughts conditioned by the then present technology.

15. VISIT TO MELPAR, DIVISION OF E SYSTEMS, FALLS CHURCH, VA

On 21 March 1978, Mr. Hamilton visited Messrs. Earl Diehl and Max Orr at Melpar. Noteworthy comments are as follows:

a. They both have generated environmental test specs. Their observation is that the customer (the Government) generally "beefs up" the specifications.

b. Regarding vibration testing, they note that 810C provides for sinusoidal vibration only. Also, the costs go up when you test to 10g. They believe 5g is sufficient; 2g is a more likely limit in nature, one example being a military jet aircraft in its flight mission environment.

c. They have developed many test specifications. From their experience with customers, they generally "beef up" the specs beyond likely extremes in order

to gain early approval. They observe an inconsistency in the spec approval process among their customers.

d. Their equipment has generally had success in passing the fungus test (at Fort Huachuca (TECOM)).

e. They cited a reason for raising a contractor-developed spec limit as clashing with "generally accepted" service standards, without ever really defining what is meant by "generally accepted". They say that generally the contractor-to-contractor interface is good in this regard. They also note a general inconsistency in dealing with spec approval and waivers, and cited some examples.

f. They note a clash between the limits of MIL-STD-210B and MIL-STD-810C.

g. They question the need for the salt fog test in 810C.

h. The wording in 810C is vague in certain areas. One example, in the salt fog test, is "There shall be no evidence of. . ." What constitutes evidence?

i. MIL-STD-810C contains some unrealistic testing requirements. Some tests reflect a casual approach to scientific testing.

16. VISIT TO MERADCOM T&E LABORATORY, FORT BELVOIR, VA

On 21 March 1978, Mr. Hamilton met with Mr. Ivan Silver, Chief, T&E Lab, MERADCOM. Noteworthy comments made by Mr. Silver during this discussion include the following:

a. Equipment today is more rugged - even commercial, off-the-shelf equipment - than that in use when many of the 810C tests were constructed. He feels most equipment can pass the 810C tests easily.

b. A laboratory test can only approximate the real world. To exaggerate limits is more costly.

c. He noted that 810C vibration levels were lower than those in 810B.

d. The 810C vibration test is sinusoidal, leaving the problem of random vibration open to question.

e. Suggested improvements to 810C should include:

- o Accounting for the limits of lab testing,
- o Including separate guidance,

- o Removing hard limits from the test procedures, causing people to think more about the factors involved for their particular equipment.

17. VISIT TO NOAA T&E LABORATORY, WASHINGTON NAVY YARD, WASHINGTON, DC

On 23 March 1978, Dr. Plotkin met with Mr. Eugene Russin, Chief, Sensor Test Branch, T&E Lab, National Ocean Survey, NOAA, and Al Kalvaitis (a lab associate). They have no requirement to use MIL-STD-810 in procurement or development, and only make use of it as an occasionally applicable document or as a starting point. They then decide if the tests are useful for their purposes and, if not, they develop their own tests.

In fact, they have a contract out to develop an environmental testing handbook (a National Ocean Survey version of 810) for their own use.

In their document, they intend to include much more rationale and background than currently found in 810. They tend to favor the amount and type of material contained in the background document for MIL-STD-210B (the Sissenwine-Cormier report).

They do very little product development - they generally buy commercial, off-the-shelf equipment to suit their needs, providing it meets their specifications and can pass the requisite tests.

18. VISIT TO NAVSEA ADVANCED LIGHTWEIGHT TORPEDO PROJECT OFFICE, CRYSTAL CITY, ARLINGTON, VA

On 31 March 1978, Messrs. Hamilton and Plotkin met with Mr. Robert J. Wieck, NAVSEA Code 662E-241, test engineer for the Advanced Lightweight Torpedo Project.

Their philosophy on testing maintains that during advanced development limited environmental tests are conducted, because they want to make sure the torpedo works first. Then, during engineering development, they will harden the torpedo for shock tests after they know it works.

They use 810C tests; however, they downgrade testing severity during early developmental stages. Past experience on the MK 46 and 48 torpedoes, plus research and project group engineering inputs, were all used to formulate temperature and other test limits.

The basic determination of environmental test parameters was founded in the Operational Requirement (OR) prescribed by the CNO.

19. VISIT TO NAVSEA RELIABILITY AND QUALITY ENGINEERING OFFICE, CRYSTAL CITY, ARLINGTON, VA

On 31 March 1978, Messrs. Hamilton and Plotkin met with Messrs. A. R. Frizalone (Chief), Art Bowman, Melvin Landis and Henry Itkin of NAVSEA R&QE Office, plus Mr. Tom Brenner of NAVSEA Standardization Office. The substance of the discussion was as follows:

a. NAVSEA is guided by MIL-E-16400G, Amendment 1 for environmental test limits for shipborne equipments, which are categorized according to location aboard ship. Then MIL-STD-810C tests are used.

b. They believe that 810C should contain the most extreme case limits, to ensure that test equipment manufacturers keep making "capable" test chambers.

c. Environmental tests should be considered as tests of survivability.

d. It is their belief that MIL-STD-781 was meant primarily for production acceptance testing, not for design qualification testing.

e. They advised that the team contact NAD Crane to talk with test engineers on ammunition testing, and that NAVELEX also be contacted for their opinions.

20. VISIT TO HEADQUARTERS, NAVAL MATERIAL COMMAND, CRYSTAL CITY, ARLINGTON, VA

On 31 March 1978, Mr. Hamilton met with Mr. Kenneth LaSala, NAVMAT Research and Engineering Branch (MAT-08E).

Mr. LaSala expressed interest in the 810C project, agreed with the approach to putting test guidance in a separate section of the Standard, and would like to be kept advised of team progress.

21. VISIT TO NAVSEA RDT&E DIRECTORATE, CRYSTAL CITY, ARLINGTON, VA

On 31 March 1978, Dr. Plotkin met with Mr. A. R. Paladino, NAVSEA Research and Technology Directorate, Sound and Vibration Research Branch (NAVSEA 037). His field is vibration testing, so he is not directly concerned with our work, but his general comments are of interest.

He feels that standard packaging and mounting must be taken into account in testing. Equipment should be designed to the mission profile, not the transportation profile, and then should be packaged and mounted in such a way as to counteract adverse transportation and storage effects. It is much more expensive to design equipment to meet both transportation and mission requirements without considering packaging/mounting during tests.

He feels that something like a tailoring matrix is required, and that numbers should be left out of the test procedures. Specifically, he wants a road map for use with 810.

22. TELEPHONE INTERVIEW WITH MR. MARV LINN, ARADCOM, DOVER, NJ

On 4 April 1978, a telephone interview with Messrs. Marv Linn and Chet Kochan, ARADCOM, DRCPM-CAWS, Conventional Ammunition Weapon Systems Project Office, Dover, New Jersey, was conducted.

Mr. Linn stated that new Army guidance is currently being developed which will call for equipment design for temperature regions only. Already only zones 1-7 from AR 70-38 are specified, dropping out zone 8, i.e., severe cold.

He thinks environmental test planners need to obtain more knowledge of the "realism" of the environment, in the way they attempt to simulate the real world.

He thinks there should be more active participation by developing commands in the generation of ROCs. Project people also need a voice, because they will be the ones to execute the program.

He also said that planners should look for the "limiting element" of a system, then test to that limit only. Also, look at each system element in its environmental location, e.g., a radio inside a tank and an optical rangefinder mounted on the outside of the tank.

He says that the tests in 810 should be tempered so that testing is performed only to the extent necessary. Also, guidance should be written as simply as possible.

23. TELEPHONE INTERVIEW WITH MR. JOHN KICAK

On 14 April 1978, a telephone interview was conducted with Mr. John Kicak, DRCDE-E, DARCOM HQ, Office of Specifications, Standards and Engineering.

Mr. Kicak stated that the ROC was a joint TRADOC/DARCOM responsibility, but that TRADOC was more in the initiative phase. TRADOC uses its field activities and schools for advice on developing the ROC. He also stated that Army equipment is presently designed for use worldwide, but that may change.

24. VISIT TO IES MEETING, FORT WORTH, TX

Dr. Plotkin attended the IES convention held from 17-20 April 1978 in Ft. Worth, Texas. He gave out the preliminary report (Preliminary Ideas for Guidance to High Temperature Test, MIL-STD-810C) to Messrs. Kidd (Bell Helicopter), Schafer (China Lake), Irving (APL), Wise and Slusarski (TECOM), Earls (AFFDL), Askin (ARADCOM), Caruso (Westinghouse), Hancock (Vought), Stuart (Boeing), and Allan (DMSSO).

Sessions attended: Early Bird Reception (Mon. eve), Keynote Panel (Tues. morning), Reliability Session 1A: DoD Planning (Tues. afternoon), Reliability Session 2A: Specification Tailoring and Reliability Development (Wed. morning), Climatics Sessions 4E and 5E: Combined Climatic Environments and MIL-STD-810C (Thurs. morning and afternoon).

His general impression was that everybody agrees on the need for more guidance in 810 (and standards in general). There are many uses for 810 - among them test planning and design, actual testing, and contractual compliance. There is little or no information in 810 as to differences in the way to use the document for these various purposes.

Too many people are using 810 as a specification to which equipment must be designed, instead of a guidance document for use in assuring that equipment meets environmental specifications imposed by others (the final user, program manager's office, etc.).

The panel discussion during session 5E highlighted that there is still some disagreement between those who favor more flexibility in the way 810 is to be used and those who feel that too much flexibility may allow too much slack in the way requirements are enforced. The need for tailoring has to be balanced against the need for a cookbook approach to specify the tests in a procurement contract. ManTech feels (although this did not come out at the meeting) that the two-section approach which is being followed by David Earls (WPAFB), as head of the revision committee, will allow both points of view to be satisfied. The first section can give the guidance that will allow (and indeed force) 810 to be tailored to an individual piece of equipment at a specific time in its life cycle, and then once the tailoring has been done and all the blanks have been filled in, the second section would be a straightforward test procedure description.

25. CONSULTANT REPORT OF IES ANNUAL MEETING, FORT WORTH, TX

Mr. Maurice H. Simpson, consultant to ManTech, attended the IES annual meeting at Fort Worth, Texas on 17-20 April 1978.

Purposes of Trip: (1) To take advantage of the opportunity to interview key environmental test engineers and managers from the three military services, industry, and private test laboratories attending the meeting, and (2) to present and chair the Meeting Session 5E panel discussion specific to the thrust of MIL-STD-810C for employment in developing environmental test requirements for different phases in the RDT&E cycle of materiel, in order to elicit rationale of experienced environmental test engineers and managers in the use of MIL-STD-810C for such requirements.

Narrative: Regarding Purpose (1), various key environmental test engineers and managers were contacted throughout the four days of the meeting. These poeple were also introduced to Dr. Plotkin, who formally interviewed them.

Regarding Purpose (2), discussions were held individually with each of the Session 5E panel members in order to tone their discussion to the topics relative to MIL-STD-810C points in question. The discussion was held at Session 5E on the last day after all other sessions of the meeting were completed and other points about MIL-STD-810 had been brought up, especially those relative to Reliability Testing and Analysis. The members of the 5E Panel spoke in the following order:

Maruice H. Simpson	Chairman
David Askin	USAARADCOM, Picatinny Arsenal
Sidney Wise	USATECOM, Aberdeen Proving Ground
Howard Schafer	Naval Weapons Center, China Lake
David Kidd	Bell Helicopter Textron, Fort Worth
I. B. Irving	Applied Physics Laboratory, Johns Hopkins University
David Earls	AFFDL/FEE, Wright-Patterson AFB

Each of the panel members delivered a 10-15 minute talk on his views about the application of MIL-STD-810C provisions and methods for testing relative to the requirements in the three following test phases of the RDT&E cycle:

a. Development testing
b. Field/operations testing
c. Acceptance and production testing.

Each speaker provided reasons why or why not MIL-STD-810 was applicable to each particular one of the type tests. David Earls summarized the objective of the attempt to modify to MIL-STD-810D.

Results: Interviews were obtained with key environmental technical persons. Conclusions derived from the Session 5E Panel provided considerable background information for the MIL-STD-810C analysis in addition to the deductive rationale for employment of MIL-STD-810C provisions in specifying and performing environmental tests. Summary of conclusions reached in the panel discussions are that the Standard's methods are useful for development testing, production and acceptance testing, but not for field testing. Criticisms included: MIL-STD-810C too often serves as a "test-by-the-numbers" crutch for project engineers and specification writers; the Standard is good for its time but needs updating in accordance with advanced technology; compromises have left the Standard incomplete; and, there is a need for two parts in its makeup - one part to establish criteria for environmental tests, and another part to provide methods for performing the environmental tests in accordance with selected criteria. The latter suggestion will aid in "tailoring" of test specifications against blind cost-driving specifications for environmental tests during the different phases in the military equipment acquisition process.

26. TELEPHONE INTERVIEW WITH MR. HARTWELL WEBBER, CERCOM

On 18 April 1978, Mr. Hamilton conducted a telephone interview with Mr. Hartwell Webber, CERCOM, QA Division, Fort Monmouth, New Jersey.

Mr. Webber was involved in the 810B revision. He feels that test procedures are unsatisfactory, especially the salt fog, humidity and vibration tests. He stated that the tests in 810B were transferred bodily to 810C, thus the errors have been perpetuated.

He advised that we contact Thermatron, Holland, Michigan, which builds test chambers, as a good source for chamber capabilities.

We agreed that Dr. Plotkin would personally interview him at a later date.

27. VISIT TO TRADOC, FORT MONROE, VA

On 20 April 1978, Mr. Hamilton visited various activities at TRADOC to discuss the development of the Army ROC and other documents which provide guidance for or impact on environmental testing.

Experimentation and Test Directorate

Discussions were held with LCOL John B. Mapes, Jr., Test Coordinator, his assistant, Major William Creech, and the Technical Advisor, Mr. Don Reich.

LCOL Mapes stated that risk analysis needs to be made (during development of ROC) with full knowledge of all the environments to which the equipment will be exposed.

Mr. Don Reich feels that it is important to properly define equipment classes, as being critical to applying 810. Then the environment must be defined clearly and completely.

Mr. Reich explained the TRADOC/DARCOM relationship in ROC development, followed by an LOA between them. The two commands coordinate the ROC, then specs are written to the ROC and sent back to TRADOC (representing the user) for comment and approval.

Mr. Reich is concerned with making 810 too flexible, for fear of giving away the basics, and not obtaining the desired article.

Combat Developments Directorate

Discussions were held with Mr. Jack E. Harris, Senior Technical Director for the DCS, Combat Developments.

Mr. Harris further explained TRADOC's organization for and mission in ROC development. He said that DARCOM makes the state-of-the-art determination, but the overall technical aspects, cost, schedule and other program factors are determined jointly.

Despite the formal LOA, there is a need for greater agreement between TRADOC and DARCOM on the investigation into requirements, since they drive the development.

Mr. Harris also mentioned that there is a DA letter (originated by DCS OPS) that says equipment design will be based on use in Europe (this correlates with Mr. Linn from ARADCOM).

28. TELEPHONE INTERVIEW WITH MR. ROBERT WILLIS, TRADOC, FT. SILL, OK

On 20 April 1978, Mr. Hamilton conducted a telephone interview with Mr. Robert Willis, Field Artillery Specialist, TRADOC (ATSF-CD), Fort Sill, Oklahoma.

Mr. Willis discussed environmental test limits, and argued for more realism in simulating the actual operating environment.

He noted that, from his experience, the user often doesn't know what he wants, and cannot define a system to match the requirements of the ROC. He noted that in developing the ROC for a new howitzer, not enough input came from R&D (i.e., DARCOM) and the subsequent ROC reflected too much TRADOC and user input.

He suggested calling LCOL Varley on the Artillery Field Testing Board at Fort Sill.

29. TELEPHONE INTERVIEW WITH LCOL VARLEY, FT. SILL, OK

On 26 April 1978, Mr. Hamilton conducted a telephone interview with LCOL Wm. Varley USA, Artillery Field Testing Board, TRADOC, Fort Sill, Oklahoma.

He discussed field testing during DT/OT II. He said faults uncovered in OT II were, in most cases, traced back to DT I and engineering development. The fault, in most cases, was detected during DT I and engineering development but was not acknowledged. The problem was not overlooked - it was decided not to correct the problem. Army field boards note this and report it. The boards' reports of faults are not always concurred with - usually because of cost, schedule or a conscious engineering decision.

In a recent test program, it was noted that the faults were partly environmentally induced.

He feels that design engineers don't, in general, know the conditions in the field. Also, field conditions are not described adequately in the ROC.

30. TELEPHONE INTERVIEW WITH COL B. H. SWETT USAF, PENTAGON, WASHINGTON, DC

On 3 May 1978, Mr. Hamilton conducted a telephone interview with COL Ben H. Swett, USAF, OUSD (R&E), Pentagon.

COL Swett reiterated the need for using 810 in engineering development testing, but added that it could also be used for qualification testing.

He thinks performance monitoring during test should be improved, so that intermittent failures can be detected for certain stress types. He thinks we (the Tri-Service Group) need to take a hard look at exposure durations; too many testers stand back and "wait until the equipment breaks".

Furthermore, more emphasis should be placed on test methods, rather than stress levels; he wasn't sure that stress levels should be defined in the test procedure itself (he was informed that the current plan was to remove all numbers from the test procedures).

He thinks we should advertise the source of empirical data and associated analysis for each 810 test, to make it available to test designers and analysts.

He stated his opinion that PM offices don't have enough people to screen all SPECS/STDS applicable to their equipment. Hence, inadequate specs are generated, often overloaded with "cautious" requirements.

COL Swett thinks the matrix in the front of 810 is fairly good, and aims at the tailoring concept.

He thinks acquisition people - particularly development engineers - tend to pursue their own special interests and this drives costs upward. PM people are not forceful enough in overriding them to keep cost of testing down, for one example.

He thinks 810 needs flexibility in providing guidance to the test planner and the tester, but not too much (he seemed to accept the statement that by providing a range of limits and durations of exposure, the test planner would be forced to select his own criteria, which would, in effect, constitute tailoring).

He did agree that there should be no hard numbers in the new 810 (he was assured that this was not the aim).

COL Swett heartily agreed to the "logic tree" approach to providing guidance in 810. He thinks those who write specs and develop test plans need to be led by the hand through each step of the problem. He also agrees that if the process can include making the individual write down data as he progresses through the logic process, so much the better.

He recommended that we be aware of the "mind set" of the individual as he approaches environmental testing - as shaped by the philosophy of testing according to the stage of the acquisition process. MIL-STD-810 guidance must accommodate the "mind set" of each person who has occasion to use it, whether it be the spec writer or the test planner, and the stage of development for which the requirement is being written or the test planned.

31. VISIT TO CERCOM, FT. MONMOUTH, NJ

Dr. Plotkin visited Messrs. Art Landberg, W. I. Neveroski, Al Mindnich and Hartwell Webber of CERCOM on 4 May 1978 at Fort Monmouth, New Jersey.

It is their feeling that not enough thought goes into the choice of tests at the beginning of the development process in that equipment designers are basically interested in top performance, and that they regard environmental testing as a very peripheral requirement. The best way to get around this problem is for production, procurement and maintenance people to get together with design and development people at

the very beginning of an acquisition program in order to mutually educate each other so as to better choose testing requirements.

As part of that process, they feel that a step-by-step guidance procedure to take designers through the test planning process would be extremely helpful.

The second (and larger) part of the meeting was with Mr. Webber alone. He was mainly concerned with details of the test procedures which lead to non-repeatability of test results, such as conditions which either cannot be met or cannot be measured with sufficient accuracy. It was felt that his experience with the test procedures would be very valuable to the 810 revision committee, and since ManTech is not directly concerned with the test procedures, it was suggested that he get in touch directly with the committee.

32. VISIT TO DMSSO, ALEXANDRIA, VA

Dr. Plotkin and Mr. Hamilton visited Mr. Jeff Allan of the Defense Materiel Standards and Specifications Office (DMSSO) on 5 May 1978.

He is concerned with the proliferation of and lack of coordination between military documents in the environmental area (both DODISS and non-DODISS). He would like to see 810, as a testing document, coordinated with design requirements documents (such as the report on Rotary-Wing Aircraft that Don Artis is writing), and climatic information documents (such as MIL-STD-210B or AR 70-38). If there is no design requirements document for a particular piece of equipment, the guidance section of 810 should contain enough information, preferably in the form of a step-by-step procedure, to lead a test planner through the process of designing the necessary environmental tests.

He is troubled by the apparent clash in the terms "standardization" and "tailoring", but he thinks that our approach to the two-section format - guidance for tailoring in Section 1 leading to a strict test procedure in Section 2 - can reconcile the two philosophies.

He would like more prominence given to the ideas of synergistic and sequential environmental effects and the possible need for combined testing and/or sequential testing.

33. PROJECT MEETING AT FORT BELVOIR, VA

On 9 May 1978, Messrs. Hamilton and Plotkin met with the Project Sponsors, Messrs. McPhilimy and Niedringhaus, and two representatives from USATECOM, Aberdeen, Maryland, Messrs. Wise

and Slusarski. The purpose of the meeting was to prepare the way for commencement of work on the final report, including investigative results and recommended guidance for the revision of MIL-STD-810.

Mr. McPhilimy summarized the goals of the ManTech project effort. Mr. Wise commented on the paper ManTech prepared for the annual IES meeting. Mr. McPhilimy said that most comments directed to him agreed with Mr. Wise's comments that the guidance therein was not firm enough and lacked thoroughness and continuity. ManTech concurred.

The ManTech team then reiterated the goals of their participation and explained their approach to providing guidance through use of a "logic tree". Following considerable explanation and discussion, concurrence was obtained from all present on the feasibility and worth of this approach.

34. VISIT TO AEGIS PROJECT, NAVSEA, ARLINGTON, VA

Dr. Plotkin visited Mr. Dick Ball, head of System Definition and Testing for AEGIS, on 12 May 1978. His test engineer, John George was not available for the meeting.

MIL-STD-810 was not used for AEGIS. Specifications used were MIL-S-901 for shock, and MIL-E-16400 for other conditions covering general shipboard electronic equipment.

The only environmental test failures in AEGIS were in the area of shock, and they led to redesign and retest - no waivers.

At the time environmental standards for AEGIS were set up (over 10 years ago), the project office was very small, and it is possible that insufficient thought and guidance went into the standards.

He feels that additional guidance, in the form of a step-by-step procedure, designed to make early development personnel think more about the environmental testing process instead of passing it off as a peripheral matter, would be very useful.

35. VISIT TO NAVELEX, ARLINGTON, VA

Dr. Plotkin visited Mr. Bill Wallace of NAVELEX Specs/Standards Office on 12 May 1978. He feels that a combined testing approach to 810 might overlap the testing in MIL-STD-781C, which is mission profile testing. The difference would be that 781 testing would be designed to reflect mean conditions and ranges, while 810 testing should reflect extreme conditions. NAVELEX is collecting data on ship and aircraft

environmental conditions - for example, ship radar room and control room temperature and humidity - for use in the revision of 781. They feel that the 810 guidance should involve or include a risk analysis approach - that is, for example, there should be guidance to decide whether to design an item to the 99th percentile, the 95th percentile, or some other value.

He feels that 810 needs corrective action guidance. Presently, if an items fails on test, there is no guidance as to what to do next.

He feels that 810 is more suited to engineering development testing, and very ill-suited to acceptance testing.

He thinks that someone should look at integrated test planning.

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