

**THE  
HISTORY AND  
RATIONALE  
OF  
MIL-STD-810  
(EDITION 2)**

**(“TEST METHOD STANDARD  
FOR  
ENVIRONMENTAL ENGINEERING CONSIDERATIONS  
AND LABORATORY TESTS”)**

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**January 2010**

## ABOUT THIS EDITION

This document is a revision of the widely successful first edition of *The History and Rationale of MIL-STD-810*. The author has provided editing marks in the left margins to indicate additions and modifications for those who wish to find this material quickly or to make comparisons with the previous edition. New material in Edition 2 includes background and analysis of MIL-STD-810G, the latest version of *Test Method Standard for Environmental Engineering Considerations and Laboratory Tests*, published in October 2008.

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# THE HISTORY AND RATIONALE OF MIL-STD-810, EDITION 2

by  
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January 2010

**Disclaimer:** Any views presented in this paper are those of the author and contributors, and do not necessarily represent the views of DOD or its components.

## FOREWORD

In October 1965, Mr. Virgil J. Junker<sup>2</sup>, a project engineer with the Vehicle Dynamics Division, Flight Dynamics Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, published a report titled “The Evolution of USAF Environmental Testing,” Technical Report AFFDL-TR-65-197. The report presented “supporting data and background information on the origination and development of natural and induced environmental tests intended for United States Air Force (USAF) aerospace and ground equipment.” At that time, MIL-STD-810A, “Military Standard, Environmental Test Methods for Aerospace and Ground Equipment” was, in effect, an Air Force document. MIL-STD-810 has since progressed through six (6) revisions (MIL-STD-810B being the first Tri-Service version), with -810G being the sixth and “new kid on the block.” Please note that, as of this writing, MIL-STD-810G has been on the street for some 14 months. My procrastination in writing this update results in continued work on “fixing” changes to -810G for Change Notice 1, and an effort to capture at least some of the changes or anticipated changes in this paper. We now estimate Change Notice 1 will be available for review in September or October 2010.

As a point of information, I began writing the original paper somewhere around 1996, with the intent of capturing what I knew or could obtain concerning the evolution of MIL-STD-810F. I began my government career in 1970 at the US Army Electronic Proving Ground, Fort Huachuca, AZ. After one year as a project officer, I transferred to the Environmental Test Facility where I became immersed in MIL-STD-810 (-810B at that time) and environmental testing. After nine years I moved to the Test and Evaluation Command’s Headquarters at Aberdeen Proving Ground, MD, where I assumed the responsibility of Army Custodian for -810 (transferred from CECOM at Ft. Monmouth, NJ). After working with Tri-Service personnel through several iterations of -810, I offered to take over Tri-Service management of MIL-STD-810F (with Wright-Patterson Air Force Base retaining the “Preparing Activity” status). My intent was to prepare a document that was not only totally written in the same style, but also to try and make it a more user-friendly document.

<sup>1</sup> I have included numerous comments and other text submitted by friends and associates, hence, I cannot take full credit for this document.

<sup>2</sup> I had the pleasure of speaking with Mr. Junker in the summer of 1999, and later found out that he passed away on 26 Oct 99. He had remembered his paper and was interested in what I have been preparing. Following his passing, Mrs. Junker noted that she supported my effort, and that she would like a copy of the original paper when completed, and that was accomplished. She later responded that she and their children appreciated reading it.

Although still a government document, it is not specifically focused on military equipment, and I removed essentially all use of the term “military.” Anyhow, on 1 October 2002 I retired from the Government, and began working as a Government contractor. This document, therefore, has been written both while I was a Government employee, as well as essentially on my own time, or as a contractor for my old office at Aberdeen Proving Ground. This paper includes both expanded information from the original paper, as well as information from MIL-STD-810G and some changes to be included in Change Notice 1 to -810G.

It’s interesting to note the sheer growth in size of MIL-STD-810 from the original -810 on 14 June 1962 with 66 pages, to the latest version, MIL-STD-810G (31 October 2008), with 804 pages, and using the same smaller font to save space! This time (post -810F) the changes can, for the most part, be attributed to not only clarification, definitions, and technical updates, but to five “new” environments with associated test methodology - things that took Virgil Junker and me (with a lot of outside help) almost 250 pages to explain! In addition to the “new” methods, I personally feel that a large amount of the expanded text resulted from improper interpretation and improper use, and the authors of various editions of -810 trying to cover all bases. (I say “new” because the Rail Impact test was removed from Method 516, and created as a new Method 526, and included with several other new Methods as mentioned below.). Tailoring and common sense by users were often ignored, and it continues to this day.

One of the biggest challenges in writing the original edition of this paper was finding information that tracked the evolution of the early versions of MIL-STD-810. In addition to Mr. Junker’s wonderful paper, one boon (for me) was that on March 11, 1975, the Chesapeake Chapter of the Institute of Environmental Sciences sponsored a seminar on MIL-STD-810C (10 Mar 75) in Baltimore, MD. This was my first real introduction to some of the experts in the environmental test field such as David Askin, Dr. Bill Brierly, Dr. Al Burkhard, Hank Caruso, David Earls, Jack Gott, Burk Senn, Irv Gringorten, and so on. The Proceedings were later published and, upon my retirement from the Army Developmental Test Command on October 1, 2002, I located the 1975 Proceedings while cleaning out my files. I have cited the Proceedings throughout this paper wherever appropriate. In it, David Askin was quoted as saying that “About eight years ago MIL-STD-810B was published. It was basically a minor revision of MIL-STD-810A, which had been in existence for four to five years before that. MIL-STD-810A (14 Jun 62) and MIL-STD-810B (15 Jun 67) were oriented to Air Force and Navy type aircraft equipment and specifically earmarked as an Equipment General Specification.” (In fact (as I mentioned earlier), MIL-STDs -810 and -810A were USAF documents; MIL-STD-810B was the first Tri-Service version of -810.)

A committee of experts was created to determine to what extent the numerous existing military standards could be standardized. It was noted that there is no standard that is applicable to everything in any field. One of the primary prerequisites for using MIL-STD-810C was good common sense and good engineering judgment in the application of the document – picking from it what is applicable to the particular problem. The MIL-STD-810C committee decided on several basic concepts, one of which was to put into MIL-STD-810C some leniency, or the allowance for any design group to either use the limits that were in -810C with each of the test methods, or to select their own limits if they had justifiable reasons. (In fact, this option has been available since

the original -810 (1962) that had an up-front statement **“WHEN IT IS KNOWN THAT THE EQUIPMENT WILL ENCOUNTER CONDITIONS MORE SEVERE OR LESS SEVERE THAN THE ENVIRONMENTAL LEVELS STATED HEREIN, THE TEST MAY BE MODIFIED BY THE DETAIL SPECIFICATION.”**).

One of the more significant overall changes in -810C (in the climatic area) was the introduction of a concept of operability during testing. The test engineer or designer had the option to select some place during a test procedure when he could operate the equipment in the chamber, and make the necessary measurements to determine whether or not the equipment could operate at the extreme of the environment. MIL-STD-810B and other such documents required operation before and after the test, but not during it. Also added to -810C was a definition of some of the most common failure criteria that can be expected, as well as a brief recommended area of application. During the development of -810C, there was much discussion and thought of creating a “MIL-STD-811” that would contain environmental criteria; spell out the environmental limits and explain how to use them, and spell out the failure criteria and show how to use them. Unfortunately, this never came about – mainly because the state-of-the-art was such that specification writers could not specify military test methods for -810C without some explanatory information at the beginning of the document so that the test engineers would be able to use the document intelligently.

Many have questioned the numbering system used for the individual methods in the various editions of -810, i.e., 504.3, 514.5, etc. Based on text in the 1975 Proceedings, I assumed this originated with the -810C Committee. They decided that, in the future, changes to individual test methods or procedures could be simplified by merely re-issuing the revised method with numbering that reflects the change number, i.e., 500.1, 500.2, etc. This would obviate the need to revise the entire document. However, in the original -810, the intent was to assign letters to each revision of individual test methods, i.e., 500, 500A, 500B, etc. Contrary to what I assumed from the 1975 Proceedings, MIL-STD-810A was, in fact, the first document to reflect the current numbering system.

The transition from MIL-STD-810C to MIL-STD-810D (19 Jul 83) was one of the more significant, in that -810D focused more on “tailorability” - a concept promoted by the “Shea Report.” This document was the “Report of the Task Force on Specifications and Standards,” March 7, 1977. Dr. Joseph F. Shea, Senior Vice President of the Raytheon Company chaired the Task Force. The report noted basic problems with Department of Defense (DoD) specifications and standards in that they centered more on application and enforcement, rather than with the detailed content of the documents. Past versions of MIL-STD-810 contained up-front statements to the effect that users should modify the tests if the anticipated conditions would be more or less severe than those addressed in the standard. As I mentioned earlier, MIL-STD-810 (USAF), 14 June 1962, noted in paragraph 1.2 in uppercase letters that **“WHEN IT IS KNOWN THAT THE EQUIPMENT WILL ENCOUNTER CONDITIONS MORE SEVERE OR LESS SEVERE THAN THE ENVIRONMENTAL LEVELS STATED HEREIN, THE TEST MAY BE MODIFIED BY THE DETAIL SPECIFICATION.”** This, in effect, prescribed tailoring, but there was little other guidance to explain the cookbook parameters provided, i.e., the significance of a parameter, or options for

changing it. The result was to test by rote. I also emphasize here that MIL-STD-810 test methods are not intended for component/material testing or for safety testing (e.g., munitions) but, in some cases, they could be appropriately tailored and applied.

Mr. Henry (Hank) Caruso, at that time a Fellow Engineer at Westinghouse Electric Corporation's Product Qualification Laboratory, Baltimore, MD, had published a number of articles on environmental testing, including a series of articles in the Institute of Environmental Sciences' (now known as the Institute of Environmental Sciences and Technology (IEST)) *Journal of Environmental Sciences* from the March/April 1985 edition through that for November/December 1985, that highlighted the more significant changes from -810C to -810D. During my final preparation of the original version of this paper, I tried to capture the more significant changes from Hank's articles. In 1990, Hank published a four-part change comparison in the *Journal*, but this time for MIL-STDs-810D and -810E. In the March/April 1993 edition of the *Journal*, Hank and I published a similar article highlighting the major changes from MIL-STD-810D to MIL-STD-810E. Hank coined the phrase "sacred cow" for those parameters that had been previously used (on a continuing basis) without consideration of their significance, and from which users had a difficult time departing. From Hank's IES *Journal* article of March/April 1985, I extracted the following: "Overall, MIL-STD-810D was the result of a cooperative effort between representatives from industry and each of the three military Services working together for several years." ".....significant changes were made that encourage the involvement of the environmental engineering specialist, and the tailored application of realistic criteria whenever possible. On these points there seemed to be a strong consensus of all parties involved." The Summer 2001 edition of the IEST *Journal* contained a general comparison of MIL-STD-810E versus MIL-STD-810F procedures. In his introduction, Hank noted **"No other commercial or military test standard has a wider range of tests or greater depth of guidance. Most important, no other test standard treats test tailoring and implementation as a systems' engineering process.** This engineering process was the foundation of MIL-STD-810F, and continues to be the same for -810G. All too often, contract requirements and other test documents treat testing as a loosely linked patchwork of individual test procedures, which may or may not be linked to each other or to the operational requirements of the product being tested. In MIL-STD-810F and -810G, the intent is to integrate, rather than separate all of the design and test elements." (Actually, this conversion of intent from cookbook to a systems' engineering process began in the "D" revision, and has evolved progressively through the "E," "F," and "G" revisions.)



Just why the edition changes were necessary has not been comprehensively documented. Personnel involved (in many cases) have passed on, and their knowledge has been lost. Others have retired and may or may not be able to provide substantial support. In this paper I will attempt to not only provide a summary of changes from MIL-STD-810F to MIL-STD-810G, but when possible, a better understanding of the thought processes behind the current MIL-STD-810G methods and their evolution from earlier versions of MIL-STD-810. Of course, there are numerous instances where the rationale was lost. I will use or paraphrase text from Junker's paper, as well as information provided in the IEST *Journal* articles, and will introduce previously unpublished background information (if

available) on a method-by-method basis (in italics). I have been fortunate to have received information from a number of friends and associates who have greatly strengthened this paper. Not everyone will agree with my discussion sections in this paper, but during my 38-year association with environmental testing and MIL-STD-810, I feel I have a reasonably firm grasp of a number of issues associated with the development of the various versions of MIL-STD-810, and I feel comfortable sharing my thoughts and opinions.

There is one issue that I feel compelled to address: The technical review of new editions prior to release as an approved document. We encourage technical experts to review drafts prior to official release, but more often than not, comments do not filter to the responsible parties until maybe a year or two after release and use in the laboratories. For the -810G edition, a new approach was taken in that the draft version was posted on the ASSIST web site. This resulted in a significant number of comments to be considered prior to publication. Many were accepted and included in the final edition of -810G and, because of necessary technical discussions, a number were labeled as “to be considered for the first revision.” We anticipate Change Notice 1 to MIL-STD-810G will be available for comment in the fall of 2010.

As a point of information, in February 1986 at a meeting in Washington, DC of representatives from various NATO groups involved with environmental testing, the group agreed to develop a single NATO standard that might be used in lieu of the numerous documents then in existence, and MIL-STD-810D would serve as the base document from which it would be developed. Blended in would be other national and multinational documents such as the French GAM-EG-13, the British Defence Standard 07-55 (now 00-35), the International Electrotechnical Commission's Publication 68, the FINABEL standard (France, Italy, Netherlands, Germany, Belgium, England, and Luxembourg), etc. The first meeting of environmental test experts tasked to prepare this document was held in June 1986 in Paris. The first edition of NATO STANAG 4370 and its associated Allied Environmental Conditions and Test Publications (AECTPs) was promulgated in 1994; a revision to the AECTPs in 1998, and Edition 2 of the entire package was completed in 2000. Edition 4 of most of the AECTPs has since been published. What is interesting is not only the international acceptance of -810D, but the cooperation achieved in developing the NATO STANAG that, by the way, is a technical improvement over -810D and -810E. We have subsequently introduced many of the international concepts back into MIL-STD-810F and, subsequently, to -810G. It has truly been a cooperative international effort, i.e., the US gave to STANAG 4370, and STANAG 4370 gave to the US. Whether or not STANAG 4370 (climatic and mechanical portions) will eventually replace MIL-STD-810, only time will tell, but at this point I personally feel -810G contains (US) information not in STANAG 4370, and there are a few areas in STANAG 4370 with which some US technical personnel are not in agreement. MIL-STD-810G has adopted some of the NATO (multinational) ideas to make the documents more compatible.

The 1994 specifications and standards reform issue (resulting from the Shea Report) resulted in MIL-STD-810E (14 Jul 89) being approved for conversion to a Test Method Standard. The “MIL-STD” designation was retained, i.e., “MIL-STD-810F,” but the title was changed to “Test Method Standard for Environmental Engineering Considerations and Laboratory Tests” to accommodate both the standardization reform issue, and to reflect the significant change to the front end of both -

810E and -810F (and now -810G) in the form of Part One that encapsulates guidance to the users of the Standard.

Annex A is a copy of an article from *TEST* magazine that delineates the major changes from MIL-STD-810F to MIL-STD-810G. Annex B is a brief list of proposed changes and corrections to either -810G, or whatever else is agreed in the future as the way forward. Annex C is a compendium of weather and climatic extremes, with a few changes from that published in the original version of this document.

All in all, the evolution of MIL-STD-810 from its original 1962 version to its 2008 status has been quite an experience. We who have contributed to the development of this latest revision feel that, in many cases, it is a vast improvement over previous editions, but there is always room for improvement. One last thing to remember is something I have been preaching, but that I found in writing in the MIL-STD-810C Seminar Proceedings (March 11, 1975): Mr. Jack Gott of the Naval Ordnance Laboratory in White Oak, MD commented that “...**so many of these tests really don’t try to simulate the environment – they try to simulate the effects.**” All too often laboratory test results are accepted as the ultimate verification that the tested equipment will survive in the natural environment but, in fact, natural environment testing (arctic, desert, and tropic) has uncovered numerous critical problems not found during laboratory testing. The two approaches (natural and laboratory testing) can provide reasonable confidence that equipment surviving both and functioning as required will function as intended during its life cycle.

No matter how careful we are in writing MIL-STD-810 and trying to cover all loopholes, there always seems to be a “bean-counter” or other critic that finds some miniscule issue that has little impact on test methodology and results. I can’t emphasize enough to **USE COMMON SENSE** when using this complex document and, when in doubt, focus more on the intent rather than the numbers or text themselves.

One other interesting tidbit is that the Defense Logistics Agency (DLA) that manages the ASSIST program and the thousands of documents included in its library, have continually experienced an access or download for MIL-STD-810 that exceeds any other DLA document by AT LEAST 2-1! This indicates the popularity and/or need for this internationally accepted document. As an example, in the 4<sup>th</sup> quarter of FY 2008, there were over 72K downloads of on-line documents and 754K eAccess requests. Of the 72K Assist downloads, 572 were for -810, and the 2nd document had 290 downloads. Of the 745K eAccess requests, MIL-STD-810F had 12102 downloads, and the 2<sup>nd</sup> highest had 5617 downloads.

As an “aside,” DTC has both an S&V technical committee, and an Environmental (Climatic) issues and minutes may lend additional insight into testing considerations for the future. (Ken Thompson, DTC; (410) 278-1476)

Lastly, the US Army Developmental Test Command’s website at [www.dtc.army.mil](http://www.dtc.army.mil) has several documents (under “Publications” then “Regulations/Standards,” then “Military Standards”) that may be of interest, including the first environmental test document, Army - Air Force Specification 41065 (7 Dec 1945), the original MIL-STD-810, and Junker’s report from which I have gained so much wonderful background information. I sincerely hope this paper provides helpful information.

All too often we hear of specification writers or test offers who, when hearing of some extreme environmental condition, insist on using that extreme for testing, regardless of its reality, appropriateness, or applicability. What most people don't understand is that for the majority of the values in -810, it's a one-for-one. You're NOT accelerating testing (and you don't try to create a test to simulate the environment, just the effects of that environment (at best)). In the first edition of this paper, I thought it would be interesting to some readers to include occasional references to record climatic events so they could have a better feel for reality. Accordingly, I contacted Dr. Paul Krause of the Army Topographic Engineering Center (Corps of Engineers) (now retired) who sent me the latest information. I inserted appropriate events in various climatic test procedures where appropriate (in bold), and have added an Annex C to this paper with a more extensive list taken from "**Weather and Climate Extremes**" by Dr. Paul Krause and Ms. Kathleen Flood. The full citation is in Annex C.

Finally, below is a brief summary of the issues of MIL-STD-810 from its inception. I cannot explain the chronological anomaly of -810B Change Notices 1 & 2 or the questionable size of Change Notice 2 to -810E – unless it relates to conversion into pdf format.

| EDITION      | CHANGE          | DATE               | PAGES      | SIZE              |
|--------------|-----------------|--------------------|------------|-------------------|
| MIL-STD-810  | <b>Original</b> | <b>14 Jun 1962</b> | <b>40</b>  | <b>2487.7 KB</b>  |
| MIL-STD-810A | <b>Original</b> | <b>23 Jun 1964</b> | <b>71</b>  | <b>4091.4 KB</b>  |
| MIL-STD-810B | <b>Original</b> | <b>15 Jun 1967</b> | <b>113</b> | <b>4814.4 KB</b>  |
|              | 1               | 20-OCT-1969        | 64         | 3230.6 KB         |
|              | 2               | 29 Sep 1969        | 17         | 515.0 KB          |
|              | 3               | 18 Sep 1970        | 18         | 411.9 KB          |
|              | 4               | 21 Sep 1970        | 8          | 227.7 KB          |
| MIL-STD-810C | <b>Original</b> | <b>10 Mar 1975</b> | <b>258</b> | <b>7697.3 KB</b>  |
|              | 1               | 7 Apr 1981         | 16         | 545.7 KB          |
| MIL-STD-810D | <b>Original</b> | <b>19 Jul 1983</b> | <b>416</b> | <b>15035.1 KB</b> |
|              | 1               | 31 Jul 1986        | 47         | 1811.5 KB         |
| MIL-STD-810E | <b>Original</b> | <b>14 Jul 1989</b> | <b>461</b> | <b>35838.1 KB</b> |
|              | 1               | 9 Feb 1990         | 5          | 373.2 KB          |
|              | 2               | 1 Sep 1993         | 253        | 20105.0 KB        |
|              | 3               | 31 Jul 1995        | 8          | 100.4 KB          |
| MIL-STD-810F | <b>Original</b> | <b>1 Jan 2000</b>  | <b>539</b> | <b>5766.8 KB</b>  |
|              | 1               | 1 Nov 2000         | 7          | 24.4 KB           |
|              | 2               | 30 Aug 2002        | 164        | 5186.2 KB         |
|              | 3               | 5 May 2003         | 72         | 759.0 KB          |
| MIL-STD-810G | <b>Original</b> | <b>31 Oct 2008</b> | <b>804</b> | <b>24482.5 KB</b> |

### Biography

Mr. Egbert began his government career in June 1970 at the US Army Electronic Proving Ground, Fort Huachuca, AZ, where he spent eight years in the environmental test laboratory. In 1979 he moved to the HQ, US Army Test and Evaluation Command (TECOM) at Aberdeen Proving Ground, MD, and assumed Army custodianship of MIL-STD-810. In 1990 he received a BS in biology from Towson State University. He was heavily involved with the development of MIL-STDs-810D and -810E. During tri-Service discussions of developing MIL-STD-810F, Mr. Egbert offered (and accepted) to be the tri-Service administrator of the document. As such, he focused not only on updating the technical aspects of the numerous test methods, but also on the text format and writing style. He has a Level III certification with the Army Acquisition Corps, and is a Fellow of the Institute of Environmental Sciences and Technology (IEST). In August 2002 he completed Change Notice 2 to MIL-STD-810F, and soon began developing Change Notice 3. He retired from the Government (DTC) on October 1, 2002 and, on October 14 he began working for Science Applications International Corporation (SAIC) as a Senior Analyst. He completed Change Notice 3 under contract to the Army Developmental Test Command (DTC), and finalized the original paper at home. Mr. Egbert is an IEST Fellow, and was recently employed as an Environmental Engineering Specialist by TRAX of Yuma, AZ, in support of current DTC environmental test efforts, and the development of MIL-STD-810G. Accordingly, this 2<sup>nd</sup> Edition was mostly completed while under contract for TRAX and DTC.

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## ACKNOWLEDGEMENTS

The following people have made significant contributions to either the original paper or to this revision of my original paper, or both, and I thank each and every one of them for his or her assistance. It would not have reached the stage at which it is now without their help. I did not include the contributors to my original paper unless they also contributed to this revision. I sincerely apologize to anyone I missed.

|                   |                                                                                           |
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## **BACKGROUND**

The following paper is composed of essentially two (integrated) parts. The first contains background information (but not necessarily verbatim) from Virgil J. Junker's "The Evolution of USAF Environmental Testing." The second part (in italics) is a continuation of background information that I was able to obtain that brings us to the present (early 20109). In some cases, some information is either non-existent, or I was not able to locate a contributor.

### **ABSTRACT (Junker)**

This report presents supporting data and background information on the origination and development of natural and induced environmental tests intended for USAF aerospace and ground equipment.

The information provided in the discussion portion of the text write-ups is intended to give the designer, application engineer, and those individuals responsible for specifying test requirements a clearer understanding of the interpretation, application, and relationship of tests as called out in various environmental test documents.

### **The Evolution of USAF Environmental Testing (Junker)**

Simulated natural and induced environmental tests for evaluating USAF material have evolved gradually over a period of nearly thirty years (as of 1965). Devising some tests was comparatively simple, while the development of others has been more complex.

Along with tests that have been developed scientifically, there are those that have resulted from trial and error. The trial and error method may continue to be a necessary procedure for the environmental engineer conducting laboratory tests intended to be comparable to those environments experienced under actual field service conditions.

Prior to 1940 environmental testing as it is known today (1965) was practically non-existent. With World War II came the requirement for worldwide military operations involving all types of vehicles, ground support equipment and aircraft operating under a wide variety of environmental conditions. Improper packaging, handling, transportation, storage, and arctic, desert, and jungle operations resulted in extensive damage to vehicles and equipment. During the war years, environmental testing at Wright Field, Ohio, was greatly increased. However, such testing was conducted by individual laboratories on those items of hardware within their jurisdiction. There were few standard procedures for performing tests among the various laboratories, and deficiencies in environmental test chambers and associated facilities were revealed. As a result, industry was motivated to speed the development of environmental facilities having greater capability.

As the workload increased at Wright Field, especially for qualification approval testing of new devices, they began to assign routine environmental testing to industry and many independent labs were established. The multitude of individual specifications for military equipment caused varying

requirements for the same type tests, and inconsistencies in specifying like requirements from one test program to another.

After some time, and through the cooperation of several laboratories at Wright Field, the first environmental test document, Army Air Force Specification No. 41065, “General Specification for Environmental Test of Equipment,” 7 December 1945, was issued as a 7-page document (see Annex A). The principal objective of this initial effort was to standardize testing by reducing the number of test procedures for the same environment to the (hopeful) figure of one. However, each laboratory's insistence that a certain test procedure was necessary for a particular item of hardware resulted in as many as ten or twelve optional procedures for performing the same test. Eventually, through recognition of common problems and a better understanding of the end effects resulting from exposure to the environment, the number of procedures was gradually reduced.

On 1 December 1949, specification MIL-T-5422 (BuAir), “Environmental Testing of Aircraft Electronic Equipment,” was issued by the Navy as a companion environmental test specification to MIL-E-5400, “General Specification for Aircraft Electronic Equipment.” In addition to the single environment tests as outlined in Army Air Force Specification 41065, MIL-T-5422 (BuAir) also contained, for electronic equipment either operating or non-operating, a temperature-altitude cycling test intended to simulate the varying conditions of temperature and altitude encountered during a typical aircraft mission. This additional test was later included in MIL-E-5272, and was subsequently carried forward to MIL-STD-810 (USAF). During 1952, MIL-T-5422 (BuAir) was coordinated with the Air Force, and on 11 May 1953 was, therefore, reissued by the Aeronautical Standards Group (ASG) as MIL-T-5422C (ASG).

In compliance with a general order to change all Army Air Force specifications to “MIL” documents, AAF 41065 was, on 16 August 1950, re-issued as MIL-E-5272 (USAF), “Environmental Testing, Aeronautical and Associated Equipment,” without significant technical change. MIL-E-5272 (USAF) was subsequently coordinated with the Navy and, on 16 September 1952, became MIL-E-5272A. By this act, two coordinated ASG environmental testing specifications became current and, with the exception of difference in titles and language, both contained almost identical test procedures. Combining the two specifications seemed logical. However, by this time each specification had been widely referenced in many procurement documents. It was argued that combining the two specifications under a new title and number would result in utter confusion. In consideration of these facts, the duplication was condoned.

In early 1960, a study was initiated to determine what measures could be taken to bring about the standardization of environmental testing. Attention was focused on five specifications: MIL-T-5422, “Environmental Testing for Aircraft Electronic Equipment,” MIL-E-5272, “Environmental Testing, Aeronautical and Associated Equipment,” MIL-E-4970, “Environmental Testing, Ground Support Equipment,” MIL-A-26669, “Acoustical Noise Tests for Aeronautical and Associated Equipment,” and MIL-S-27507, “Shock Test, Saw Tooth Pulse,” which was about to be published. The result of the study clearly indicated the need for upgrading test procedures and criteria, and establishing a single standard environmental test document. Work was begun to accomplish this aim

and, on 20 December 1961, the first draft copy of MIL-STD-810 (USAF), “Environmental Test Methods for Aerospace and Ground Equipment,” was circulated within the Air Force for coordination. The standard was issued on 14 June 1962.

Although extensive research was accomplished in acquiring the material contained in the following sections, certain details, reasons for technical changes, etc, have escaped the author; however, it is believed that sufficient information is included to accomplish the purpose of this report. In presenting this background information, data are given for each type test in chronological order as to purpose, early problems, test development, discussion of present procedures, and relation to other tests.

### **Discussion. (Egbert)**

*The initial document was 66 pages in length! MIL-STD-810A (USAF) was published on 23 June 1964. In comparing -810A test methods, I noticed that, although most of the methods reflected a change of some sort, the page numbering system that was used did not reflect the revision as we have since used in the -810B version, i.e., 509.1, 514.1, etc. MIL-STD-810B was the first tri-Service version of the standard and was dated 15 June 1967. MIL-STD-810C was released on 10 March 1975, and MIL-STD-810D on 19 July 1983<sup>3</sup> see Caruso’s introduction of -810D below). During compilation of what was to be a Change Notice 2 to -810D, the volume of changes was so great that we decided to create a new revision instead. MIL-STD-810E (448 pages<sup>4</sup>) was published on 14 July 1989. For MIL-STD-810F (1 January 2000) we wrote it with a 10-point font to minimize its volume, but the final draft was still about 540 pages. This included the deletion of more than 20 pages of ground vehicle vibration data from Method 514.5 (Vibration) (that can be found in International Test Operations Procedure (ITOP) 1-2-601), “Laboratory Vibration Schedules,” that is available from the Defense Technical Information Center (DTIC), OCA, STE 0944, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6218, and citing their accession (AD) number of B238288, and the addition of several new methods (504 - Contamination by Fluids; 517 - Pyroshock; 518 - Acidic Atmosphere, and 522 - Ballistic Shock). MIL-STD-810G was released on 31 October 2008. It incorporates five new methods and a new Part Three (and an obvious increase in volume to 804 pages) that includes Method 524 – Freeze-Thaw; 525 – Time Waveform Replication; 526 – Rail Impact (Extracted from Method 516), 527 – Multi-Exciter Testing, and 528 - Mechanical Vibrations of Shipboard Materiel (Type I – Environmental and Type II – Internally Excited) (from MIL-STD-167-1A). Part Three contains climatic guidance on climatic regions of the world.*

*It is significant to note that upon release of MIL-STD-810G, the responsibility of Preparing Activity was transferred from Wright-Patterson Air Force Base to the Army’s Developmental Test Command and, specifically, Ken Thompson.*

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<sup>3</sup> It is interesting that during the development of -810D there had been discussion of making units of measurement metric followed by soft US units. There was significant opposition to this, noting that “we are not ready for this.” However, MIL-SPEC 41065 (1945) did exactly this.

<sup>4</sup> Much of the added text was required because of misuse and a necessity to clarify the text and intent.

Note that in -810G, the term “shall” was re-introduced in paragraph 3.3 of each Method (Post-test information) and, to satisfy Navy requirements, throughout Method 528. Additionally, with respect to referenced / related documents, NATO STANAG 2895 has been replaced by NATO AECTP 230 that incorporates the technical information previously contained in STANAG 2895.

One issue that surfaced in December 2002 was measurement uncertainty during testing. The tolerances for test instrumentation have been somewhat ignored, and some have questionable origins. In MIL-STD-810 and MIL-STD-810A, for instance, there is a statement with respect to the tolerances of test conditions that “the maximum allowable tolerances of test conditions (exclusive of accuracy of instruments).....shall be as follows: a. Temperature....etc. It then goes on to discuss the accuracy of the test apparatus and, among other things, says that all instruments and test equipment shall have an accuracy of at least one-fifth the tolerance for the variable to be measured. In MIL-STD-810B (and later editions of -810), this was changed to one-third the tolerance for the variable to be measured. Unfortunately, I cannot locate documentation that explains the change, much less the rationale for original figure, but can only surmise that the writers of -810B felt the one-fifth requirement to be too stringent. Regardless, the various editions of -810 do not require measurement uncertainty in determining test compliance.

At the -810C Symposium in 1975 (see Foreword), tolerances were a hot subject, and especially temperature and humidity tolerances. In order to make it easier for the test laboratory, -810C opened the temperature tolerance to  $\pm 2.5^{\circ}\text{F}$  (from the previous  $\pm 2^{\circ}\text{F}$ ), and changed the humidity tolerance from  $\pm 4\%$  to  $\pm 5\%$ . There was general agreement that the closer to 100% RH, the more difficult to control. Condensation should occur on surfaces whose temperatures are below the dew point. Cycling is encouraged to force condensation. With regard to test sequence, the -810C table changed little from that of -810B, except that more explanatory notes were added as to why certain of the procedure sequences were selected. They are offered as guidance when there is nothing else on which to make a decision. It is the best judgment of the experts who were at the 1975 meeting.

At the 1975 Symposium, Dr. William Brierly, formerly of the Corps of Engineers’ Engineering Topographic Laboratory, made an extensive statement regarding test parameters, and I think it’s appropriate to quote some of it here. Speaking of dry desert conditions, he said, “The 160-170°F area is recognized as an extreme condition. It occurred on tents that were erected at Yuma, Arizona. It occurred in seams of tents and other attachments; tarpaulins that we bound up and put our supplies in as was specified in some of the early storage manuals of the ‘40s and ‘50s. This type of storage proved to be the worst thing we could have done – the manuals have since been corrected. The temperatures were valid for a given situation. The 90% relative humidity” (speaking of the high temperature and humidity used in earlier humidity tests) “is a very valid criterion and parameter for the Tropics where it occurs day after day. Both temperature and humidity parameters are realistic. But, the trouble came when the people started to put these parameters together and tried to cut corners and say “We’ll make a composite test of all of these,” and this interpretation is where we went wrong. The climatic parameters, as they were originally intended and used, were valid; it’s the misinterpretation of the information that was a problem. And this is where the communications between R, D, & T people failed. This is a thing that has plagued us from the very beginning. The people that prepared the criteria – the meteorologists, climatologists, or geographers dealt with

*facts and didn't talk to the test people or to the engineers; they went along their own merry way. The military said "We may go into any part of the world, tell us about the climatic conditions that we're going to meet there." The information provided by the environmental scientists answered that question, and that is how many of the extreme parameters were established for all areas of the world. ---- But this is where the trouble occurred. People took that interpretation ..... they said "Okay. We're going to call these natural conditions criteria." The conditions were correct, the environmental descriptions of the areas were correct, but when they changed them into criteria for design, they went berserk. Then the testing people came along and said "We've got to cut these things down. We want a humidity cycle in here. We want to put in later a shock and vibration and other sequential tests," and they put them all together. And, as a result, this monstrosity came up of 160°F with a 95% relative humidity, which does not occur on the face of the Earth under natural conditions. If you get a 5% relative humidity with 160°F, this is an extreme condition. But the trouble is we didn't communicate, and we're still not communicating across the board."*

*In the first edition of this paper, I inserted this comment from Dr. Paul Krause: **The highest recorded naturally occurring temperature and RH level equating to a dew point of 93.2°F (100% RH,) and was recorded at Sharjah, Saudi Arabia during the period 1949-1953. The extreme was based on 88 once-daily, 1200 GMT observations during the month of July.***

**Source: Salmela, H.A. and D.D. Grantham. 1972. Diurnal Cycles of High Absolute Humidity at the Earth's Surface (Technical Report AFCRL-72-0587, Environmental Research Paper No. 416). Bedford, MA: Air Force Cambridge Research Laboratories.**

*Since then, Paul provided an update to that record: **The highest accepted dew point observation is 35°C (95°F) and occurred at Dhahran, Saudi Arabia at 3 PM on 8 July 2003. The air temperature was 42°C (108°F) with a relative humidity of approximately 67%.***

*The July/August 1978 IES Journal included an article that summarized a panel discussion on -810C and -810D climatic test methods at the Annual Technical Meeting (ATM) in Fort Worth, Texas. The panel discussion began with an introduction that -810C is a "high cost driver in the acquisition of military equipment, and the possible misapplication of military specifications that are based upon specific type standards such as MIL-STD-810." It went on to say that there has been much evidence of this such as the premature application of the requirements of environmental standards in the early phases of research and development; the over-application of environmental requirements, excessive to the mission functional performance needs of the equipment, and the application of environmental standards not intended for the purpose for which they have been invoked. DoD Program Managers and project engineers face two risks in their decision-making process for environmental test requirements: over-application (that can result in increased initial quoted costs, cost overruns, and reduced quantities of items from what was originally desired), and under-application (reduced operational suitability, reduced performance capability, increased life cycle costs, and early obsolescence). A central question of the panel session was "Is there – or can there be – any correspondence between the requirements of MIL-STD-810C climatic methods, and the test criteria for each of the three phases of testing (development tests, acceptance tests, and field/operational tests) in the military acquisition process?"*

*David Askin of the Army Armament R&D Command noted “A critical defect (in environmental testing) is the lack of documentation concerning laboratory versus field correlation for the test parameters indicated – especially those of “aggravated” tests.”*

*Sid Wise of the Army’s Test and Evaluation Command (TECOM, now DTC) commented that MIL-STD-810 is a laboratory simulation, and we all recognize the problems associated with simulation. In looking at the alternatives (natural environment testing), we must recognize inherent problems. Field testing gives us reality though we may not be able to understand and can’t define what reality really is. Unfortunately, the necessary conditions are frequently not available to us when we want them. This is especially true in the Arctic where winter temperatures can range from maybe the freezing point down to  $-70^{\circ}\text{F}$  (e.g., Jan 1975). MIL-STD-810 (laboratory) testing results in reproducible and controllable conditions. Sid noted that within TECOM, we are working backwards, starting not with the test, but with the evaluation. We are asking the evaluator what type of data is needed as input to the evaluation, and how a decision is made. That determines what sort of data we are going to require from our tests. Then we can deal with mechanics of the test.*

*Howard Schafer of the China Lake Naval Weapons Center took a different approach. His opening comment was that “-810 as written now (1978) is strictly a simulation document. Simulation connotes that we don’t know what we are doing to start with, that we are going to “monkey see, monkey do” as close as we can to reality because we don’t know enough to compress time.” “Let’s get rid of simulation. Let’s actually know why we’re testing, know what the end item and result of the test are going to be, know what the engineering data is that we are going to look for, and on that basis, test our equipment, not haze it.” My personal response to Howard’s comment (he has since passed away) is that except for maybe for S&V tests, we cannot simulate the real world in a chamber, and we specifically say we are testing on a one-for-one basis (no time compression).*

*The March/April 1981 edition of the IES Journal contained two articles on MIL-STD-810, one by me (“MIL-STD-810D – A Progress Report”), and one by Karl-Heinz Schrader, a German Exchange Engineer at WPAFB (“Comparison of MIL-STD-810 with International Environmental Testing Standards”). In my article I tried to summarize some of the early work on -810D that involved both Germany and France. Germany had been looking for a model for its new VG-95 on environmental testing that was to replace some 150 to 170 documents in use at that time (1979) in Germany. They finally settled on MIL-STD-810C, but we then told them that we were busily working on -810D. At discussions in Koblenz in October 1980, we reached mutual agreement on a set of pass/fail criteria that were eventually used in -810D and, as a matter of fact, have been carried forth in every edition of -810 since then. At the same time, France was trying to update its standard on environmental testing, AIR 7304, and using MIL-STD-810C. Monsieur Pierre Lemann of the French Association pour le developpement des Sciences et Techniques de l’Environnement (ASTE), invited us to, and arranged an international symposium in Paris in October 1980 at which about 50 representatives from France, Germany, the United Kingdom, and the US participated. The US delegation gave four presentations relative to -810D. There was concern that if a mutually acceptable document was developed among the four nations, but retained the “MIL-STD” identification, it would lose its strength in Europe. We explained that it was necessary for the US to retain the “MIL-STD”*

identifier, but possibly an international document could be developed and published that would resemble -810D. The ultimate desire would be to then offer this international document to NATO for consideration as a Standardization Agreement (STANAG). We emphasized that, despite European concern that the US would only provide “lip service” to its comments; international input was desired and would be considered for inclusion in -810D, along with all other comments received. This is indeed what happened and, it’s interesting (ironic?) that in June 1986, an initial NATO conference on environmental testing (in which I participated) resulted in agreement to develop a single NATO standard on environmental testing that ended up to be STANAG 4370, “Environmental Testing” and that is discussed elsewhere in this paper.

In the “Comparison of MIL-STD-810 with International Environmental Testing Standards” article, Herr Schrader compared MIL-STD-810C and its test method with the:

- Air Standardization Coordination Committee’s (ASCC) “Air Standardization Agreement on Environmental Tests for Aircraft Equipment of the ASCC,” (among the USAF, Royal Australian AF, Royal AF, Royal Canadian AF, and the Royal New Zealand AF);
- Radio Technical Commission for Aeronautics’ (RTCA’s) DO-160 (An association of aeronautical organizations in the US (and recently, some European participants) with mostly industry, but some government participation);
- British Standard 2011 (Describes standard general procedures for climate and mechanical robustness tests of components used in equipment for telecommunications and electronic equipment employing similar techniques);
- USSR Civil Aviation Requirements (Only applicable to airborne equipment), and
- NATO STANAG 3518, “Environmental Test Methods for Aircraft Equipment and Associated Ground Equipment.”<sup>5</sup>

Herr Schrader’s comparison of the various (mostly climatic) test methods was well done but, unfortunately, did not include a summary of his findings, or an evaluation of the various documents. Granted, the intent of his article was only to compare the documents.

In a transcript of a session on MIL-STD-810D at the Institute of Environmental Science’s Annual Technical Meeting (April 21, 1983, Los Angeles, CA), Hank Caruso was quoted in a wrap-up of the introductory discussions as saying “MIL-STD-810C created an adversary situation between the customer and the contractor. It was always a “prove-it-to-me” relationship. The concept behind the “D” revision is to create a cooperative win-win atmosphere where the right people talk to the right people.” At the same session I was asked to introduce the climatic test methods, and was pleasantly surprised at the wide acceptance of this “new way of doing business.”

In November 1985, Hank Caruso published the fifth in a series of IES articles comparing -810C and -810D in the IES’ Journal of Environmental Sciences. In it he said “Overall, MIL-STD-810D was the result of a cooperative effort between representatives from industry and each of the three military Services working together for several years. This is not to say that there was always

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<sup>5</sup> Following the publication of MIL-STD-810D, the NATO Air Electrical Working Party (AEWP) that is responsible for 3518, essentially cover-sheeted -810D with the STANAG 3518 identification. When STANAG 4370 was published, STANAG 3518 was cancelled.

*complete agreement among the parties on technical and policy matters. But nevertheless, in most cases significant changes were made that encourage the involvement of the environmental engineering specialist and the tailored application of realistic criteria whenever possible. On these points there seemed to be a strong consensus of all parties involved.” Hank went on to say “Since the introduction of MIL-STD-810 in June of 1962, there has been a lack of clarity in the minds of most users as to where it fits into the overall procurement cycle. This is not too surprising since nowhere was an effort made to put MIL-STD-810 into any specific program context. Congress instructed the Department of Defense (DoD) to change its way of doing business in Congressional Law 92-156, Section 506. (This section contains only vague references to any specific environmental engineering functions.) The DoD then developed the DoD 5000 Directive series to conform to this law. LTC Ben Swett, USAF, then guided the early evolution of the “D” revision of MIL-STD-810 to comply with these documents. Thus, the way of doing business described in MIL-STD-810D is not an isolated anomaly, but has a legitimate lineage.”*

*In the July/August 1986 edition of the IES Journal of Environmental Sciences, Hank wrote another article that highlighted the cost impact of MIL-STD-810D, with specific references to test facility changes from -810C to -810D, and test duration changes. Because of the extensive nature of this article, I did not originally attempt to address his text in the original issue of this paper, but in this 2<sup>nd</sup> Edition, I attempted to include most of the text.*

*In the March/April 1990 edition of the IES Journal, Hank Caruso began a series of articles comparing -810E with -810D. He noted that “What has not changed is that MIL-STD-810E is still based on the intelligent application of tailoring principles to ensure test realism and practicality. This process is based on determining what environmentally-related situations exist in actual service, what causes these situations to exist, and what practical steps can be taken to recreate these situations in the test laboratory.” Hank goes on to say “One of the most important changes to the MIL-STD-810E revision is the addition of a Pre-Introduction titled “How to Use this Document.” It includes a new Figure 1 that shows the interrelation of the Data Item Descriptions associated with this standard, the necessary environmental engineering tasks, and the application of MIL-STD-810 test methods.”*

*The March/April 1993 edition of the IES Journal included an IES Technical Department report on “MIL-STD-810E - Significant Changes to be Implemented with Change Notice 2.” Because of the extensive work involved in developing -810D (that had already begun), this Change Notice was necessary to provide interim corrections to MIL-STD-810E. In the article we noted that there were some 122 replacement pages that included new technical information, technical corrections and clarifications, and administrative and typographical corrections. I will note other information from this article in the appropriate test method discussion that follows.*

*Hank Caruso, in his article “Revision Highlights of the New MIL-STD-810F, Test Method Standard for Environmental Engineering Guidelines and Laboratory Tests,” in the Summer 2001 Journal of IEST, provided highlights of the changes from -810E to -810F. I will use some of his text throughout this paper where appropriate. In his opening comments, he stated “No other commercial or military test standard has a wider range of tests or greater depth of guidance. Most important, **no other test***

**standard treats test tailoring and implementation as a systems' engineering process.** *This engineering process is the foundation of MIL-STD-810F.” He later goes on to say “Much has changed in the F-revision of this important document, yet much remains essentially the same.” Later, Hank says “...the most important revisions by far are in Part One. This section of the document is where management concerns and environmental engineering specialists are integrated with laboratory test implementation.”*

*MIL-STD-810F, “Test Method Standard for Environmental Engineering Considerations and Laboratory Tests,” 1 January 2000, was followed by Change Notice 1 dated 1 November 2000. The change is better explained below under discussion of Method 511.4, but it unfortunately called for more than what had been agreed, and resulted in some confusion with respect to Procedure I of Method 511.4, “Explosive Atmosphere.” We released Change Notice 2 on 30 August 2002. It not only corrected the change to Method 511.4 in Change Notice 1, but also provided numerous other corrections and administrative changes. As mentioned earlier, Change 3 was published on 5 May 2003.*

*A major contributing factor for the technical improvement of MIL-STD-810F was the co-development of a NATO standard on environmental testing, STANAG 4370, “Environmental Testing.” The development of this covering STANAG began in Paris in late June 1986 with participants from Belgium, Canada, France, Germany, Italy, the Netherlands, the United Kingdom, and the United States. MIL-STD-810D served as the prime guide, but was then blended with other national standards such as France’s GAM EG-13 and the UK’s Defence Standard 07-55. The bulk of the work was included in a series of five sub-documents under STANAG 4370 known as Allied Environmental Conditions and Test Publications (AECTPs), numbered 100 through 500. AECTP 100 has basic guidance on the development of an environmental test program. AECTP 200 provides information and guidance on environments that are induced in materiel, as well as definitions (or reference to definitions) of the climatic, mechanical, and electrical environments. AECTP 300 is a series of climatic test methods. AECTP 400 is a series of mechanical test methods (S&V), and AECTP 500 is a series of electrical environment test methods. Note that the AECTP 200 series has since been converted to a series of independent AECTPs (e.g., AECTP 230, AECTP 240, etc.) covering various aspects of the included environments. STANAG 2895 that was the original guide for climatic information has been replaced by AECTP 230. The technical improvements to environmental testing that are embodied in these AECTPs were generated by the NATO ad hoc technical working groups and, with the exception of AECTP 500 (electrical environmental test procedures) were, for the most part, brought back into MIL-STD-810F. We intended, as far as practical, to align the two documents with respect to test methodology.*

*During the development of the first edition of this paper, I asked Roger Williamson (now retired), Senior Scientist for TRI-S, Incorporated (Aberdeen, MD), and former TECOM employee, along with Hank Caruso, principal authors of Part One of MIL-STD-810F, to prepare text giving the genesis of the -810F effort and an overview of Part One of the document. Roger went above and beyond the basics to produce the following:*

# MIL-STD 810F Part One -- The Rest of the Story

Roger L. Williamson, TRI-S, Inc.

## The Story

*The environmental engineering guidance now appearing in Part One of MIL-STD-810F was a long time coming. Many professional and technical people in the scientific and engineering fields surrounding environmental effects (effects of environments on materiel system performance and reliability) have been operating according to the concepts and practices upon which this guidance is built, but it has never before been written in one place, coordinated and organized for various types of users, and made available as an official document. Table 1 is a short display of the extent to which environmental engineering issues were recognized and articulated within MIL-STD-810 throughout its history. In 1962, the original MIL-STD-810 recognized that detailed specifications needed to have an environmental portion to cover the concerns of environmental effects. A sentence on tailoring covered the need to choose test limits that were realistic for the item under test. That was about it as far as written guidance went in MIL-STD-810, -810A, -810B, and -810C. After twenty-one years, MIL-STD-810D included a section on tailoring and a systematic approach (through Data Item Descriptions (DIDs) for accomplishing it, and recognizing the existence of Environmental Engineering Specialists (EES) - those professionals who were already out there helping their organizations to consider environmental factors systematically in system design and testing. That was a large enough leap to change the title of the document to "Environmental Engineering Considerations and Laboratory Tests," focusing on general guidance in addition to laboratory test methods. Now, in 2000, MIL-STD-810F is divided into two parts. Part One is a full-fledged, top-level document that provides environmental engineering guidance and tasks for acquisition managers, EES, and design/test engineers.*

**Table 1. The Evolution of Part One, MIL-STD-810F.**

| <b>MIL-STD-810 Version</b> | <b>Date</b>   | <b>User Audience</b> | <b>Extent of Focus on Environmental Considerations throughout the Acquisition Process</b>                                                                                                                                                  |
|----------------------------|---------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 810 (USAF)                 | 14 June 1962  | Laboratory Testers   | One sentence under "Purpose" states that the laboratory test methods serve as a guide to those who prepare environmental portions of detail specifications. One sentence on tailoring.                                                     |
| 810A (USAF)                | 23 June 1964  | Laboratory Testers   | Same as 810.                                                                                                                                                                                                                               |
| 810B                       | 15 June 1967  | Laboratory Testers   | One sentence under "Purpose/Scope" states that the standard establishes methods for determining the resistance of equipment to the effects of natural and induced environments peculiar to military operations. One sentence on tailoring. |
| 810C                       | 10 March 1975 | Laboratory Testers   | Same as 810B.                                                                                                                                                                                                                              |

|      |                        |                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------|------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 810D | 19 July 1983           | Laboratory Testers<br><br>Environmental Engineering Specialists (EES)                       | <p>A section on tailoring contains several pages of guidance on how to consider environmental issues throughout the materiel development process, including development of, use of, and Data Item Descriptions (DIDs) for Environmental Management Plans, Life Cycle Environmental Profiles, Environmental Design Criteria and Laboratory Test Plans, Operational Environmental Verification Plans, and Environmental Test Reports.</p> <p>Includes detailed diagrams on the environmental tailoring process and on environmental life cycle histories of various classes of military hardware.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 810E | 14 July 1989           | Laboratory Testers<br><br>EES                                                               | <p>Same as 810D with addition of a flow diagram, "How to Use MIL-STD-810E," that shows how the DIDs (listed above for 810D) relate to each in the acquisition process and who is responsible for preparing them.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 810F | Draft<br>1 May<br>1999 | Field/Fleet and Laboratory Design and Test Engineers<br><br>EES<br><br>Acquisition Managers | <p>Newly created "Part One" is a 54-page detailed explanation of how to implement the environmental tailoring process throughout the materiel acquisition cycle. It focuses separately on the roles and actions of the three types of users shown at the left. A one-page Environmental Engineering Program Guide (Figure 1-1) organizes, integrates, summarizes, and indexes guidance for all three types of users.</p> <p>The guidance goes beyond laboratory testing to placing appropriate importance on natural environment field/fleet testing. Alternatives to testing hardware prototypes (e.g., modeling &amp; simulation, coupon samples, similarity techniques, and other analyses) are recognized in MIL-STD-810F as standard environmental engineering test practices.</p> <p>A detailed subject index steers users to needed topics. New appendices support the guidance. Annex A contains environmental management and engineering tasks that replace the DIDs. Those tasks, along with management considerations in Annex B and EES guidelines in Annex C (including maps of global climatic categories and descriptions of climatic conditions within daily cycles as found in AR 70-38) support the direction and guidance in Department of Defense (DoD) 5000-series documents.</p> |

*So, that's the story. But, what is the rest of the story? Why did it happen? What were the events that prompted this evolution? Who were the people behind it?*

### **The Rest of the Story**

PART ONE

- 20 -

## The DMSSO Dozen

*I can take you back to 1978, when the Department of Defense (DoD) emphasized the need to consider how environmental factors in “dirty battlefields” (e.g., smoke, debris, and electronic emissions interacting with natural cold, tropic, and desert climate factors) influence materiel system hardware and human performance. In response to that need, the Defense Materials Specifications and Standards Office (DMSSO) took action to glean environmental effects specifications and standards data and other information from the “miscellaneous” category, and gave that group of information a home of its own, the “ENVR” (environmental) standardization area, with TECOM as the custodian. In February 1979, as part of that action, DMSSO convened a tri-Service group of about 12 scientific and engineering experts to formulate an approach for considering environmental effects in materiel system design and testing. With apologies to other attendees whose names I cannot recall at this time, definitely present were Kurt Green (DMSSO), David Earls and John Wafford (Air Force), Toshio Inouye and Howard Schafer (Navy), Sidney Wise, Roger Williamson and Herb Egbert (Army). At that time, most of us were at the middle of our careers. By now, I believe, almost all of us are retired from Government service, and DMSSO no longer exists as such. During that two or three day meeting, we discussed what an environmental engineering program may involve, and debated at some length what the elements of an environmental considerations process may be. One of the major results of the meeting was identifying the need for a “Top Document” that would explain why the program is needed, what the program covers, how it will function, who the responsible people in the program/processes would be, and how they would interact. This was no small objective --- from scientific, engineering, or administrative perspectives!*

## The Paradigm

*By May of 1979, I had mulled over my notes from that meeting, and discussed them enough with the meeting participants and other interested persons to put together a consensus paradigm for considering environmental effects in materiel acquisition. The paradigm put into perspective the effects of factors in natural environments, platform environments, and item design, including tradeoff analyses to determine if some projected requirements of an item should be an integral part of the new item or of the platform on which the item is established. Because a number of us were involved in the Institute of Environmental Sciences (IES) – now the Institute of Environmental Sciences and Technology (IEST), I took the opportunity to present the paradigm through a paper at the 1980 Annual Technical Meeting of the IES, in Seattle. Subsequently, the paper was published in an article in the Journal of Environmental Sciences, July/August 1979. During the meeting in Seattle, Hank Caruso (reliability engineer with Westinghouse, editor of the IES Journal, and soon-to-be president of the IES) and I spent an evening redrawing the visual model of the paradigm and condensing the associated explanation into forms that would fit well with the environmental engineering guidance being drafted at that time for MIL-STD-810D.*

## The Environmental Tailoring Process

*The resulting model and explanation became the now-familiar environmental tailoring diagram and explanation that appear in MIL-STD-810D, -810E, and -810F as the Environmental Tailoring Process: designing and testing a materiel item or system to function in specific environments that it would see during its life cycle; no more - no less, no over-designing, no under-designing, no over testing, no under testing, no arbitrary levels of temperature or other parameters used across the board. With time, and a great deal of effort on the parts of Herb Egbert (Army), Steve Tanner (Navy), John Wafford (USAF), Hank Caruso, and others in the US and international arenas to prepare the Environmental Engineering DIDs enumerated in Table 1, the environmental tailoring process and the DIDs that organized and supported it had become just plain common scientific/engineering sense, calling for environmental profiling and life cycle homework concomitant with system design and testing. The tailoring section in MIL-STD-810D certainly was not the "top document" we envisioned, nor was there any thought given to the possibility that it may be. But, although we did not know it at the time, it was a start.*

### **The Nashville Gambit**

*In May 1992, the IES again became the forum for discussing the future of MIL-STD-810, bringing together an international group of government, industry, and academic visionaries and doers. Hank Caruso, who is consistently far more insightful and ambitious than I or most others I know in this field, took this opportunity to push for a new level of excellence in MIL-STD-810 by proposing that the document be reorganized and expanded to focus on the three main groups of users: managers, EES, and field/fleet/laboratory design/test engineers, providing in-depth guidance for each of these groups. I supported him strongly. And, as these things usually go, we were tasked with the job of redoing the MIL-STD-810 front-end guidance. One year later at the IES meeting in Las Vegas, we presented a detailed, structured proposal, establishing a separate portion of MIL-STD-810F as guidance (Part One) and the remainder as laboratory tests (Part Two). The proposal was accepted. During the next two years, we coordinated the content and format of Part One with the established community, presenting updates at the IES Annual Technical Meetings. By 1995, most of the details were worked out and accepted by all.*

### **The Home Stretch**

*Because I left my job at TECOM in 1995 for yet another tour at the Tropic Test Center in Panama, Herb Egbert was left with the task of handling the final coordination of Part One as well as Part Two, both of which he did magnificently, working out technical, format, and administrative details with his partners, Steve Tanner (Navy) and John Wafford (USAF), and a host of other significant contributors. They saw MIL-STD-810F through official coordination, and produced the final copy before us now in January 2000.*

### **The Score**

*Indeed, it took a score of years to fulfill the need for a “top document” in the Environmental Engineering arena as envisioned by the “DMSSO Dozen” in their meeting in 1979! It is very satisfying for those of us who persisted over the years to make this happen. It will be equally satisfying to see the next generation of scientists and engineers improve this guidance to give our fighting men and women even better equipment in the future.*

## **Part One Technical Changes**

*General: Figures 4-2a & b depict generalized life cycle histories for military hardware. These provide a starting point in the thought process for developing a life cycle environmental profile. Early in the 1980s, this figure was borrowed from a French standard on environmental testing, and cleaned up somewhat to fit the -810 format. MIL-STD-810F incorporates metric units (Le Système International d'Unités ((Système International) or “SI”) as its prime measurement system, followed (in most cases) by the equivalent US units.*

## **Foreword**

*MIL-STD-810D was the first edition to contain a “Foreword” that provided a general overview of the document. It encouraged determination and application of realistic environmental stress criteria, introduced a requirement for an environmental engineering specialist, and provided addresses and phone numbers for technical points of contact in each military Service. The new “Foreword” emphasizes test tailoring and involvement of environmental engineering specialists (EES). A systems’ engineering approach is defined in Figure 1-1, and is detailed in subsequent paragraphs and Tasks. A note at the beginning of each test method warns that “Tailoring is essential,” and that successful implementation of each test method depends on following the tailoring guidance of Part One, and substantive new tailoring guidance has been added to many of the test methods. Use field/fleet data whenever possible to substantiate proposed test levels.*

## **General Laboratory Test Method Guidelines**

*In addition to amplifying guidance on test tolerances, we provided new guidance on how to handle scheduled or unscheduled test interruptions, over tests and under tests. We added descriptions of various climatic regions (hot, basic, cold, and severe cold) from sources such as AR 70-38, “Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions,” and (NATO) STANAG 2895, “Extreme Climatic Conditions and Derived Conditions for Use in Defining Design Test Criteria.” A section on test item temperature stabilization is applicable for many of the test methods. Previous “cookbook” guidance on test sequencing was deleted in favor of specific test-unique sequence guidance in the individual test methods. Because of extensive concern over water purity and its significance in certain tests, a section describing our intent was added to Part One. The*

phrase “continuously monitor test parameters” in previous versions of -810 created a stir when trying to define “continuously monitor.” This led to additional guidance in Part One to clarify the intent. Finally, we introduced the idea that total materiel temperature conditioning exposure duration for the test program should be less than the life expectancy time of any component material.

### **Discussion of Test Method Development**

Prior to introducing discussion on the various test methods and procedures of MIL-STD-810, it is appropriate to address changes that evolved in -810 that are common to several or all of the methods and procedures. Former “cookbook” guidance on such areas as test sequence may have caused unnecessary expense. General guidance (requirements) was first introduced in MIL-STD-810B, 15 June 1967. This included standard ambient conditions, measurement tolerances, accuracy of the test apparatus, temperature stabilization, recommended test sequences, etc. In looking realistically at a typical life cycle scenario, it is obvious that there is no cut-and-dry sequence of events. High storage temperatures, for example, could be encountered during outdoor storage at a manufacturer's facility while waiting for transport, dockside while awaiting loading on a ship, in a railroad box car, etc. Should the test sequence include high temperature before transport vibration or after? What about the very realistic combined temperature-vibration environment? In later discussion of the transit drop (shock) test, I note that, quite often, sealed equipment will undergo immersion following the drop tests to verify any seals are functioning as required. This may not represent any portion of a realistic life cycle, but there is logic in this sequence. But how do we know the seals were functioning before the drop test? Maybe we should run a drop - immersion - drop sequence! MIL-STD-810B suggests the immersion test following temperature shock tests, but not after dynamic (shock and vibration) tests. Other real considerations include how many test items are available for test, and the availability of test facilities. Invariably, these considerations far outweigh test sequence based on the life cycle scenario. Of course there are also sequence limiters inherent to certain environmental tests and combinations of such. Fungus tests, for example, should not follow dust or salt fog tests because latent dust could provide nutrients to support fungal growth and lead to a false indication of the biosusceptibility of the test item, and salt deposits could affect germinating fungal growth. All-in-all, test sequence is a difficult area to address because of the numerous factors involved. It is illogical to specify any sequence in MIL-STD-810 other than sequences that will be impacted by method-to-method relationships.

### **MIL-STD-810D**

MIL-STD-810D was published without three of the “old” test methods: Method 504, “Temperature-Altitude,” Method 517, “Space Simulation” (originally called “Low Pressure – Solar Energy” in -810 and -810A), and Method 518, “Temperature-Humidity-Altitude.” Both 504 and 518 were combined into a new Method 520, “Temperature, Humidity, Vibration, Altitude,” and Tri-Service representatives agreed that space simulation was a unique environment that should be addressed outside of MIL-STD-810D. Method 521, “Icing/Freezing Rain” was introduced because of the obvious need to test equipment exposed to such an environment. At the request of the US Navy at Point Mugu,

*Method 523, “Vibro-Acoustic Temperature” was added. Also new in -810D (and carried over to -810E) was the two-section format for each method. This was originally thought to be an aid to the user because of the “new” tailoring concept. Guidance information was separated from the procedural information. This format was removed in -810F in order to simplify use of the methods.*

### **MIL-STD-810E**

*MIL-STD-810E introduced guidance on how to use MIL-STD-810E, and emphasized that it is not to be invoked on a blanket basis but, instead, assessing each requirement in terms of need.*

*Regarding use of international agreements, NATO STANAG 3518 was replaced by a new NATO standard on the climatic environment and climatic conditions, STANAG 2895, that was developed by a new international group (organized in 1986) on environmental testing, AC/301, Sub Group 3.*

### **MIL-STD-810F**

*There are four new test methods and nineteen “old” methods in Part Two of MIL-STD-810F. The new methods are: Method 504, “Contamination by Fluids,” Method 517, “Pyroshock,” Method 518, “Acidic Atmosphere,” and Method 522, “Ballistic Shock.”*

*One “significant” change was removal of the controlled ambient conditions. I seem to remember discussion that focused on it being a lack of need and cost driver because of the variations in test laboratory sites and climatic conditions, but that is just my “remembrance.”*

### **MIL-STD-810G**

*MIL-STD-810G expanded the number of Methods by five:*

*Method 524 – Freeze-Thaw*

*Method 525 – Time Waveform Replication*

*Method 526 – Rail Impact (separated from Method 516.6)*

*Method 527 – Multi-Exciter Testing*

*Method 528 – Mechanical Vibrations of Shipboard Materiel (Type I – Environmental and Type II – Internally Excited)*

*Note that Ron Merritt requested a name change for Method 519.6 to “Gunfire Shock” that more accurately reflects the rewritten text.*

*Also added in -810G is a new Part Three, “World Climatic Regions – Guidance,” that provides planning guidance for realistic consideration (starting points) of climatic conditions in the research, development, test, and evaluation (RDTE) of materiel and materials used throughout their life cycles in various climatic regions throughout the world. A comparable addition as Part Four covering dynamic testing is anticipated for a future revision.*

*Before introducing -810G changes to individual Methods, I'll try to summarize general changes throughout the new document:*

- a. We made every effort to ensure references to the climatic categories throughout the Methods use the standard climatic category cycle designations as exist in NATO STANAG 4370, AECTP 230, (formerly NATO STANAG 2895), MIL-HDBK-310, and AR 70-38, such as "A1" for the Hot Dry cycle, "B2" for the Variable High Humidity cycle, "C2" for the Cold cycle, and so on. Although climatic categories A3 and C0 are used by some NATO nations and may appear on some -810G figures, they are not specifically addressed in MIL-STD-810G, MIL-HDBK-310, or AR 70-38.*
- b. In most cases, "notes" that have previously been imbedded in text paragraphs, have been "boxed" so as to make them more obvious to the user.*
- c. A general statement – "Tailoring, i.e., necessary variations in the basic test procedures to accommodate LCEP requirements, and/or facility limitations" was added to the pretest requirements for many of the methods in order to ensure LCEP variations are addressed.*
- d. Another general statement has been added to test facility instrumentation requirements to ensure unique issues are addressed: "Record chamber "parameters" at a sufficient rate to capture data necessary for post-test analysis (see Part One, paragraph 5.18)." Specific rates for data sampling were not agreed upon for several methods.*
- e. Throughout the evolution of MIL-STD-810, there has been little or no guidance on how to proceed following a test item failure during testing. Accordingly, we have incorporated new text in each of the methods under "Test Interruption." "Interruption due to chamber malfunction," "Interruption due to scheduled event," "Interruption due to exceeding test tolerances," etc., continue past guidance associated with malfunction of laboratory equipment or various other issues. One or more new paragraphs, "Interruption due to test item operation failure," provide two or more alternatives with respect to test item failures during or following testing. This information has also been referenced throughout the test procedures whenever an operational check is required. A note has been inserted in each Method that "When evaluating failure interruptions, consider prior testing on the same test item, and consequences of such."*
- f. Rather than following prior formatting, attempts have been made throughout the various MIL-STD-810G procedures to insert figures and tables immediately following their initial mention in the text. This, we hope, should make the methods more user-friendly by eliminating any ensuing search for the tables and figures. Unfortunately, this change occasionally extends the text significantly so that users may lose track of their immediate position in the Method.*
- g. The previous paragraphs with "Reference/Related Documents" have been separated into two separate paragraphs, 6.1 "Referenced Documents," and 6.2 "Related Documents." Only those specifically cited in the "Referenced*

*Documents” paragraph are considered part of the methods. Also, every effort has been made to cite all references (regardless if in the base portion of the methods or in Annexes) in paragraph 6.1.*

*It seems appropriate to mention that the official review of the draft of -810G resulted in some 240 technical comments submitted, as well as about 164 format issues. Each of these was addressed during the 130 or so telephone conferences, and an agreed position on each was noted. A number were labeled as “Defer to the next revision or edition.” I will attempt to summarize (below) those accepted for the final edition of MIL-STD-810G, and the rationale supporting each.*

*So as to alert users, I made an effort to “side bar” areas where we made changes. I don’t guarantee every change was covered.*

***When reading the following text, bear in mind that, except for the “Discussion” section (in italics) and the “Purpose” paragraph from MIL-STD-810F and G, the text is essentially verbatim from Junker’s paper, and without any editing. Where I felt obvious comments were necessary, I footnoted his text.***

*Finally, there are several references to Test Operations Procedures (TOPs) or International Test Operations Procedures (ITOPs) within the following text. TECOM (now DTC) maintains a library of some 600 TOPs and ITOPs. The TOPs program began in the late 1960s to document and standardize on recurring test procedures used throughout TECOM’s Test Centers. In 1980 TECOM held bilateral discussions under a data exchange annex (DEA) and memorandum of agreement (MOA) with Germany (West Germany at that time) that resulted in a number of mutually agreed bilateral “TOPs” that, because of the international aspect, were then designated “ITOPs.” In 1985, discussions with Germany, France, and the UK resulted in agreement (under a Memorandum of Understanding (MOU) to create (standardized) quadrilateral mutually acceptable technical test procedures that would not only share international technical expertise, but facilitate procurement of each other’s equipment without repeat testing. To date, there are some 144 ITOPs that are used to varying levels by the four nations, and often requested by other nations. One can find the TOP/ITOP Index at <http://www.dtc.army.mil/publications/topsindex.aspx>. TOPs can be obtained from the Defense Technical Information Center (DTIC), OCA, STE 0944, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6218. You can request copies of ITOPs at [www.dtc.army.mil](http://www.dtc.army.mil).*

*Part One changes included in Change Notices 2 & 3 to MIL-STD-810F are summarized at Annex A, but a significant inclusion is a paragraph that warns about total exposure time to severe (high temperature) environments, and that it should not exceed that (exposure) identified for the total life of the materiel.*

*Part One of MIL-STD-810G includes relatively few changes, some of which are considered more significant than others. Several definitions have been added to paragraph 3.1, and to Annex D.*

*With respect to Figure 1-2, several changes were made relative to the Program Manager and EES roles. Lorraine Wright (WPAFB) provided the rationale as follows: “Changes to the circled tasks assigned Environmental Engineering Specialists were predicated on input from a reviewer familiar with plans/reports, etc., currently performed by EESs. The circled tasks assigned Program Managers were changed for the same reason: outdated verbiage and taskings no longer relevant in the defense acquisition community (e.g., “Systems Acquisition Master Plans” (SAMPs) have been replaced by “System Engineering Management Plans” (SEMPs); reference Defense Acquisition Regulation 5000.2.*

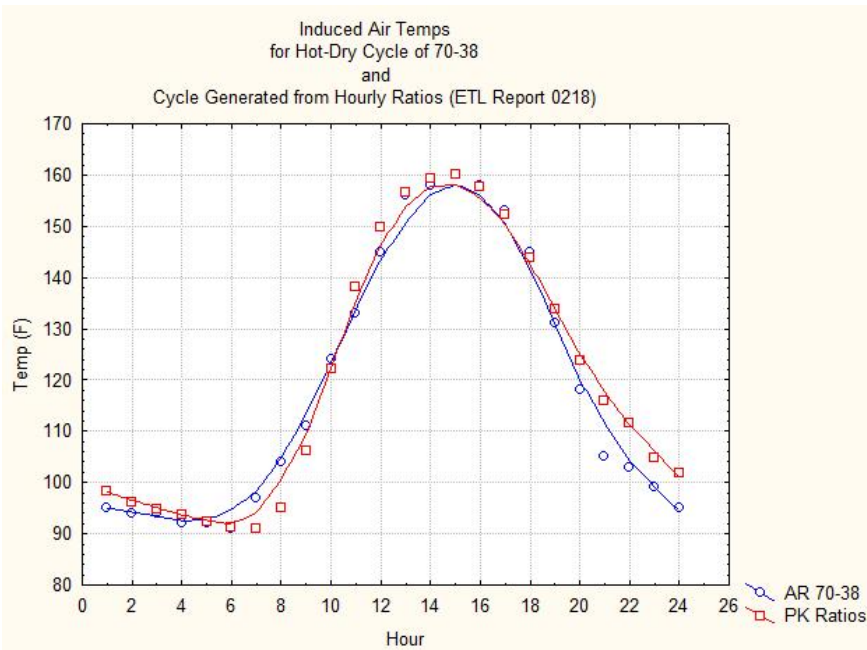
*Two of the more significant changes resulted from Dr. Paul Krause who recently retired from the Army Topographic Engineering Center. “NOTE: The terms “frequency of occurrence” and “probability of occurrence” have, unfortunately, been used interchangeably.*

*“**Frequency**” refers to the process used to differentiate among daily cycles of the climatic design types, i.e., the empirical result observed in the data (real world data). It is based on tabulations and binning of hourly temperatures obtained over many years of observations at data reporting sites. The delineation of the areas shown in Part One, Annex C (A1, A2, and A3 shown in Figure C-1, areas B1, B2, and B3 shown in Figure C-2, and areas C0, C1, and C2 shown in Figure C-3), is based on temperatures occurring one percent of the time (approximately 7.4 hours) in the worst month of the year. For the Severe Cold category (C3), the temperatures shown are those that Krause on -33lil could equal or exceed -51°C (-60°F) 20 percent of the time in the coldest month. The spatial extent and boundaries appearing in Figure C-3 are generalizations. They are based on the data availability and the spatial density of the climatic stations used in their construction. Both climatic and geographic principles were used in their derivation. However, they should be regarded as approximations. It must be remembered that most areas within extreme climatic regions are very sparsely populated. Hence, there may be an extremely low number of climatic reporting stations. Thus, there are locations within these frequency polygons that could be considered anomalous. Although there may be anomalies within any area, the perimeters of the areas shown try to reflect this.”*

*When I asked Paul of frequencies related to the storage and transit values, he responded with: “I’ve never heard of any percentiles applied to the S&T conditions. I really do not know. I guess that they were artificially created and are based on climatological and meteorological principles. They may also have been generated based on temperatures measured during the field testing of materiel. Once you have your 1% ambient cycle, you create more severe temperatures for S&T that are generated through the application of some thermal forcing function to the ambient cycle. It’s like the old “add 35F to the maximum temperature” rule to get the 160F induced value.”*

*Paul then added the following: “I have also attached a graph I just created showing the A1 S&T temperatures. The companion curve was generated using temperature ratios that*

*I created from my 1-year monitoring of a Navy Thermal Standard at Fort Belvoir in 1978-1979. These ratios were based on the surface temperature of the Thermal Standard. I just applied these ratios, which range from 0 for the min temp (91F) to 1 for the max temp (160F). Granted, the Belvoir data in no way represents the hot-desert, but the curves are quite similar. Perhaps somebody way back when did the same thing when the 70-38 S&T curves were generated. Then again, perhaps not.”*



**“Probability”** Is a measure of how likely it is that some event will occur. In this case, it refers to the possibility of the occurrence of a certain temperature – on a world-wide basis (excluding Antarctica). It is the theoretical distribution and not the actual distribution of the temperatures themselves. It is similar to a sample mean from a data set versus the actual mean of the underlying distribution from which the sample is drawn. Whereas ‘frequency’ refers to actual real-world data, ‘probability’ is just the mathematical or statistical theory or abstraction behind it. The more extreme the temperature, the less the probability it has of occurring (Table 502.5-II).

“Controlled Ambient” has been re-introduced into paragraph 5.1 – similar to that from MIL-STD-810E. There was concern that without starting many tests with tighter tolerances than offered by “standard ambient,” repeatability of test results among laboratories may be affected.

I questioned the range of ambient atmospheric pressure in the “Controlled ambient” paragraph (5.1b) and Paul Krause provided the following: “The controlled ambient puts tighter conditions into place. As to the pressure it has a range of 25.5 to 30.5 inches of mercury. The highest ever measured surface pressure was 32.0 inches of mercury, and the

*lowest was approx. 25.7. So the range of pressures set for in 810G is realistic. Who came up with these values is unknown to me.”*

*We occasionally receive questions regarding measurement uncertainty such as suggested in paragraph 5.2. The general consensus of DTC technical experts from various technical centers is that the customer will request calibration data rather than end-to-end uncertainty. At this point, the plan is to develop measurement uncertainty guidance to support the concept of test condition tolerances, as well as instrumentation or measurement inaccuracies. Hopefully, this will be included in Change Notice 1 to MIL-STD-810G.*

*Paragraph 5.11, “Test Interruption,” has been modified to include guidance on how to proceed in the event of test item failure during or following each test procedure, as well as failure implications during sequential testing with the same test item.*

*Judy Galloway proposed changing paragraph 5.16 (water purity) to 0.20 megohm.cm from 0.15 megohm.cm, and said “Am writing up justification-rationale for this. 0.25 megohm.cm is equal to 250,000 ohm in the book. The 0.20 megohm.cm is better water, but not great. The ASTM guidance for salt fog recommends using Type IV water that is 0.20 megohm.cm.; for humidity tests, chamber manufacturers recommend 5 megohm.cm (RO water). Higher quality of water can be used for Humidity and Immersion tests (that many of us use with the new water systems) up to 10 megohm.cm. If you go too pure you tend to leach out the brass, et al metals in the humidity system (and possibly your test item).” Due to problems some laboratories had with meeting the 0.20 megohm.cm, Judy acquiesced to using 0.15 megohm.cm – at least for now, due to the many older distilled water systems still in use.*

*Paragraph 5.18.3 (Total High Temperature Exposure Duration) was renumbered as paragraph 5.19, but with no text changes.*

*A proposal to add a paragraph 5.20, “Temperature Transitions” to ensure consistency during temperature changes, and such changes do not cause thermal shocks – unless otherwise noted, is being considered for the first revision to -810G.*

*There’s been some concern that the Annex C discussion of “Climatic categories” is out of place with respect to the preceding paragraphs, so one consideration is to move the discussion to Part Three, maybe for Change notice 1. There is also consideration of moving Figures C-1 through C-3 to Part three.*

*A similar concern was received that Part One, Annex D would be better located in another Part. We are planning on introducing a Part Four for shock & vibration guidance and, if so, this Annex will be considered for inclusion in the new Part Four.*

*Note that in the following changes to specific Methods, I have attempted to quote the specific (positive) comments and their resolution. Hence, the text will be expanded from that of previous discussions.*



## **METHOD 500 - LOW PRESSURE (ALTITUDE)**

### **Purpose:**

- To determine the deleterious effects of low pressure on unpressurized aerospace and ground equipment (**Junker**).
- *To determine if materiel can withstand, and/or operate in, a low pressure environment, and/or withstand rapid pressure changes (MIL-STD-810F and G). (Egbert)*

### **Recognition of the Problem (Junker):**

- Low pressure became a recognized problem when aircraft began flying at altitudes higher than a few thousand feet above sea level. Low pressure problems vary in severity from aircraft flying in the Earth's atmosphere to the near perfect vacuum of space encountered by space vehicles.

### **Development of Low Pressure Test (Junker):**

The low pressure test, like other environmental tests, has varied from one specification to another over the years. Requirements outlined in test procedures for ground support and aerospace equipment, with emphasis on the latter, have steadily increased in severity to be coincident with the vehicle mission. Numerous specifications contained requirements for altitudes up to 100,000 feet and temperatures as low as -65°C. MIL-E-4970 was superseded by MIL-STD-810 (USAF) and provided tests for ground support equipment. Altitude conditions of 50,000 feet for non-operating air transportation and 6,000 or 10,000 feet operating, whichever specified, were included. The latter requirement was intended for ground operation at high mountain sites.<sup>6</sup> A temperature of +77°F was specified. The requirements contained in the final product (MIL-STD-810 (USAF)) were intended to reconcile the different requirements in various specifications.

### **Discussion of the MIL-STD-810A Altitude Test (Junker):**

With the advent of the space vehicles, no set limit, short of perfect vacuum, could be specified for installed equipment operation. Accordingly, Method 500, Procedure II simply states that “the test chamber internal pressure shall be reduced to the lowest pressure for which the item is designed to operate.” The 50,000 feet non-operating air transportation requirement for ground equipment was used in Method 500, Procedure I. However, the 6000 feet altitude requirement, with equipment operating, was dropped in preference to the 10,000 feet test since it could not be guaranteed that an equipment supposedly designed for operation at 6,000 feet would never be operated at 10,000 feet.

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<sup>6</sup>AR 70-38, “Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions,” 1 August 1979, states that “For materiel subject to transport through high mountain passes, the temperatures and pressures for elevations as high as 15,000 feet apply.” It also provides low air pressures and temperatures that could result in aircraft (transport by air) from failure of cabin pressure and temperature regulation.

The low temperature requirement is -65°F which is derived from a -70°F average outside air temperature at altitudes from 37,500 feet to 80,000 feet, with an allowance of 5°F for temperature rise due to aerodynamic heating and/or equipment generated heat. For altitude testing of ground equipment under operating conditions, rather than provide a specific temperature (which implies precise control), the temperature is uncontrolled in consideration for the fact that it will not usually differ greatly from +77°F.

### **Discussion (Eqbert):**

#### **MIL-STD-810D**

*The non-operational exposure time of not less than one hour has been carried over from the original MIL-STD-810 into each of the preceding versions. Equipment operation at low pressure (maximum operational altitude) was reintroduced in MIL-STD-810D (deleted in MIL-STD-810C in favor of Method 504.1), because some equipment will be required to operate in reduced pressure environments, be it on the ground at high elevations, or in aircraft. We also introduced Procedure III, "Rapid Decompression," as a means of verifying personnel and aircraft safety in the event of rapid pressure loss. In MIL-STD-810D we noted that Procedure II could be used alone or in combination with Procedures I and III. In an effort to provide data for cargo compartment pressures, I queried various aircraft manufacturers and developed a table of minimum cargo compartment pressures for -810D, i.e., if pressurization systems failed, these are the worst-case pressures that would occur before bringing the aircraft down. This does not include structural damage that could result in rapid or explosive decompression. This table, along with altitude change rate information for transport aircraft was included in "D" as a tailoring aid.*

*In MIL-STD-810D we introduced the maximum anticipated altitude for ground military operations of 4570 m (15,000 feet) from AR 70-38. Operation was to be performed at the maximum operational altitude, and for a duration that was based on the operational conditions and time required for an operational check. Testing was done at ambient temperature. We also introduced what we referred to as a "rapid decompression" test that was intended to ensure personnel and aircraft safety. The rate of decompression was arbitrarily chosen as 15 seconds to change from cabin pressure to 12200 m (40,000 feet) equivalent pressure, such as may occur as a result of gradual structural failure (minor damage), and with the aircraft's pressurization system still functioning. We mentioned that in contrast, explosive decompression should be accomplished in (an arbitrary) 0.1 second (essentially instantaneous), but we did not provide a specific procedure.*

*According to Dave MacMartin of the Quality Engineering Test Establishment, Ontario, Canada, due to some experimental investigations, and examinations of both civilian and military incidents in recent years, it was found that the Rapid Decompression Test did not adequately test for events such as large ruptures in aircraft fuselages or shattered windshields. However, the Rapid Decompression test was maintained in the latest revision of the Military Standard (MIL-STD-810F) to accommodate situations where the aircraft did not experience a rupture, but rather a significant pressure leak, such as failure of an aircraft door seal. Additionally, it may also be applied to equipment that is transported in*

*a container that has a pressure relief valve, which of course would release its internal pressure over a period of several seconds. Unlike slower pressure leaks, the investigations of the large ruptures showed that the pressure drop to 40,000 feet would be experienced in about 0.1 second in the area near the point of the large rupture, and a second or two longer in areas that were farther from the rupture. Of course, this depends on the size (internal volume) of the aircraft and how it was loaded. Thus, a need for a more realistic test was identified and the Explosive Decompression test (essentially instantaneous) was developed. Since then, because of the validity and significance of the Explosive Decompression Test, it has been accepted by a number of foreign countries, and is also now in the process of being adopted into international standards.*

#### **MIL-STD-810E**

*It was not until -810E that low temperatures normally associated with altitude were suggested to be considered as part of the test environment. In fact, Junker's reference to 77°F (25°C) is not considered accurate since both ground and air temperatures can fall far below freezing. In Change Notice 2, the text was changed in paragraph I-3.2b to ensure the user is not mislead into using less than suitable altitude change rates. A combined temperature altitude environment was introduced to reflect reality of lower temperatures at altitude.*

#### **MIL-STD-810F**

*MIL-STD-810F has four test procedures including both a rapid decompression test with a decompression rate of up to 15 seconds (an arbitrary rate that was mentioned earlier), and a new explosive decompression test with a 0.1 second pressure change requirement. Method 500.4 also encourages the use of combined temperature and low pressure environments. The 1-hour minimum duration applies to only Procedure I (Storage/Air Transport). Because of the wide range of aircraft and service ceilings, the ability of pressurization systems to keep up with minor air leaks, and the possible misleading information contained therein, the table with minimum cargo compartment pressures from earlier versions of -810 was deleted.*

*Change Notice 2 to -810F contains only minor administrative corrections.*

#### **MIL-STD-810G**

*MIL-STD-810F had a ceiling limitation of 30,000m (98,425 ft), but an old friend, retired USAF C-130 pilot and BG, John Schnell, suggested inserting "21,300m (70,000 ft)," and that the test should be tailored to the maximum altitude normally reached by the appropriate mode of transportation."*

*Following Change Notice 3 to -810F, it became obvious that more guidance was required for the explosive decompression procedure to distinguish it from the rapid decompression procedure. An incident that creates an explosive decompression situation in the cargo compartment will, most likely, be such that the aircraft does not survive, so this procedure will not be appropriate for large cargo items such as missiles, rockets, and vehicles.*

*Boeing engineer (Marshall Mooreman) provided the following: "Got one of our structural engineers to play with this. To go from a cabin altitude of 8000' to an ambient altitude of 40000' in one second would require a hole of approximately 350 square feet. That would*

be a hole approximately 19' x 19.' To instantaneously create a hole that large in the side of the airplane would be catastrophic to the airplane. We did some 'what ifs' and figured if we could cut enough small holes at selected locations we could dump the pressure and not have structural failure. Please note that the 350 square foot hole is for a 1 second depressurization. To depressurize in one tenth of a second would require a hole ten times as large.

We recommend that you test your equipment for a rapid decompression but not for an explosive decompression.”

However, specific devices located in the cockpit such as sealed instruments in commercial aircraft, fighter jets flying at high altitudes, etc., or items mounted on the pilot's person may be affected by cockpit window breakage, canopy ejection, etc., that results in a sudden loss of pressure, i.e., explosive decompression, hence the appropriate application of the explosive atmosphere procedure. It has been noted in paragraph 1.3 (Limitations) that the explosive decompression test is not intended for materiel transported in a cargo bay.

Because of potential temperature, humidity, and low pressure synergistic effects, a pointer has been inserted to suggest users consider applying Method 520 in addition to Method 500. There has been application of Method 520 in lieu of one or more of the four environments addressed in individual methods. While the synergistic effects are important, we have noted before that we cannot produce the real environments in a chamber, so until technology improves, we emphasize that **520 is NOT a substitute for altitude, temperature, humidity or vibration methods.**

Unless otherwise specified, all temperature transitions are to be performed at a rate not to exceed 3 °C/min (5 °F/min).

To continue with comments received and their resolution for -810G, a contradiction seems to exist between wording in 500 versus wording in 520: 500 (paragraph 1.2 – Application, suggests considering materiel transported as cargo could use Method 520, but 520 says it does not normally apply to materiel transported as cargo. This issue is unresolved as of the publication of MIL-STD-810G, and identified as one of many issues to be worked for a future edition or Change Notice 1.

Another comment that was received said “Method 500.5, paragraph(s) 1.2(b) (Application) and paragraph 2.2 (Selecting Procedures), page(s) 500.5-1 and 500.5-2 respectively - Reference is made in the NOTE for Method 520.3 as an addition to Method 500.5, Procedure II.” The resolution is “Change the note as follows: Place the note box after Method 500.5, paragraph 2.3.1b(2). “Cargo aircraft may transport cargo in either pressurized or un-pressurized conditions for various reasons including fuel economy.” **Method 520 is NOT an alternative for this Method.**” While Method 520 subjects the materiel to anticipated synergistic effects, its test durations are abbreviated and do not subject the materiel to the stresses of the individual methods that are intended to simulate the effects experienced in those environments.

METHOD 500

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## **Method 501 - High Temperature**

### **Purpose:**

- To determine the resistance of aerospace and ground equipment to elevated temperatures that may be encountered during service life either in storage without protective packaging or under service conditions (**Junker**).
- *To obtain data to help evaluate effects of high temperature conditions on materiel safety, integrity, and performance (MIL-STD-810F and -810G). (Egbert)*

### **Recognition of Problem (Junker):**

Many types of equipment are affected by high temperature, but not all in the same way. 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 +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 in equipment of complex construction, such as bombsights and various instruments, may occur. This in general, is the result of using dissimilar metals and the close tolerances which must be maintained between moving parts to insure accuracy.

### **Development of High Temperature Test (Junker):**

A high temperature test was included as part of the first Army Air Force environmental test specification 41065 dated 7 November 1945. The test specified a temperature of +160°F and a total test time of 15 hours. In test specifications that followed, the test time was increased, in some cases, to as long as 50 hours. The temperature of +160°F and a test time of 48 hours<sup>7</sup> is presently specified in MIL-STD-810 (USAF), Method 501. The temperature of +160°F represents the probable high temperature extreme for storage and transportation.<sup>8</sup> Operation of ground equipment can also experience this temperature due to heat developed through operation. The temperature of +125°F is representative of the highest temperature of the ambient air. The temperature of +160°F results from the addition of 35°F due to solar radiation.

### **Discussion of the MIL-STD-810A High Temperature Test (Junker):**

The high temperature test is recommended for all classes of aerospace and ground equipment. In the absence of well-defined system criteria regarding compartment temperatures, intended heat exchangers, ram air available for cooling, etc., general test procedures can, only at best, give general guidance and test levels for performing the average test.

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<sup>7</sup>There is no apparent explanation for the test duration.

<sup>8</sup>Extensive studies by Mr. Howard C. Schafer of the Naval Weapons Center, China Lake, CA, indicated that incidences of temperatures approaching +160°F (71°C) during transportation and storage were rare.

## Discussion (Eqbert):

*The original MIL-STD-810 and -810A used a starting temperature of 52°C (125°F) that represented the maximum temperature of ambient air, and an upper temperature of 71°C (160°F) that resulted from adding 35°F due to solar radiation, along with a maximum RH of 15%. MIL-STD-810B used 120°F to 160°F for Procedure I (storage exposure), and 154°F for storage and operation. In MIL-STD-810C, Method 501, Procedure II, the range of temperature cycling was changed from between 49°C (120°F) and 68°C (155°F) to 49°C and 71°C (160°F). I have not been able to locate an explanation for this, but assume it is for the same reason the low extreme temperature was changed, i.e., to agree with MIL-STD-210B.*

*The 48-hour constant high temperature (storage prior to operation) exposure to +160°F as included in MIL-STD-810C did not represent exposure to diurnal (cyclic) high temperature environments, and was thought to be a cost driver. Constant high temperature exposure will most likely only be experienced by equipment in close proximity to a constant heat source such as a motor or engine. After consideration of several alternatives, in MIL-STD-810D we agreed to substitute the old storage test requirement with a minimum of seven 24-hour diurnal cycles representing the most extreme environment anticipated for the materiel to be tested. Since the 1% frequency of occurrence of the hours of extreme temperatures during the most severe month in an average year at the most severe location equates to approximately seven hours (AR 70-38), seven cycles would result in seven hours of the extreme test condition for the test item (one hour per cycle).*

*Yuma Proving Ground personnel, through experimentation, noted that materiel exposed to cyclic high temperatures will normally maximize its response temperature cycle after three cycles. Accordingly, Procedure II of MIL-STD-810D (Operation) was changed to require a **minimum** of three cycles with the test item operating (to reflect any heat-generating mechanisms). If cyclic response stabilization (repeatability) is difficult to achieve, or if there is a requirement to expose the test item to what is referred to as the “1 percent extreme temperature values” (defined in AR 70-38<sup>9</sup>) for a particular climatic category, extend the cycles up to a maximum of seven (that used for Procedure I) while ensuring proper operation is verified. A key here is to determine where the test item stabilization temperature is to be measured. Obviously, a large structural member would require longer stabilization times than smaller components, but the issue is to determine which component's failure would prevent the test item from satisfying its operational requirements. This item is referred to as the critical component, and its temperature is what should be used for stabilization purposes. MIL-STD-810D also introduced a graphical summary of temperature stabilization trends at the surface and at the center of test items based on equipment diameter or minor thickness. This graphical summary (we believe) was derived from a study by Howard Schafer of the Naval Weapons Center at China Lake, CA, (“Quantification of the Storage Logistics Thermal Environment”) that was published in the January/February 1979 edition of the Journal of Environmental Sciences. It was carried into -810D and -810E but, for some unknown reason, we deleted it from MIL-STD-810F. During discussion of the NATO “equivalent,” STANAG 4370, the Swiss representative suggested the internal stabilization curve be reintroduced, and provided data to support an adjustment to the curve. We are considering this new information, but it is not*

<sup>9</sup> At this writing, AR 70-38 (1979) is being revised to reflect recent verbiage and regulations.

*included in Change Notices 2 or 3 because of complexities in determining the values to be used. MIL-STD-810D also introduced the concept of a controlled chamber air velocity of  $\leq 1.7$  m/s (325 ft/min) in order to assist in the standardization of chamber environmental testing.*

## **MIL-STD-810D**

*Tailoring aids introduced in -810D included tabular high temperature cycles for hot and basic hot categories, guidance and procedures for establishing equipment thermal response, a graphical summary of temperature stabilization trends, and information relating test duration to natural exposure.*

*Relative humidity in open areas normally drops as temperatures increase. The typical hot and basic hot cycles reflect low levels of relative humidity. Because test laboratories typically incur increased costs trying to control and measure these low RH levels, we felt it to be an unnecessary cost driver that should only be required if low RH levels are known to cause problems, such as with computers.*

## **MIL-STD-810E**

*There were relatively few changes from MIL-STD-810D to the original MIL-STD-810E or Change Notice 1 to MIL-STD-810E.*

*Change Notice 2 to MIL-STD-810E introduced the potential use of high temperatures in conjunction with shock and vibration tests. It also clarified that conversion of temperature values originally recorded in °F to metric (SI) values to °C such as in Tables 501.3-I and -II may introduce occasional inconsistencies. Two other changes were in the humidity guidance where unless low RH may impact high temperature testing, control of RH during high temperature testing is not necessary, and in the referenced documents where NATO STANAG 2831 was replaced by NATO STANAG 2895.*

*With regard to the humidity statement, while I was actively involved in environmental testing at the Army Electronic Proving Ground, I witnessed a situation in which during a checkout of a new walk-in temperature – humidity chamber, the temperature exceeded the programmed high temperature value. Inside the chamber was a tool with a plastic handle that over hung the edge of a counter. The plastic handle bent. I then placed a similar tool in another chamber and in about the same overhand position, and raised the temperature above that in the previous chamber with no change. I then placed another new tool in the same chamber, raised the temperature to the same level, and introduced humidity (90-95%). After an hour or two the plastic handle bent. This, in my opinion, is a classic example of synergistic effects.*

## **MIL-STD-810F**

*As in all of the MIL-STD-810F Methods, the format of the entire Method has changed (updated), and the “Tailoring is essential” note was inserted at the beginning of the Method.*

*The purpose was rewritten to emphasize the effects of high temperature on materiel safety, integrity, and performance.*

Unfortunately, we neglected to “side bar” changes in technical information from MIL-STD-810E so that they could be readily identified.

## MIL-STD-810G

*Since solar radiation is an influence on high temperature, we suggest conducting Method 505 (Solar Radiation) to obtain response and stabilization temperatures for items exposed to solar radiation.*

*For “Test Duration,” we found that the previous statement for constant temperature exposure has been misused in that users stabilized the test item temperature but ignored the “maintain the test temperature for at least two hours following stabilization.” Additionally, this constant temperature test has been used as a substitute for thermal cycling, so we added a note to the effect that this is not a substitute for thermal cycling.*

*A new procedure was added (Tactical Standby to Operational) that is intended to be used for materiel that is subjected to non-operational conditions, and then required to operate as needed in a relatively short time such as standby aircraft.*

*Table 501.5-I was modified to clarify Basic Hot and Hot Dry design type locations.*

## **METHOD 502 - LOW TEMPERATURE**

### **Purpose:**

- To determine the effects of low temperature on aerospace and ground equipment. (Low temperature is encountered from ground level to all altitudes. The adverse effects of low temperature on equipment can be operational or mechanical. Operational effects may not cause a system to fail, but can prevent it from fulfilling its intended mission. For example, snow and ice prevent an aircraft from taking off even though all systems function perfectly. Mechanical effects can actually prevent a system from functioning properly, e.g., freezing of lubricants causing a pump or motor to malfunction.) **(Junker)**.
- *To measure how low temperature conditions during storage, operation and manipulation affect materiel safety, integrity and performance (MIL-STD-810F and G).*

### **Recognition of the Problem (Junker):**

A need for an extensive low temperature program was indicated prior to World War II. Congealing of lubricants caused operating difficulties at sub-zero temperatures. Tires and other rubber parts were easily cut and cracked. Some types of solder would disintegrate when subjected to vibration at low temperatures. Canvas and leather became stiff at low temperatures and were easily cracked and torn. Differential contraction caused buckling of aircraft skins and caused leaks in hydraulic systems. Ice and snow caused structural damage and moisture problems.

### **Development of Low Temperature Test (Junker):**

Low temperature testing was first begun under the Army Air Corps at outdoor exposure sites. These tests were conducted from 1930-1938 at Selfridge & Oscoda, Michigan, and in New England for the purpose of determining the ability of aircraft and crews to operate in cold climates. In 1938 the Air Corps Cold Weather Experimental Station was established at Ladd Field, Alaska.

In 1941 Wright Field, Ohio, was designated as the coordinating agency in the design and development of low temperature equipment. In the same year results of a world wide temperature study indicated that -65°F should be regarded as the minimum temperature requirement for operating conditions. A temperature of -85°F was indicated as a probable extreme for storage in some areas.

During the winter months of 1942 to 1943, extensive testing at Ladd Field showed that aircraft and ground equipment, and associated auxiliary and accessory equipment, would not operate satisfactorily in temperatures below -25°F. During 1941 and 1942 new greases were

developed for low temperature operation. In 1944 test results indicated that aircraft and equipment were suitable for operation to about -40°F.

Investigation of low temperature effects continued through the winter of 1946-1947. At this time low temperature testing became part of the normal development cycle of aircraft systems and associated equipment. As early as 1943, requirements for aircraft operation at -65°F outside air temperature were established by the Director of Military Requirements. Three low temperature test procedures appeared in Air Force Specification MIL-E-5272, dated 16 August 1950. Procedure I required operation<sup>10</sup> of the test item at -65°F for 72 hours followed by operation while at that temperature. This procedure<sup>11</sup> was used when there was a possibility that an item which produced proper temperature distributions and heat flows at -65°F might not operate properly at the higher temperatures. Procedure III required exposure to -85°F for 48 hours then exposure to -65°F for 24 hours or longer, if required, for test item stabilization. Operation was required at -65°F at the end of the exposure period. Investigation has shown that most airborne equipment will not encounter temperatures below -65°F because of the heat rise within the aircraft. Ground equipment, in some instances, could be stored in areas where the temperature could be as low as -80°F.

In 1952, Procedure II was eliminated from MIL-E-5272. It required equipment to be exposed to and operated at each of four temperatures ranging from 0°F to -65°F. This elimination was based on the assumption that if equipment could operate at -65°F, satisfactory operation could be reasonably assured at the higher temperatures. The exposure requirement was also changed from -85°F to -80°F. In a 1959 revision, the exposure time was increased to 72 hours from 48 hours.

As a result of low temperature testing experience gained at Wright Field in the many years past, and based on criteria established in MIL-STD-210A, the following conditions were established as standard in MIL-STD-810 (USAF):

- 80°F for transportation and storage
- 65°F for worldwide operation
- 40°F for operation in continental United States
- +35°F for equipment operated in temperature-controlled areas

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<sup>10</sup> It is obvious that this was intended to say "storage."

<sup>11</sup> I assume this was meant to refer to Procedure I. Procedure II was, for some reason, not mentioned. It included three test schedules, 48 hours at -20°F, 48 hours at -40°F, and 72 hours at -65°F, and the equipment was operated and examined at the end of each temperature level.

### **Discussion of MIL-STD-810A Low Temperature Tests (Junker):**

At present, low temperature testing in accordance with MIL-STD-810 (USAF) will provide the lowest natural temperature conditions aerospace and ground equipment can be expected to experience, except for possible extreme conditions in the Antarctic<sup>12</sup>.

MIL-STD-810 (USAF) is basically a combination of MIL-E-4970 (USAF) (which requires a non-operating 72-hour exposure to -80°F) and MIL-E-5272C, and takes into consideration the lowest temperature at which the test item is designed to operate. Differential contraction and other low temperature effects cannot be complete until stabilization at a low temperature is complete. The exposure time must be sufficiently long to insure the effects which will occur during operational use will, also, occur during the test. Investigations of changes in organic materials, such as lubricants, plastics and rubber, and test experience have indicated that seventy-two hours is usually a correct time duration.

### **Discussion (Eqbert):**

#### **MIL-STD-810B**

*MIL-STD-810B (June 1967) removed the “cookbook” low temperature values and durations and directed the user to apply values from the (equipment) specification and for the time specified. This encouraged tailoring but failed to provide guidance/rationale.*

#### **MIL-STD-810C**

*MIL-STD-810C (10 March 1975) reintroduced -70°F (-57°C) as the lower temperature limit, “or as specified in the equipment specification,” and for the period specified. The 1975 seminar proceedings mentioned that this change was made to agree with the value specified in MIL-STD-210B. (AR 70-38 (May 1969) included the value for the extreme cold climatic category.) In the seminar proceedings it went on to say that, wherever possible, the limits from -210B were used. The data were evaluated according to certain guidelines handed down by the Joint Chiefs of Staff, that certain calculated risks would be taken beyond which the government would not design equipment. In other words, we’ve decided to use a 1% calculated risk, i.e., we ignore any extreme values of temperature that occur less than 1% of the time in a specific area. In some of the older climatic tests the temperature limits were much exaggerated over what occurs in nature, especially for operational purposes.*

**Comment:** *Excluding Alaska, the US’ lowest temperature was -69.7°F (-56.5°C) at Rogers Pass, Montana on 20 January 1954. Alaska’s lowest temperature was -79.8°F (-62.1°C) at Prospect Creek, Alaska on 23 January 1971. The world’s lowest temperature (excluding Antarctica) of -90°F (-67.8°C) occurred on 5 and 7 February 1892 and 6 February 1933 in Vekhoyansk and Oimekon, Russia.*

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<sup>12</sup> Excluded from consideration by international treaty restrictions

AR 70-38, "Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions" (August 1979), noted that the "severe cold climatic design type areas have the lowest temperatures on the surface of the Earth, except Antarctica" (that is excluded from consideration by international treaty restrictions, i.e., the "Antarctic Treaty" of 1959 that includes Part 1 "Antarctica shall be used for peaceful purposes only. There shall be prohibited, inter alia, any measure of a military nature, such as the establishment of military bases and fortifications, the carrying out of military manoeuvres, as well as the testing of any type of weapon."), and essentially limited design of Army materiel to a low temperature extreme of -60°F (-51°C), i.e., the extreme cold climatic category was no longer to be applied. This value has been carried forth into MIL-STD-810D, -810E, and -810F.

### **MIL-STD-810D**

During the development of MIL-STD-810D, a question arose as to just how long to keep test items at a specified low temperature. This issue was debated, and personnel at the US Army Cold Regions Test Center, Fort Greely, Alaska, commented that they have no data that show deterioration once the test item has been stabilized at the required low temperature. Considering that internal measurement for temperature stabilization may not always be practical, we arbitrarily recommended a 4-hour soak following (what is thought to be, or what is actually measured) temperature stabilization. In most cases this would ensure stabilization actually occurred. An exception to the deterioration theory was noted in that some explosives, restrained glass (e.g., lenses) and organic plastics may continue to deteriorate following stabilization. In these situations we recommended a 72-hour soak period since constant severe low temperatures have lasted for that length of time.

A 1981 methodology investigation on improved validity of cold weather testing<sup>13</sup> focused on the results of laboratory low temperature tests and their use in predicting subsequent failures of items in a natural cold arctic environment. The study found that the realism of laboratory chamber tests should be improved by:

- having test personnel wear cold weather gear similar to that issued to soldiers in the field;
- utilizing items and equipment in the same configuration as those issued to soldiers in the field, and
- assembling/disassembling items and equipment when appropriate after stabilization at the low temperature.

Regardless, there are enormous amounts of data that indicate that testing in the natural environment reveals significant problems not found in laboratory testing, but appropriate laboratory testing prior to natural environment testing can minimize problems normally encountered in the natural environment.

MIL-STD-810D not only introduced a Procedure II (Operation) that separated it into an independent test (from the previous storage and operation) with operation before, during and

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<sup>13</sup> "Methodology Investigation of Improved Validity of Cold Weather Testing," August 1981, Thomas A. Lucas, Organization: US Army Aberdeen Test Center.

*following low temperature exposure, but also introduced a Procedure III to address the above concerns from the 1981 report. Procedure III was called a “Manipulation” test procedure. This term (“manipulation”) has received frequent comments, but no other term seemed to fit the intent of the test. “Handling,” “assembly, disassembly,” etc, were all considered, but none encompassed the unpacking, assembly, operation, disassembly and re-packing required, all while at low temperature and while wearing appropriate arctic gear.*

*As was mentioned in discussion of the high temperature test, MIL-STD-810D also introduced the concept of a controlled chamber air velocity of  $\leq 1.7$  m/s (325 ft/min) in order to assist in the standardization of chamber environmental testing.*

*Tailoring aids provided in -810D included a tabular summary of low temperature diurnal cycle temperature ranges by climatic region, and guidance for determining test temperatures and durations based on probability of occurrence.*

*While ambient high temperature environments are directly related to solar loading and diurnal cycles, the sun has virtually no impact on the severe low temperature environment, and cycling is minimal. On a typical winter day in the arctic, temperatures may cycle as much as 15°F (8°C). If the equipment being tested could be sensitive to this small fluctuation, we recommend cycling the test temperature rather than soaking at a constant temperature. Winds are normally thought of as creating an even colder environment but, in fact, the lowest temperatures occur when there is no wind. The 1987 ALBE report echoes this position and includes “A diurnal cycle is not provided because the effect of solar radiation during these extreme conditions is minimal.*

#### **MIL-STD-810E**

*MIL-STD-810E included mostly editorial changes from the “D” version, but there were a few changes to note such as the rate of temperature change that went from “shall not exceed 10°C per minute,” to “shall not exceed 3°C per minute.” This change was introduced to prevent the user from inferring that the test involves a thermal shock, thereby requiring a more complex test facility. The 3°C change rate is representative of that in ‘current’ international standards (such as NATO STANAG 4370).*

*Change Notice 2 to -810E included reference to cyclic low temperature testing, but because of the relatively small temperature variations in the natural cycles, suggested that “Although the natural low temperature environment is normally cyclic, in most instances it is acceptable to use a constant low temperature test. Only in those instances where design assessment suggests that exposure to varying low temperatures may be important are the appropriate cold cycles from MIL-STD-210C recommended.”*

#### **MIL-STD-810F**

*With respect to low temperature tests, MIL-STD-810F is essentially the same as -810E, except for format and a few minor modifications such as the addition of new data describing low temperature conditions and their likelihood of occurrence (Caruso – 2001). However, an interesting question was submitted by Stanley Poynor in July 2003 with reference to AR 70-38 values: “Since there are THREE cold limits (Basic Cold, Cold, and Severe Cold),*

the 1% numbers given in -210, -310, and -810 for frequency of occurrence are from the Severe Cold region (-61C) as stated in MIL-STD-810F. Where does the -33C (induced ambient) come from for Basic Cold? Is that a 1% number? The footnote at the bottom of 502.4-9 says 'these represent typical conditions' and the discussion sections of the various documents say that if you are where you can see a given cold temperature, the conditions can prevail for days (as opposed to peaking with the diurnal cycle for high temp). If the -33C does represent 1% conditions, what document references it as such”?

Dr. Paul Krause of the Army Topographic Engineering Center responded as follows: “I believe that I managed to find the source of the lower induced Basic Cold value. I found a document that was used to justify the rationale for updating AR 705-15 -- the predecessor of AR 70-38. Its citation is: **“Williams, L. (1962); Report of the Subcommittee on Climatic Design Criteria for Revision of AR 505-15. Natick, MA: Quartermaster Research and Engineering Center.”**

It appears that the Committee felt that they should take into account that “net heat loss by long-wave radiation...may chill equipment below air temperature. In areas of basic design conditions it is most likely that the lower temperatures will occur under synoptic conditions favorable to strong nocturnal radiational cooling.” They recommended a ground (snow surface) temperature of -40C (-40F). The -40 value appears in Change 1 of AR 705-15, dated 14 October 1963. This was later modified in the 1969 version of AR 70-38 to -34C (-30F) and then modified to -33C (-28F) in the 1979 version of the regulation.

Why the modifications of the original -40 value? I really don't know. The problem is that there is very little written history of 70-38. Those that were involved in the 1950s through 1960s are retired or dead. Hopefully this will explain the rationale behind the lower storage temp. Afraid I can't tell you why they finally settled on that particular value.”

My opinion (related to the original question) is that there is confusion between “frequency of occurrence” and “probability of occurrence.” In fact, the -61°C stated earlier is the “Probability of Occurrence” and not the “Frequency of Occurrence” for the “Severe Cold” climatic design type. The “frequency of occurrence” information relates to the data that were used to establish the climatic categories (see MIL-HDBK-310) in that geographical areas with values that occur one percent of the hours in the most severe month (approximately 7.4 hours), were enveloped (disregarding anomalies) to define the regions of specific climatic types. This information has little to do with the “probability of occurrence” information that is more related to climatic extremes outside the normal test considerations.

- One more justification for this “Evolution” publication.

## MIL-STD-810G

In MIL-STD-810G, as in Method 501, we inserted “Because of potential temperature, humidity, and low pressure, synergistic effects, a pointer has been inserted to suggest