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Treatise Helps Users Interpret and Apply MIL-STD-810—A Test Method Standard

Touted for its visionary treatment of environmental tailoring in test procedures, MIL-STD-810F, *Test Method Standard for Environmental Engineering Considerations and Laboratory Tests*, is undergoing revision for the next issue. How did this standard evolve from a 66-page booklet with a single sentence on using realistic test limits to a 540-page document containing an entire section on tailoring? Insights can be found in *The History and Rationale of MIL-STD-810*, available exclusively from the Institute of Environmental Sciences and Technology (IEST).

Publication of *The History and Rationale of MIL-STD-810*, by Herbert W. Egbert, is particularly timely as a Tri-Service Working Group undertakes the development of the next edition of the standard, *MIL-STD-810G*. The 140-page *History* captures the thought process behind the evolution of each test method and explains the significance of each revision. Members of the design, test, and evaluation and product reliability technical communities will find guidance for interpreting MIL-STD-810 and for tailoring tests to simulate the effects of the environmental conditions the materiel is expected to encounter.

Egbert brings 35 years of environmental testing experience to his analysis, including his work on MIL-STD-810D and 810E, and his role as Tri-Service administrator for the development of 810F. He supplements his own considerable expertise with contributions from other leaders involved in developing the standard.

"When we were working on 810F, I began thinking that nobody had ever captured in one place the reasoning behind the changes over the years," Egbert told the *Journal of the IEST*. "As we progressed, someone would ask why we did this or that. I would do the research to find out the background and logic behind it. If it wasn't documented, I used my intuition and made educated guesses." Egbert then decided to compile a formal history and used as groundwork a 1965 report titled "The Evolution of USAF Environmental Testing," by Virgil Junker, a project engineer with Wright-Patterson Air Force Base, Dayton, Ohio. The report presented background information on natural and induced environmental tests for US Air Force (USAF) aerospace and ground equipment.

Advances in Environmental Tailoring

"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," writes Egbert in the *History*. "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."

The first edition of MIL-STD-810 in 1962 included a single sentence allowing users to modify tests to reflect environmental conditions. "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," writes Egbert. As a result, few took advantage of this option.

Subsequent editions of the standard contained essentially the same phrase, but did not elaborate on the subject until 810D was issued in 1983, marking one of the more significant revisions of the standard, according to Egbert. Table 1 highlights the approach each edition takes to the environmental tailoring issue.

Table 1. The evolution of MIL-STD-810 as it relates to environmental tailoring.

MIL-STD-810 Version	Date	Extent of Focus on Environmental Considerations
810 (USAF)	6/14/62	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)	6/23/64	Same as 810.
810B (First Tri-Service Edition)	6/15/67	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	3/10/75	Same as 810B.
810D	7/19/83	A section on tailoring explains how to consider environmental issues throughout the materiel development process. Includes diagrams on the environmental tailoring process and on environmental life cycle histories of various classes of military hardware.
810E	7/14/89	Same as 810D with addition of a flow diagram, "How to Use MIL-STD-810E," that shows how Data Item Descriptions relate to each other in the acquisition process and who is responsible for preparing them.
810F	1/1/00	New 54-page "Part One" explains how to implement the environmental tailoring process throughout the materiel acquisition cycle, focusing separately on the roles of the different users. Includes Environmental Engineering Program Guide. The guidance goes beyond laboratory testing to encompass natural environment field/fleet testing. Alternatives to testing hardware prototypes (e.g., modeling and simulation) are recognized as standard environmental engineering test practices.

Note: Adapted from a table prepared by Roger L. Williamson, TRI-S Inc., for *The History and Rationale of MIL-STD-810.*

Egbert quotes Roger L. Williamson, senior scientist, TRI-S Inc., Aberdeen, Maryland: "[In 1978] 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." The working group developing MIL-STD-810D took this as a mandate and produced "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 over-designing, no under-designing, no overtesting, no undertesting, no arbitrary levels of temperature or other parameters."

The most current edition, MIL-STD-810F, is divided into two parts. Williamson describes the 54-page Part One of the standard as a "full-fledged, top-level document that provides environmental engineering guidance and tasks for acquisition managers, EES [environmental engineering specialists], and design/test engineers." In a technical article in the Summer 2001 edition of the *Journal of the IEST*, quoted in the *History*, Henry J. (Hank) Caruso wrote, "…no other test standard treats test tailoring and implementation as a systems' engineering process. This engineering process is the foundation of MIL-STD-810F."

Tailoring Reflected in Humidity Testing

Egbert's exposition on Method 507 for humidity testing illustrates the attention MIL-STD-810 gives to environmental tailoring and the complexity of developing an effective test procedure. The evolution of Method 507 parallels the standard's growing emphasis on tailoring over the years (see Table 2).

Table 2. Evolution of requirements for Method 507 – humidity.

MIL-STD-810	MIL-STD-810B	MIL-STD-810C	MIL-STD-810D	MIL-STD-810F
2-hr temperature increase, 6-hr soak, and 16-hr temperature drop, repeated 10 times (10 days); used unrealistic factors of 71 °C and 95% relative humidity	Five procedures intended to meet requirements of the three military services; four of the cycles included unrealistic requirements	Same as 810B except the temperature for Procedure I was changed from 71 °C to 65 °C, a compromise among the three military services	Supplemented "aggravated" (extreme) cycles with five natural cycles; the test durations were found inadequate for simulating natural exposure	Includes only the aggravated cycle; calls for caution in conducting tests and interpreting results in cases where natural or induced cycles are mandated

Early work on developing lab tests for humidity used the assumption that if the results matched field results, the lab test represents field conditions. Egbert quotes Jack Gott of the Naval Ordnance Laboratory, White Oak, Maryland: "…so many of these tests really don't try to simulate the environment—they try to simulate the effects." At the time the first edition of 810 was being developed, the US Army, US Navy, and USAF had been using different humidity test cycles, all of which imposed severe testing parameters such as 71 °C (160 °F) and 95% humidity and exposure durations as long as 30 days. Edition 810C lowered the temperature to 65 °C (149 °F) for one test procedure, which was, according to the *History*, "a move in the right direction, but not enough … more and more complaints arose citing these tests as cost drivers, i.e., design to pass the test rather than design to survive the real environment."

The emphasis on tailoring incorporated into 810D was applied to the revision of Method 507. According to the *History*:

> … several of us decided that four different unrealistic extreme cycles were inappropriate, i.e., why should USAF equipment be tested differently from Army equipment that is in the same environment? The problem with the natural cycles was how long to test? In the tropics, for example, the rainy season (during which there are high RH and temperature combinations) exists six months a year. If we were to try and perform a chamber test to represent a year in the tropics, we would have to test for six months! We believed this would be unacceptable, so we arbitrarily reduced the test durations to levels we thought would be acceptable, but that would still ensure (we thought) some reasonable exposure. In order to prevent extended test durations when the test item had already failed, we added "quick look" durations. Unfortunately, some users tended to use them and not the recommended durations.

There were other shortfalls. A test chamber can reproduce temperature and humidity conditions, but not environmental aspects such as microbial growth, insect and animal contamination, and atmospheric elements. The intention was to sufficiently stress test items to provide an indication of potential problems, but it was found that a laboratory simulation that correlates to exposure for a specified duration in the natural environment for one item might not hold true for another item.

Further, the specified test durations proved to be shorter than required to simulate natural exposure; humidity tests performed using the published natural cycles did not sufficiently stress materiel; and the origin of the parameters used in induced cycles came into question. Consequently, the natural and induced cycles were removed from 810F, and only the aggravated cycle was retained. A proviso was added that if natural or induced cycles are used, caution should be exercised in applying such cycles and in interpreting test results.

An Account of Evolving Technology

The *History* provides a record not only of the progression of MIL-STD-810, but also of advances in technology affecting the practices governed by the standard. This is particularly evident in Egbert's discussion of Method 514 for vibration testing. He quotes Jim Bair, retired from Wright-Patterson Air Force Base:

> The changes in the vibration technology of Method 514 as it evolved from MIL-STD-810 (1962) to MIL-STD-810F (2000) are immense. MIL-STD-810 was written before the digital revolution that in turn, resulted in a revolution in data acquisition, data analysis, and vibration test control. The hardware being tested was also becoming more complex and sophisticated … Equipment … has changed from vacuum tubes and relatively simple mechanical devices, to a mix of microelectronics, electro-optics, electro-chemical, and highly sophisticated mechanical elements. …
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> The change from sinusoidal to random vibration testing … has been difficult. Much of the hardware used by the military today originated before this change, and the contracts are governed by original requirements. Many of the items developed since were developed to specifications that were written by copying outdated specifications and standards. The new technology required updated laboratory equipment and training. At any rate, this revolution is still proceeding.

"Vibration has always been a difficult area," Egbert told the *Journal of the IEST*. "Formatting the methods to make it user friendly is one of the biggest challenges." The *History* thoroughly documents how each edition of MIL-STD-810 coped with advances in hardware and testing methods. In 810E the test method was reformatted for clarity, continuity, and internal consistency, but advancing technology remains an issue. For example, criteria regarding jet aircraft and helicopters are based on metal structures of conventional shape, but composite structures and unconventional shapes are becoming common. "These changes can dramatically affect the response of the airframe to dynamic excitation," Egbert states in the *History*. "The work to quantify these changes has not been done. This want list is suggested as a starting point for the editor of Method 514.6 [in 810G]."

The History and Rationale of MIL-STD-810 provides extensive background on each of the 23 test methods covered in the standard. Annexes include a summary of Change Notices 2 and 3 to 810F, an outline of anticipated future changes and corrections, and a table of weather and climatic extremes. Published in February 2005 and available exclusively from IEST, the document may be purchased for $60 ($50 for members) online at www.iest.org or by calling 847-255-1561.

Recording history is an ongoing process. Anyone who wishes to contribute additional historical information or insights concerning the development of MIL-STD-810 is invited to submit that information to IEST by e-mailing iest@iest.org.

MIL-STD-810 is developed and maintained by a Tri-Service partnership that includes the USAF, the US Army, and the US Navy. The USAF, Wright-Patterson Air Force Base, is Preparing Activity and USAF Custodian for MIL-STD-810 (Engineering.Standards@wpafb.af.mil), under the direction of Faustino Zapata (Faustino.Zapata@wpafb.af.mil). The Army and Navy provide custodianship support. The Army's Developmental Test Command (DTC) serves as Lead Standardization Activity. The Army Custodian is Ken Thompson of DTC at Aberdeen Proving Ground, Maryland (ken.thompson2@us.army.mil). The Navy Custodian is Carl Levandusky of the Naval Air Systems Command, Lakehurst, New Jersey (carl.levandusky@navy.mil). *MIL-STD-810F* and its three Change Notices can be obtained at http://assist.daps.dla.mil/quicksearch. Draft test methods containing the original 810F versions as well as the modifications included in the three Change Notices and minor improvements will soon be available for Working Group members on the IEST web board. A call for input and recommended changes can be found at http://www.dtc.army.mil/publications/milstd.html.

For this article the Journal of the IEST *spoke with Herb Egbert, author of* The History and Rationale of MIL-STD-810*. Egbert is a senior general engineer with TRI-S Inc., Aberdeen, Maryland, a private company working in support of the Army Developmental Test Command's (DTC) environmental testing efforts. He began his environmental testing career in 1970 with the US Army Electronic Proving Ground, Fort Huachuca, Arizona, and later joined its headquarters— the US Army Test and Evaluation Command (now the Army Developmental Test Command), Aberdeen Proving Ground, Maryland. Egbert contributed to the development of MIL-STD-810D and 810E, and served as Tri-Service administrator for 810F. Upon retiring from government service in 2002, he worked at Science Applications International Corporation (SAIC) as a senior analyst before joining TRI-S Inc. Egbert, who has a BS in biology from Towson State University (now Towson University), is a Fellow of IEST.*