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HOW TO USE MIL-STD-210C TO DETERMINE CLIMATIC DESIGN REQUIREMENTS

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Mr. Tattelman is a research meteorologist with the Atmospheric Sciences Division of the Air Force Geophysics Laboratory, Hanscom AFB, MA. He has been employed there since 1967, except from 1969 to 1971 when he served as a Weather Officer in the Navy. He received the B.S. degree in meteorology from the Pennsylvania State University in 1967 and has done postgraduate work at several universities. He is currently responsible for planning, conducting, and managing applied research programs to determine probability distributions of atmospheric conditions. Results are primarily used for the design, testing, and operation of systems affected by weather. He was chairman of the tri-service (Army, Navy, and Air Force) committee that developed MIL-STD-210C, "Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment." He has published numerous studies in applied climatology, and has provided consultation to many Federal agencies and their contractors.

Abstract

MIL-STD-210C, "Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment" has been completed. Some noteworthy changes for this revision include the addition of regional climatic information, upper air profiles based on temperature and density extremes, and background information supporting and supplementing the data. Other presentations have been updated, and they have been reformatted to facilitate using the standard. Perhaps the most noteworthy change is the new methodology for applying the data, which reflects current DoD acquisition policy on tailoring in the design and testing of materiel. This paper addresses the ramifications of these changes, and presents guidance on how the standard should be used to establish design and test requirements. *Keywords: Military standards, climatic data. (Reprints)*

1. Background

MIL-STD-210C includes climatic data on world-wide extremes, regional presentations, and values aloft up to 80 km. This information is intended to serve as natural environment starting points for the sequence of engineering analyses to derive design criteria for materiel. It is also a source of data for deriving climatic test values for MIL-STD-810. Since each system, or item of equipment should be designed to function in and survive only those environments that it will be exposed to its intended life cycle must be carefully considered before the standard is used. This is in keeping with current DoD policy on tailoring design requirements for each system.

Climatic data in the standard are generally presented in the form of frequencies-of-occurrence. For both worldwide and regional applications, the frequency of occurrence of climatic elements (e.g. temperature) is based on hourly data wherever possible. From hourly data it is possible to determine the total number of hours a specific value of a climatic element is equalled or

exceeded. For example, if a temperature occurs or is exceeded for an average of 7 hours in a 31-day month (744 hours), it has occurred roughly 1 percent of the hours in that month. If it occurs, or is exceeded, an average of 74 hours in the month, then it has a frequency-of-occurrence of 10 percent, etc. The value that is equalled or exceeded 1 percent of the time is referred to as the 1-percent value. The climatic values specified in the standard are for the worst month but they may occur less frequently in other months.

Data on long-term climatic extremes are also provided for most climatic elements. These are values that are expected to occur at least once, for a short duration (< 3 hours), during approximately 10, 30, and 60 years of exposure. Therefore, they are rarer climatic events than the percentile values that represent average conditions in the worst month. The most extreme value ever recorded is also provided for each element.

Climatic information for each element (or combination of elements) represents conditions in the most severe non-anomalous area in the world (or region) for that element (or combination).

The data that are applicable to a particular system depend upon the following:

- (a) The areas of the world to which it will be exposed
- (b) The operational requirements under which it must function
- (c) Safety considerations

It is then necessary to determine how the natural environment is modified by the platform on or within which the system or item must function.

The considerations above are only the first steps toward determining the appropriate design and test values. Each item being developed has its own inherent weaknesses to one or more of the climatic conditions to which it will be exposed. For some items the Achilles heel is temperature, for others it is humidity, or rain rate ... or all of the above. The bottom line is that trade-offs often need to be made by weighing performance goals, operational requirements, and safety consequences against economic and state-of-the-art limitations.

2. Initial Considerations

The first iteration in determining climatic design and test requirements is a process of defining where and when the item will have to function. At this stage the impact of the environment on the item need not enter the equation.

a. Areas of Exposure

The areas of the world that an item could encounter during its life cycle must be determined. This includes:

- (a) Geographical locations through which it may be transported

- (b) Where it may be stored
- (c) Where it may be deployed
- (d) How it will be transported
- (e) Circumstances when it will be protected from the environment.

Once the areas that an item might encounter are known, the applicable environments from 210C can be determined. If it can be stated with a high degree of certainty that an item would be limited to one or more (but not all) of the regional climates, then design to these environments are appropriate. Otherwise the worldwide environment should be designed for.

b. Operational Requirements

It would often be costly or technologically impossible to design materiel to operate under the most extreme conceivable environmental conditions. Therefore, military planners accept equipment designed to operate under environmental stresses for all but a certain small percentage of the time. The agency or department responsible for the development of materiel is responsible for determining the operational requirements of the item or system. These requirements should then be used to determine the acceptable frequency of occurrence of a climatic element. Frequencies-of-occurrence that are recommended for initial consideration are discussed in the standard. These recommended frequencies were taken from inputs to MIL-STD-210B by the Joint Chiefs of Staff, memorandum for the Secretary of Defense, JCSM-502-69, 12 August 1969.

c. Safety Characteristics

For some materiel, one-time exposure to a climatic extreme can render it permanently inoperable or dangerous. For example, suppose ordnance is stored in an unheated shelter for a period of time during which it is exposed to a temperature that damages one of its critical components. As a result, when the ordnance is subsequently used there is the potential for it to explode prematurely or not function at all. The first outcome is definitely a safety hazard, while the second outcome may be one (i.e. the enemy attacking and your weapons not firing could be construed as a safety hazard).

For such materiel, long-term climatic extremes, or the record extreme, would be more appropriate for design of equipment that is not protected from the environment. (It should be noted that highest/lowest recorded extremes depend upon the period-of-record and should not be construed as "all time" extremes). The use of these more extreme values, instead of those occurring for a percent of the time during the most severe month each year, shall be determined by the agency or department responsible for development.

3. Platform Characteristics

The climatic values arrived at after the initial considerations in section 2 represent free air (ambient) conditions. The conditions that an item will see depend on how the natural environment is modified by the platform on or within which the item is expected to function. Design requirements and test procedures can be established only after the platform characteristics are identified and the

platform environment is defined. The platform itself can take many forms. For a rifle, the platform is a soldier; for an engine, it is a plane or truck or other vehicle, etc.

Defining the platform environment is probably the most difficult step toward establishing design and test requirements. A great amount of thought is necessary to determine all the pertinent forcing functions acting on the item being developed. Then, calculations or estimates on the impact of these forcing functions have to be made. The following are some common questions that should be addressed:

- (a) Will the platform reduce the severity of the ambient conditions or add to it?
- (b) How long must ambient conditions persist before the item is affected?
- (c) Will the item need to function only at specific times of the day or year when climatic conditions are less severe?

The platform environment is not necessarily constant. That is, an item may be shipped or stored prior to its installation. Potential climatic conditions during this part of an item's life cycle need to be specified for each climatic element. For example, an item being shipped which is airborne but external to pressurized compartments may be exposed to low pressure values at altitude, but not the low ambient temperatures due to the modified environment within the aircraft.

4. Trade-Offs

Once the platform environment(s) is(are) defined, problems in designing for any of the climatic conditions will surface if they have not already done so. If design to one or more of the initially derived ambient climatic conditions proves unacceptable due to technical or cost considerations, alternatives need to be considered. Although the procuring agency establishes the requirements, the ramifications as to cost or achievability can only be evaluated after these have been factored into the design by the contractor. The procuring agency should be made aware of the problems and potential solutions. The use of alternatives, such as less extreme values associated with higher frequencies of occurrence (and reduced operational capability), must be weighed by the procuring agency.

MIL-STD-210C contains data for many climatic elements. For most elements, less severe values that occur with greater frequency than those recommended for initial consideration are provided. These are intended for use in making trade-offs. Background information and supplementary data provided in 210C can be used to assess the ramifications of backing-off to less severe conditions. This information is in the form of discussion as to where and when extreme climatic conditions occur, their areal extent, diurnal variations, durations, etc. References to sources from which the data were taken or where more information can be found is also provided.

5. Concluding Comments

The steps I've outlined for using MIL-STD-210C to determine climatic design requirements are essentially a common sense approach. Unfortunately,

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this type of approach hasn't worked too well in the past. A study by the Defense Science Board stated that problems using DoD standards arose more from a tendency to overdo both application and enforcement, rather than from the actual content of the documents. Government authorities were motivated to protect government interests, and contractors were motivated to comply rather than risk non-conformance. The net result has been a failure to use the flexibility written into DoD standards.

I recall a telephone conversation that I had with an engineer at a small company in San Diego. The company was a subcontractor developing a device that was to be installed on an aircraft. The engineer called me to question the validity of the ambient temperature at cruising altitude specified in MIL-STD-210B. It seems that there was considerable difficulty designing to this temperature. A check indicated that the temperature was valid, but I decided to question the engineer about the device. Was it protected in any way from the free air? Yes, it was covered by a dome. Would aerodynamic heating raise the temperature within the dome? Yes. Would heat conducted through the aircraft skin raise the temperature within the dome? Yes again. I asked why he was designing to the ambient temperature and not the induced environment. He said that he didn't think you could do that. In fact he was so surprised by my suggestions that he had me repeat them on a conference line that included company executives. It was the fear of non-compliance that motivated the company's decisions.

It is inevitable that questions will arise regarding the interpretation and applicability of some, or all, of the information provided in 210C. Therefore, consultation with environmental scientists is strongly encouraged. Consultation addressees for each service are provided in the standard.

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