Army Regulation 70–38

Research, Development, and Acquisition

# Research, Development, Test and Evaluation of Materiel for Worldwide Use

Headquarters
Department of the Army
Washington, DC
26 June 2020

UNCLASSIFIED

# *SUMMARY of CHANGE*

AR 70–38
Research, Development, Test and Evaluation of Materiel for Worldwide Use

This major revision, dated 26 June 2020—

- o Changes the title of the regulation from Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions to Research, Development, Test and Evaluation of Materiel for Worldwide Use (cover).

- o Reflects changes in policy, guidance, and climatic criteria to address atmospheric, terrestrial, and biological consideration for the design and performance of materiel for worldwide operation (paras 1–5 and 3–1).

- o Updates responsibilities (chap 2).

- o Recognizes change in responsibility for Deputy Chief of Staff, G–8, as Headquarters, Department of the Army staff lead for management of the Army Requirements Oversight Counsel on matters involving the Joint Capabilities Integration and Development System (para 2–6).

- o Adds a geographic classification framework for ecoregions to address atmospheric, terrestrial, and biological consideration for the design and performance of materiel worldwide in addition to climate extremes (paras 3–1 through 3–9).

- o Establishes use of global operational environment framework and operational environment analogs defined by climate and terrain factors providing direct comparisons of areas of the world from the aspect of performance of Army materiel wherever based or potentially deployed (paras 4–1 through 4–3).

- o Adds an internal control evaluation (app B).

**Headquarters**
**Department of the Army**
**Washington, DC**
**26 June 2020**

# *Army Regulation 70–38

**Effective 26 July 2020**

## Research, Development, and Acquisition

# Research, Development, Test and Evaluation of Materiel for Worldwide Use

By Order of the Secretary of the Army:

JAMES C. MCCONVILLE
*General, United States Army*
*Chief of Staff*

Official:

KATHLEEN S. MILLER
*Administrative Assistant*
*to the Secretary of the Army*

**History.** This publication is a major revision.

**Summary.** This regulation prescribes policies, responsibilities, and planning guidance for inclusion of the global operational environment climatic and natural environment factors in the research, development, test and evaluation of materiel used in combat by the Army.

**Applicability.** This regulation applies to the Regular Army, the Army National Guard/Army National Guard of the United States, and the U.S. Army Reserve, unless otherwise stated. It also applies to items of materiel developed for use by the Army unless otherwise stated. It applies to items of materiel developed by another Service to meet Army requirements and where the Army approves the capability requirements documents; has budget responsibility; and is the user.

**Proponent and exception authority.** The proponent of this regulation is the Chief of Engineers. The proponent has the authority to approve exceptions or waivers to this regulation that are consistent with controlling law and regulations. The proponent may delegate this approval authority, in writing, to a division chief within the proponent agency or its direct reporting unit or field operating agency, in the grade of colonel or the civilian equivalent. Activities may request waivers to this regulation by providing justification that includes a full analysis of the expected benefits and must include formal review by the activity's senior legal officer. All waiver requests will be endorsed by the commander or senior leader of the requesting activity and forwarded through their higher headquarter to the policy proponent. Refer to AR 25–30 for specific guidance.

**Army internal control process.** This regulation contains internal control provisions in accordance with AR 11–2 and identifies key internal controls that must be evaluated (see appendix B).

**Supplementation.** Supplementation of this regulation and establishment of command or local forms are prohibited without prior approval from the Chief of Engineers, 441 G Street NW, Washington, DC 20314–1000.

**Suggested improvements.** Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Headquarters, Department of the Army, Chief of Engineers, 441 G Street NW, Washington, DC 20314–1000.

**Distribution.** This regulation is available in electronic media only and is intended for the Regular Army, Army National Guard/Army National Guard of the United States, and the U.S. Army Reserve.

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*This regulation supersedes AR 70-38, dated 15 September 1979.



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### Glossary

## Chapter 1
## Policies and Procedures

### 1–1. Purpose
This regulation establishes policy, identifies responsibilities, and provides climate and terrain factors to ensure mission capable and reliable Army materiel for worldwide operation. In addition to design guidance, this regulation describes a global operational environment (GOE) framework and operational environment (OE) analogs defined by climate and terrain factors to provide direct comparisons of areas of the world from the aspect of performance of Army materiel wherever based or potentially deployed. Application of this regulation ensures that the research, development, test and evaluation (RDTE) decision-making process considers the natural environmental factors that affect equipment performance when preparing capability requirements documents, operation mode summary/mission profile (OMS/MP), and design criteria for acquisition specifications. Early consideration of design criteria and the OE reduces program risk and lowers life-cycle costs by addressing environmental challenges and potential reliability shortfalls early in the RDTE process when corrective actions have minimum overall impact. Army equipment tends to remain in the active inventory for extended periods and is likely to be exposed to severe environmental conditions during its lifetime. Consequently, durability, operational costs, and performance over a full range of environmental factors must be considered during RDTE process.

### 1–2. References and forms
See appendix A.

### 1–3. Explanation of abbreviations and terms
See glossary.

### 1–4. Responsibilities
Responsibilities are listed in chapter 2.

### 1–5. Records management (recordkeeping) requirements
The records management requirement for all record numbers, associated forms, and reports required by this regulation are addressed in the Records Retention Schedule—Army (RRS–A). Detailed information for all related record numbers, forms, and reports are located in Army Records Information Management System (ARIMS)/RRS–A at https://www.arims.army.mil. If any record numbers, forms, and reports are not current, addressed, and/or published correctly in ARIMS/RRS–A, see DA Pam 25–403 for guidance.

### 1–6. Policy
*a.* This regulation applies to RDTE of all equipment and materiel used for all warfighting functions throughout the full spectrum of military operations, including systems of systems and other materiel approved by Headquarters, Department of the Army (HQDA), unless specifically excluded by the applicable sections of AR 70–1. The regulation applies to the following classes of materiel as adapted from the U.S. Army Test and Evaluation Command (ATEC)—

(1) Soldier equipment.

(2) Wheeled, tracked, and special purpose vehicles.

(3) Armament—direct fire weapons.

(4) Armament—indirect fire weapons.

(5) Armament—small arms and automatic weapons.

(6) Ammunition and explosives.

(7) Missile and rocket systems.

(8) Electronic, avionics, and communications equipment (command, control, communication, computers, intelligence, surveillance, and reconnaissance).

(9) Aviation, air delivery equipment, and aircraft weapons systems.

(10) Chemical, biological, radiological, and nuclear defense equipment.

(11) Construction, support, and service equipment.

(12) General supplies and equipment.

*b.* Army equipment and materiel will deploy to and operate in all parts of the world with the exception of Antarctica, which is demilitarized under The Antarctic Treaty of 1959. Therefore, worldwide use is the requirement for military equipment unless otherwise stated in capability requirements documents or as specified in an Urgent Capability Acquisition.

Capability requirements documents and the OMS/MP will identify operating, transport, and storage quantitative testable metrics defining qualitative operational conditions. The RDTE of materiel should use these conditions throughout the entire acquisition process.

*c.* Materiel should function in all environments without modification. Cost, time constraints, and the state of technology may prevent this. However, as a minimum, equipment must be fully mission capable over a stated range of temperatures or other environmental factors without kits or special adaptations as dictated in capability requirements documents. Capability developers will refer to climatic design types as defined in chapter 3 and global operational factors defined in chapters 4 and 5 for climate and environmental guidance within capability requirement documents. Kits or protective devices may be allowable for operating beyond the stated acceptable temperature range to some maximum or minimum value called out in the requirement documents.

*d.* All design and test requirements should be structured for each materiel acquisition program based on the OEs of potential deployment, the worst-case anticipated environmental conditions, the applicable OMS/MP, and consideration of the long-term cost of fielding (total life cycle system management). These requirements are necessary to develop the capability requirements documents and performance specifications for operations, storage, and transit and test plans. Refer to DoDI 6055.01 for safety and occupational health (SOH) considerations.

*e.* A decision not to include end-item/system-level testing in a natural environment analogous to anticipated OE deployment entails eventual risk to the Soldiers deployed at the extreme conditions. The appropriate authority must approve the decision to eliminate real-world testing for the effects of critical environmental factors at the end-item or platform level.

*f.* Prior to testing in natural environments, materiel developers plan for simulated environmental testing in climatic chambers unless impractical. Developers use the results of climatic chamber tests to determine if a system will not satisfy its performance requirements. Chamber tests may also be valuable in assessing the risk associated with not conducting tests in the natural environment. Causes for failures in simulated environments must be resolved before natural environment testing. Chamber tests and simulations play a significant role in the beginning of the development cycle but must be integrated with testing conducted in real-world, natural environments. Test results from climatic chambers cannot be interpreted as a total substitute for tests conducted in the natural environment because they do not provide the synergisms associated with the natural environment.

*g.* Potentially dangerous items (for example, ammunition) will be designed to operate safely in all OEs worldwide plus meet ammunition specific requirements and applicable standardization agreements regardless of the likelihood that the munition will be used in any specific environment. It is critical that design temperatures for munitions use the maximum ambient air temperatures as a starting point with additive factors for solar loading, heat gains from the launch platform environment, and other additive heat inputs. Testing to confirm ammunition safety and performance must use temperatures based on these additional heat factors. Testing may be conducted above these thresholds when the verification method is to use accelerated life testing. However, exercise caution because over-temperature stressing may induce unrepresentative failure modes or may not adequately exercise potential failure modes. Consider the munition and any design limitations. Refer to MIL–STD–331. All safety risks will be managed following MIL–STD–882, as referenced in AR 70–1.

*h.* Developers must design Army materiel for personnel clothed and equipped for the intended environment (for example extreme cold weather).

### 1–7. Application of environmental conditions

*a.* The conditions of the environment described, quantified, and mapped in this regulation are intended for the following uses:

(1) Inputs in the development of U.S. Army capability requirements documents and throughout the materiel acquisition process (see AR 70–1 and AR 71–9), including RDTE of materiel developed by and for the Army.

(2) Materiel developed by another Service to meet Army's requirements where the Army:

*(a)* Approves the capability requirements document.

*(b)* Has budget responsibility.

*(c)* Is the user.

(3) Quantitative guidance for developing appropriate design and test requirements, based on realistic natural environment conditions.

*(a)* Non-developmental items and commercial off the shelf items purchased by the Army.

*(b)* Foreign items purchased for use in combat or by deployed U.S. Army forces.

*b.* Equipment currently within the acquisition cycle and that has completed environmental testing before the date of publication for this this document will be exempt from requirements herein.

### 1–8. Limitations

*a.* The policies and procedures of this regulation do not apply to the following:

(1) Materiel developed for the sole use of another Service. In this case, the policies and procedures of the using Service will apply.

(2) Materiel developed for the sole use of a foreign government unless the acquisition plan specifies differently.

(3) Materiel specifically excluded in AR 70–1, except that officials responsible for such materiel may use the guidance provided in this document where considered appropriate.

*b.* Some environmental factors that occur naturally can also be induced by human activity. For example, the dust environment can be a combination of dust caused by atmospheric forcing (for example, dust storms) plus that caused by anthropogenic forcing (for example, brown outs from helicopter down draft). As another example, equipment and munitions stored in shelters in a dry or desert environment with extended solar radiation may be exposed to temperatures that are much higher than ambient. This document does not address induced environmental factors such as electromagnetic radiation and nuclear radiation or induced environmental factors that are mechanical in nature (vibration, shock, and acceleration), airborne pollutants, and acoustics (reference MIL–STD–810 for induced environmental factors).

## Chapter 2
## Responsibilities

### 2–1. Deputy Under Secretary of the Army

The DUSA will coordinate all test and evaluation (T&E) policy with the Office of the Secretary of Defense, Joint Chiefs of Staff, other HQDA offices, U.S. Navy, U.S. Air Force, U.S. Army Materiel Command (AMC), Training and Doctrine Command (TRADOC), Space and Missile Defense Command, Intelligence and Security Command, ATEC, Communication and Electronics Command, and U.S. Army Nuclear and Chemical Agency.

### 2–2. Assistant Secretary of the Army (Acquisition, Logistics and Technology)

The ASA (ALT) will—

*a.* Establish policy for RDTE in environments where the Army is expected to conduct its mission worldwide.

*b.* Ensure that RDTE represents worldwide environmental conditions to reduce the risk of operational failure.

*c.* As the Army Acquisitions Executive, along with program executive officers, and program managers will—

(1) Administer, plan, and manage acquisition programs in accordance with Department of Defense (DoD) policies and appropriate regulations, policies, procedures, and standards per AR 70–1.

(2) Serve as the materiel developers.

(3) Design, plan, program, coordinate, and execute a viable RDTE program in conjunction with the RDTE working-level integrated product team. This will include coordination of the T&E strategy for their respective systems with ATEC and the research and development strategy with their respective laboratory, as appropriate.

(4) Ensure that all configuration changes of materiel consider environmental performance.

(5) Ensure that performance specifications and other capability requirements documents apply environmental conditions prescribed herein.

(6) Ensure that subsystem requirements take precedence when operation, transit, and storage environments for subsystems and components of systems are more severe than ambient.

### 2–3. Assistant Secretary of the Army (Installations, Energy and Environment)

The ASA (IE&E) will—

*a.* Support the office of the ASA (ALT) in defining, classifying, and delineating the types of environments worldwide where the Army is expected to operate.

*b.* As Designated Agency Safety and Health Official responsible for SOH in the Army as a measure to prevent loss and enable the mission, support the ASA (ALT) with risk management and SOH subject matter expertise in Army acquisition life-cycle processes.

### 2–4. Deputy Chief of Staff, G–3/5/7

The DCS, G–3/5/7 establishes overall capabilities priorities in accordance with high-priority scenarios, war plans, major force elements and operations.

### 2–5. Deputy Chief of Staff, G–4

The DCS, G–4 will—

*a.* Ensure that all configuration changes of materiel coordinated with or approved by the DCS, G–4 consider environmental performance requirements.

*b.* Incorporate environmental performance requirements into supportability assessments as appropriate.

## 2–6. Deputy Chief of Staff, G–8

The DCS, G–8 will—

*a.* Establish requirements for the development of materiel capable of operating successfully and surviving in realistic environments that meet capabilities priorities established by the DCS, G–3/5/7.

*b.* Ensure that all capability requirements documents for which the Army Requirements Oversight Council is the approval authority addresses all environmental performance requirements.

## 2–7. Commanding General, U.S. Army Training and Doctrine Command

The CG, TRADOC will—

*a.* Ensure that capability requirements documents state the environmental requirements.

*b.* Establish criteria for acceptable levels of performance in battlefield environments for all areas of intended use.

*c.* Include the following in capability requirements documents and the OMS/MP:

(1) A statement of the geographic areas and associated environmental conditions in which materiel will be operated, stored, or transported.

(2) A description of the shelters or other protective devices, if any, in which the materiel will be operated, transported, or stored.

(3) A quantitative summary of expected usage levels and environments over the life of an item (for example, provide percentages of active, training, and peace time along with operational tempo for each; expected percentages in each OE; or expected storage and uploaded durations for ammunition and missiles).

*d.* Coordinate all capability requirements documents with the U.S. Army Corps of Engineers (USACE) during worldwide staffing to determine whether all environmental factors or conditions have received adequate consideration.

## 2–8. Commanding General, U.S. Army Materiel Command

The CG, AMC will—

*a.* Incorporate approved requirements, critical issues, environmental design criteria, and adequate test and evaluation programs into the RDTE of materiel to ensure operational storage and transit capabilities and acceptable reliability for all areas of anticipated deployment.

*b.* Ensure that the appropriate chamber/laboratory tests are conducted early in the development cycle to screen materiel, components, or entire systems for possible environmentally caused performance or durability problems related to materiel selection and system design.

*c.* Test selected performance criteria under representative environmental conditions established for the system in capability requirements documents.

*d.* Ensure that systems are subjected to environmental and mechanical stress levels that are appropriate for the maturity of the system and that provide reasonable estimates of the outer limits of the operational performance envelope. This would include initial reliability testing in representative environments prior to milestone C of the integrated life cycle to demonstrate that the system is on target to meet reliability thresholds.

*e.* Ensure that environmental tests are conducted prior to milestone C of the integrated life cycle to ensure that system performance, reliability, maintainability, durability, and integrated product support and human systems integration aspects are acceptable throughout all intended use environments.

## 2–9. Commanding General, U.S. Army Test and Evaluation Command

The CG, ATEC will—

*a.* Implement the guidance of this document throughout the materiel test and evaluation process.

*b.* Include requirements to determine the effects of worldwide environmental conditions on end-item or platform/system performance for all assigned material acquisition programs. The overall evaluations will include analysis of system and operator performance in all environments of potential use.

*c.* Consider the effects of worldwide environmental conditions in the planning, conduct, and reporting of operational tests wherever possible. It will emphasize determining the effects of environmental factors on Soldier performance when using the item under test or system under test during exposure to worldwide conditions.

*d.* Through its subordinate proving grounds and test centers, include the effects of worldwide environmental conditions in test planning, execution, analysis of equipment failures, and reporting. ATEC maintains test centers in the four GOEs and has safari test capabilities for full spectrum environmental testing.

### 2–10. Commanding General, U.S. Army Corps of Engineers

Through the Director, U.S. Army Engineer Research and Development Center, the CG, USACE will—

*a.* Conduct research and development in geospatial research and engineering, military engineering, environmental quality, and installations.

*b.* Conduct special environmental studies and prepare reports as a guide for RDTE of materiel specified in capability developer documents.

*c.* Provide consulting services for interpreting environmental conditions for the RDTE of materiel.

## Chapter 3
## Climatic Criteria

### Section I

### General

### 3–1. Climatic design types

One of the vital challenges of the tailoring process is to design materiel to operate in climates of the world in which the materiel is expected to be deployed. Four climatic categories may be called out in mission need, materiel requirement, design, and test documents for tailoring purposes: Basic, hot, cold, and severe cold categories are described below. Within each category there are one or more "daily cycles" primarily based on variations in temperature and relative humidity (RH) levels. All climatic categories are defined in table 3–1 and mapped on figures 3–1 through 3–3. See North Atlantic Treaty Organization Standardization Agreement (NATO STANAG) 4370, Allied Environmental Conditions and Test Publication (AECTP)–230, MIL–HDBK–310, and MIL–STD–810. The climatic category is listed as follows:

*a. Hot climatic category.* This category includes most of the hot-dry low-latitude deserts of the world. During summer in these areas, outdoor ambient air temperatures above 43° Celsius (C) (110° Fahrenheit (F)) occur frequently. However, except for a few specific places, outdoor ambient air temperatures will seldom be above 49°C (120°F). These approximate temperatures of the free air in the shade approximately 1.5 to 2 meters (m) (about 5 or 6 feet (ft.)) above the ground (in an instrument shelter). The thermal effects of solar loading can be significant for materiel exposed to direct sunlight, but will vary significantly with the exposure situation. The ground surface can attain temperatures of 17 to 33°C (30 to 60°F) higher than that of the free air, depending on the type/color of the ground surface, radiation, conduction, wind, and turbulence. Air layers very close to the surface will be only slightly cooler than the ground, but the decrease in temperature with height above the surface is exponential.

*b. Basic climatic category.* This includes the most densely populated and heavily industrialized parts of the world as well as the humid tropics. The entire range of basic design conditions does not necessarily occur in any one place. Each single condition (high temperature, low temperature, high humidity) occurs in a wide area. When taken together, the design values should be valid for materiel used throughout the area.

(1) *Humid tropic zone.* Humid tropic areas are included in the basic climatic category rather than being considered an extreme category because humid tropic temperatures are moderate and their humidity levels are equaled at times in some of the other mid-latitude areas. The features of the humid tropics most important for materiel system design are moderately high temperatures and high rainfall throughout the year that spawn persistent high humidity and high flora and fauna diversity. These combined environmental conditions greatly increase insect and microbiological damage and promote corrosion more so than any other region of the world. This is important for DoD's Corrosion Prevention and Control Program (see DoDI 5000.67).

(2) *Intermediate zone.* These are mid-latitude areas that do not combine higher temperatures with higher humidities throughout the year, and at the same time are not climatically extreme enough to meet the conditions for hot or cold climatic categories. This zone includes the daily cycles shown in table 3–1, plus a condition known as "cold-wet" that can occur within the mild cold daily cycle at or near the freezing point (2 to -4°C (35 to 25°F)) with RH tending toward saturation (100 to 95 percent RH) and negligible solar radiation.

*c. Cold and severe cold climatic categories.* These areas include northern North America, Greenland, northern Asia, and Tibet. In the cold climatic category, the temperature during the coldest month in a normal year may be colder than the basic climatic category cold extreme of -32°C (-26°F). In the severe cold areas, the temperature during the coldest month in a normal year may be colder than the cold climatic category extreme of -46°C (-51°F). Temperatures colder than -51°C (-60°F) occur no more than 20 percent of the hours in the coldest month of the coldest part of the area (northern Siberia) where temperatures as low as -68°C (-90°F) have been recorded.

## 3–2. Summary of daily cycles

Table 3–1 is a summary table of the daily extremes (highest and lowest values in a 24–hour cycle) of temperature, solar radiation, and RH for the eight daily cycles cited in this regulation. Details of each cycle, and other atmospheric elements (hydrometers, wind, blowing sand, blowing dust, ozone, and atmospheric pressure), are given in section II of this chapter. In most cases, extremes of these other elements do not occur at the same time as the extremes of temperature or humidity. However, with certain severe cold and cold phenomena, two or more elements may occur at the same time, for example, ice, fog, and low temperatures.

*Note*. The numbers shown for the values of the climatic elements represent only the upper and lower limits of the cycles that typify days during which the extremes occur, for example, for the hot-dry cycle, 49°C (120°F) is the maximum daytime temperature, and 32°C (90°F) is the minimum nighttime (or early morning) temperature.

**Table 3–1**
**Summary of climatic conditions and daily cycles of temperature, solar radiation, and relative humidity**

| | | Operational Conditions | | | | Storage and Transit Conditions | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ambient Air Temperature[2] | | Solar Radiation | Ambient Relative | Induced Air Temperature °C (°F) | | Induced Relative | Natural Environment Exposure Testing[7] |
| Climatic Design Type | Daily Cycle | Daily Low | Daily High | $W/m^2$ (Bph[3]) | Humidity %RH[4] | Daily Low | Daily High | Humidity %RH | °C (°F) |
| Hot | Hot Dry (A1) | 32 (90) | 49 (120) | 0 to 1120 (0 to 355) | 8 to 3 | 33 (91) | 71 (160) | 7 to 1 | 32 to 49 (90 to 120) |
| | Hot Humid (B3) | 31 (88) | 41 (105) | 0 to 1080 (0 to 343) | 88 to 59 | 33 (91) | 71 (160) | 80 to 14 | Coastal Desert |
| Basic | Basic Hot (A2) | 30 (86) | 43 (110) | 0 to 1120 (0 to 355) | 44 to 14 | 30 (86) | 63 (145) | 44 to 5 | 0 to 43 (32 to 110) |
| | Intermediate[6] (A3) | 28 (82) | 39 (102) | 0 to 1020 (0 to 323) | 78 to 43 | 28 (82) | 58 (136) | See note [5] | |
| | Variable High Humidity (B2) | 26 (78) | 35 (95) | 0 to 970 (0 to 307) | 100 to 74 | 30 (86) | 63 (145) | 75 to 19 | Humid Tropics |
| | Constant High Humidity (B1) | Nearly Constant 24 (75) | | Negligible | 95 to 100 | Nearly Constant 27 (80) | | 95 to 100 | |
| | Mild Cold[6] (C0) | -19 (-2) | -6 (21) | Negligible | Tending toward saturation | -21 (-6) | -10 (14) | Tending toward saturation | 0 to -32 (32 to -25) |
| | Basic Cold (C1) | -32 (-25) | -21 (-5) | Negligible | Tending toward saturation | -33 (–28) | -25 (-13) | Tending toward saturation | |
| Cold | Cold (C2) | -46 (-50) | -37 (-35) | Negligible | Tending toward saturation | -46 (-50) | -37 (-35) | Tending toward saturation | -32 to -46 (-26 to -50) |

**Table 3–1**
**Summary of climatic conditions and daily cycles of temperature, solar radiation, and relative humidity—Continued**

| Climatic Design Type | Daily Cycle | Operational Conditions: Ambient Air Temperature[2] Daily Low | Operational Conditions: Ambient Air Temperature[2] Daily High | Solar Radiation W/m$^2$ (Bph[3]) | Ambient Relative Humidity %RH[4] | Storage and Transit Conditions: Induced Air Temperature °C (°F) Daily Low | Storage and Transit Conditions: Induced Air Temperature °C (°F) Daily High | Induced Relative Humidity %RH | Natural Environment Exposure Testing[7] °C (°F) |
|---|---|---|---|---|---|---|---|---|---|
| Severe Cold | Severe Cold (C3) | -51 (-60) | | Negligible | Tending toward saturation | -51 (-60) | | Tending toward saturation | < -46 (< -50) |
| Extreme Cold | Extreme Cold[6] (C4) | -57 (-70) | | Negligible | Tending toward saturation | -57 (-70) | | Tending toward saturation | |

*Notes.*

[1] Designations in parentheses refer to corresponding climatic categories in MIL–HDBK–310 and AR 70–38 (except the A–3 category) and NATO STANAG 4370, AECTP 230 (see Part One, 2.2.1, 2.2.2, and 2.3).

[2] ºC values (rounded to the nearest whole degree) derived from data obtained/established on ºF scale.

[3] Bph represents British Thermal Units per square foot per hour.

[4] Sequence of RH presentation corresponds to sequence of air temperatures shown (e.g., for HOT–DRY daily cycle, 8 percent RH occurs at 32oC (90oF); 3 percent RH occurs at 49oC (120oF).

[5] Relative humidity for the A3 storage condition vary to widely between different situations to be represented by a single set of conditions.

[6] Values are only found in NATO STANAG 4370, AECTP 230.

[7] Delineation to be used for natural environment exposure testing, not applicable to laboratory testing.

NOTE. The numbers shown for the values of the climatic elements represent only the upper and lower limits of the cycles that typify days during which the extremes occur; e.g., for the Hot-Dry cycle, 49oC (120oF) is the maximum daytime temperature, and 32oC (90oF) is the minimum nighttime (or early morning) temperature.

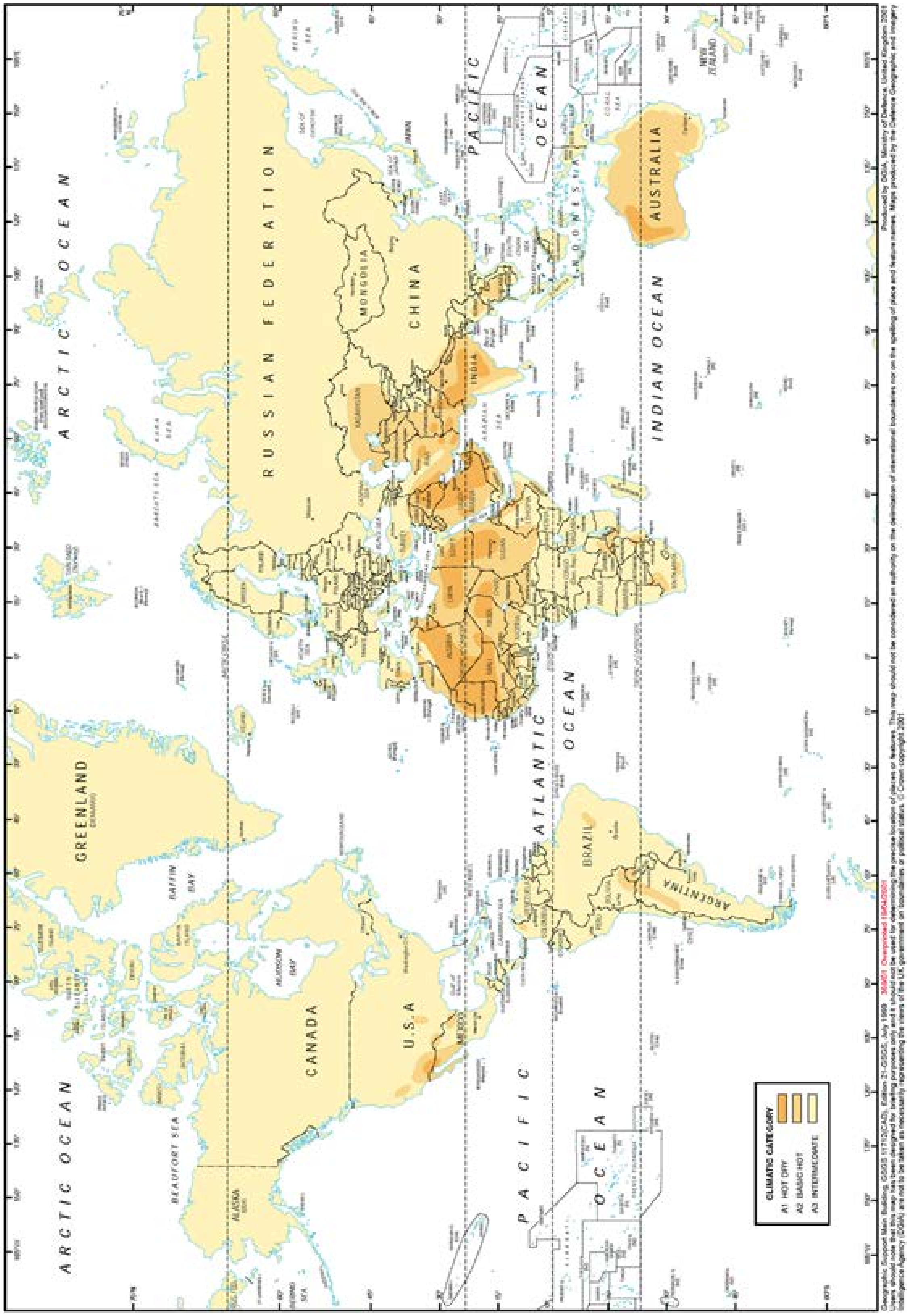



**Figure 3–1. Areas of occurrence of climatic categories A1, A2, and A3**

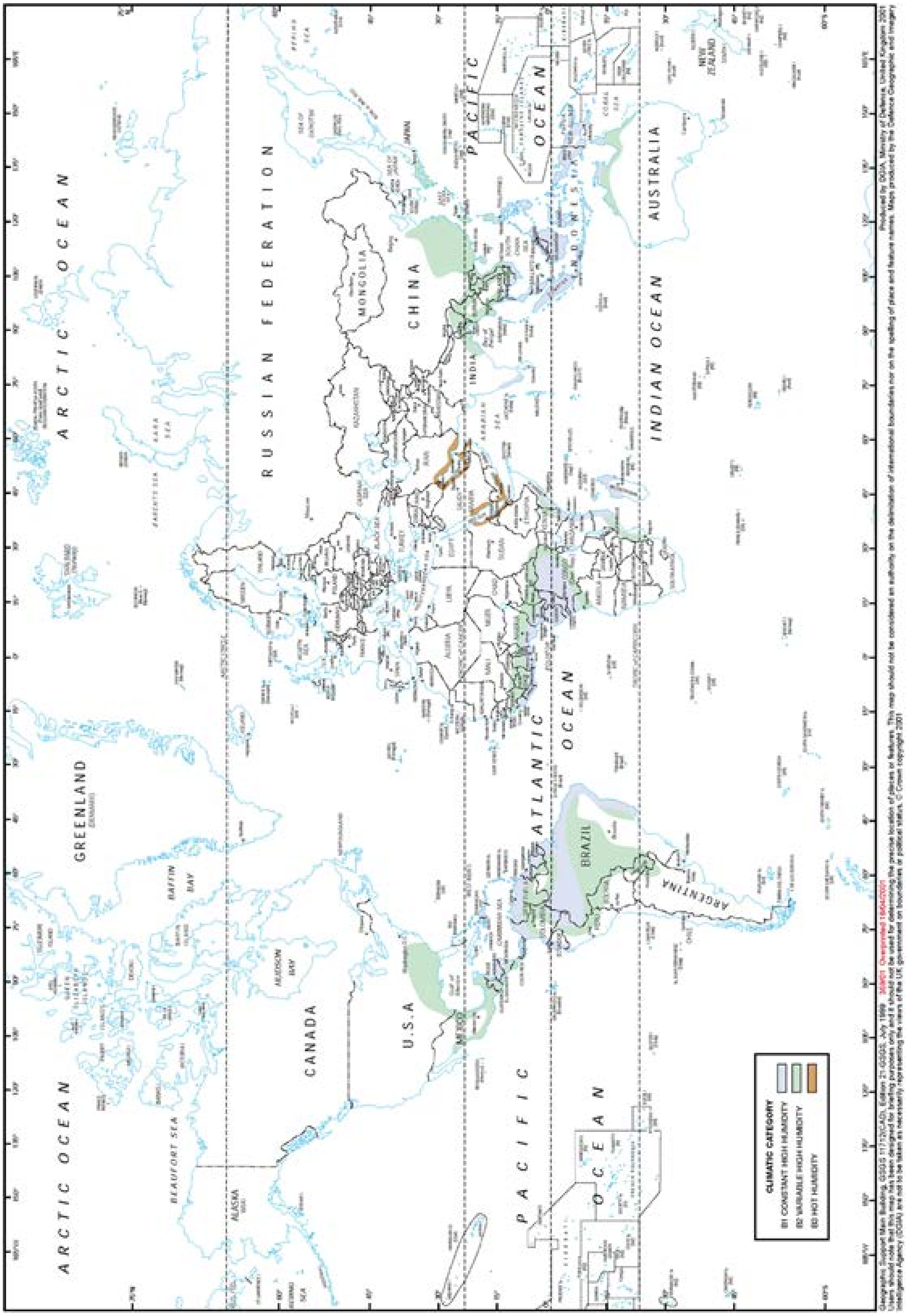
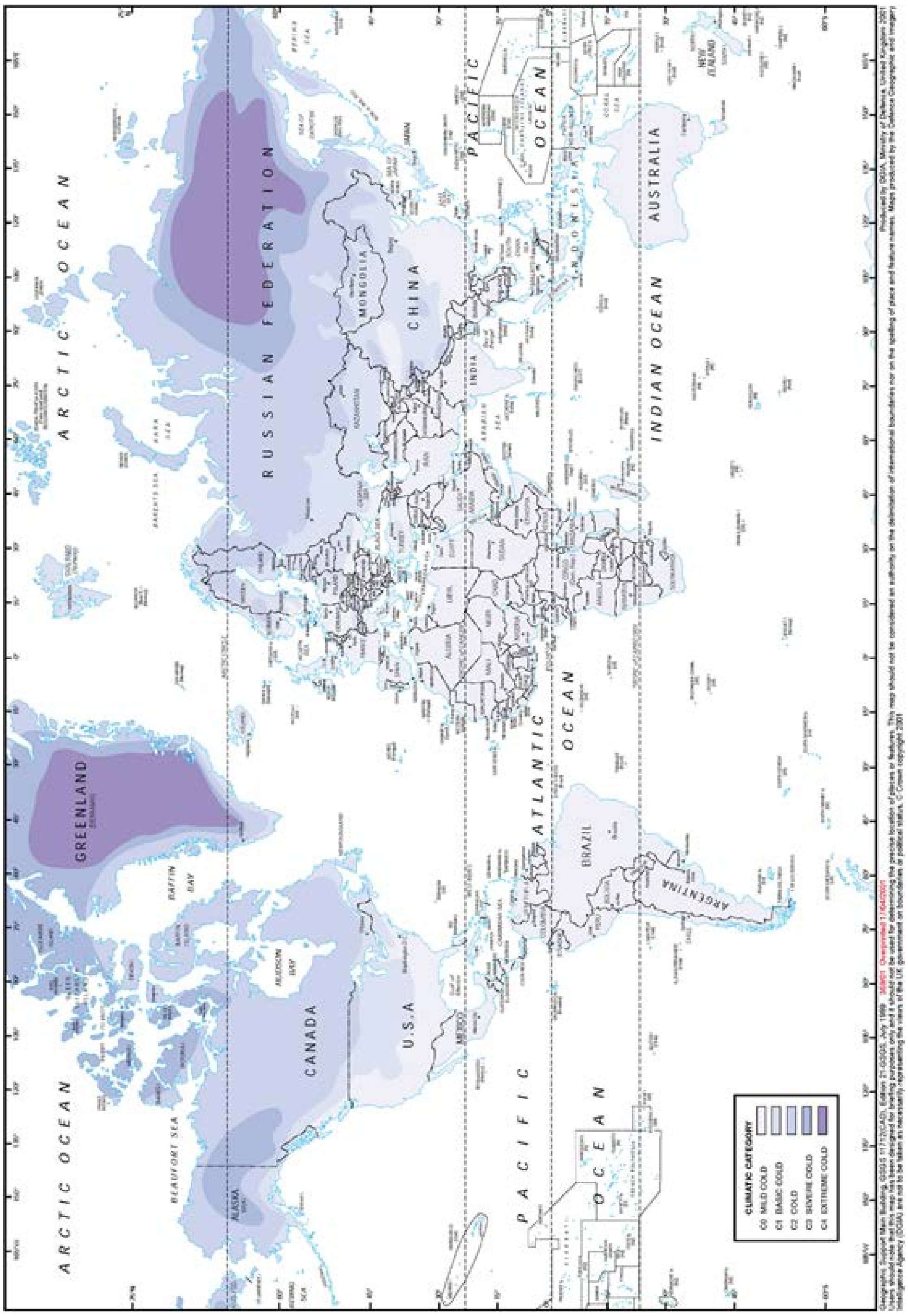



**Figure 3–2. Areas of occurrence of climatic categories B1, B2, and B3**




*Legend*.
C0 Mild Cold
C1 Basic Cold
C2 Cold
C3 Severe cold
C4 Extreme cold

**Figure 3–3. Areas of occurrence of climatic categories C0, C1, C2, C3, and C4**

## 3–3. High elevation and upper air conditions

*a.* For materiel subject to transport through high mountain passes, the temperatures and pressures for elevations as high as 15,000 ft (4,572 m) apply.

*b.* For materiel subject to shipment by air (elevations as high as 50,000 ft or 15,240 m), the low air pressure and temperature shown in table 3–2 could result from failure of cabin pressure and temperature regulation.

**Table 3–2**
**Low air pressure and temperature at evaluation**

| Height or Elevation | | Pressure | | Temperature | |
|---|---|---|---|---|---|
| **Meters** | **Feet** | **Kilopascals (kPa)** | **Millibars (mbar)** | **°C** | **°F** |
| 3048 | 10,000 | 66 | 660 | −41 | −42 |
| 4572 | 15,000 | 52 | 520 | −47 | −53 |
| 6096 | 20,000 | 41 | 410 | −56 | −68 |
| 9144 | 30,000 | 25.5 | 255 | −66 | −87 |
| 12192 | 40,000 | 16 | 160 | −72 | −98 |
| 15240 | 50,000 | 10 | 100 | −76 | −105 |

## Section II
## Climatic Design Types

### 3–4. Hot climatic design type

*a. Hot-dry cycle.*

(1) *Location.* Hot-dry conditions are found seasonally in the deserts of northern Africa, the Middle East, Pakistan and India, southwestern United States, and northern Mexico (see fig 3–1).

(2) *Temperature, humidity, solar radiation.*

*(a) Operational conditions.* On the extreme hot-dry days, temperature, humidity, and solar radiation may follow a pattern similar to that shown in table 3–3. Nominal accompanying wind speeds at the time of high temperatures are 13 feet per second (fps) (4 meters per second (mps)). The maximum ground surface temperature is 146°F (63°C). At ground elevations above 3,000 ft (915 m), maximum air temperatures will be lower by approximately 5°F per 1,000 ft (9.1°C per 1,000 m), and solar radiation may be higher by approximately 4 Bph (British thermal units per square foot per hour) per 1,000 ft (43 $W/m^2$ per 1,000 m) to 15,000 ft.

**Table 3–3**
**Hot climatic design type A1: Hot-dry daily cycle (Natural and Induced)**

| | OPERATIONAL CONDITIONS (Natural Environment) | | | | | | | STORAGE AND TRANSIT CONDITIONS | |
|---|---|---|---|---|---|---|---|---|---|
| **Local Time** | **Ambient Air Temp.** | **Solar Radiation** | | **RH** | **Dew Point Temp.** | **Wind (at 3m)** | | **Induced Air Temp.** | **RH** |
| **(LST)** | **C (F)** | **Bph** | **$W/m^2$** | **Percent** | **C (F)** | **m/s** | **ft/sec** | **C (F)** | **Percent** |
| 0100 | 35 (95) | 0 | 0 | 6 | −7 (19) | 3 | 9 | 35 (95) | 6 |
| 0200 | 34 (94) | 0 | 0 | 7 | −6 (21) | 3 | 9 | 34 (94) | 7 |
| 0300 | 34 (93) | 0 | 0 | 7 | −7 (20) | 3 | 9 | 34 (93) | 7 |
| 0400 | 33 (92) | 0 | 0 | 8 | −6 (22) | 3 | 9 | 33 (92) | 7 |
| 0500 | 33 (91) | 0 | 0 | 8 | −6 (22) | 3 | 9 | 33 (92) | 7 |
| 0600 | 32 (90) | 18 | 55 | 8 | −6 (22) | 3 | 9 | 33 (91) | 7 |
| 0700 | 33 (91) | 85 | 270 | 8 | −6 (22) | 3 | 9 | 36 (97) | 5 |
| 0800 | 35 (95) | 160 | 505 | 6 | −7 (19) | 3 | 9 | 40 (104) | 4 |
| 0900 | 38 (101) | 231 | 730 | 6 | −5 (23) | 3 | 9 | 44 (11) | 4 |
| 1000 | 41 (106) | 291 | 915 | 5 | −4 (24) | 4 | 14 | 51 (124) | 3 |
| 1100 | 43 (110) | 330 | 1040 | 4 | −6 (21) | 4 | 14 | 56 (133) | 2 |
| 1200 | 44 (112) | 355 | 1120 | 4 | −5 (23) | 4 | 14 | 63 (145) | 2 |
| 1300 | 47 (116) | 355 | 1120 | 3 | −8 (18) | 4 | 14 | 69 (156) | 1 |

**Table 3–3**
**Hot climatic design type A1: Hot-dry daily cycle (Natural and Induced)—Continued**

| Local Time (LST) | OPERATIONAL CONDITIONS (Natural Environment) Ambient Air Temp. C (F) | Solar Radiation Bph | Solar Radiation W/m² | RH Percent | Dew Point Temp. C (F) | Wind (at 3m) m/s | Wind (at 3m) ft/sec | STORAGE AND TRANSIT CONDITIONS Induced Air Temp. C (F) | RH Percent |
|---|---|---|---|---|---|---|---|---|---|
| 1400 | 48 (118) | 330 | 1040 | 3 | −9 (16) | 4 | 14 | 70 (158) | 1 |
| 1500 | 48 (119) | 291 | 915 | 3 | −8 (18) | 4 | 14 | 71 (160) | 1 |
| 1600 | 49 (120) | 231 | 730 | 3 | −7 (19) | 4 | 14 | 70 (158) | 1 |
| 1700 | 48 (119) | 160 | 505 | 3 | −8 (18) | 4 | 14 | 67 (153) | 1 |
| 1800 | 48 (118) | 85 | 270 | 3 | −9 (16) | 4 | 14 | 63 (145) | 2 |
| 1900 | 46 (114) | 18 | 55 | 3 | −7 (19) | 4 | 14 | 55 (131) | 2 |
| 2000 | 42 (108) | 0 | 0 | 4 | −7 (20) | 4 | 14 | 48 (118) | 3 |
| 2100 | 41 (105) | 0 | 0 | 5 | −6 (22) | 4 | 14 | 41 (105) | 5 |
| 2200 | 39 (102) | 0 | 0 | 6 | −4 (24) | 4 | 14 | 39 (103) | 6 |
| 2300 | 38 (100) | 0 | 0 | 6 | −6 (22) | 4 | 14 | 37 (99) | 6 |
| 2400 | 37 (98) | 0 | 0 | 6 | −7 (20) | 3 | 9 | 35 (95) | 6 |

*(b) Storage and transit conditions.* The daily cycle for storage and transit in table 3–3 shows 5 continuous hours with air temperatures above 150°F (66°C) and an extreme air temperature of 160°F (71°) for not more than 1 hour. Testing for these conditions should be done, if practicable, according to the daily cycle, because prolonged exposure to the high-temperature extremes may impose an unrealistic heat load on materiel. If not practicable, testing will be done at a temperature representative of the peak temperature that the materiel would attain during a daily cycle.

*b. Hot-humid cycle.*

(1) *Location.* These severe dew point conditions occur only along a very narrow coastal strip (probably less than 5 miles) bordering bodies of water with high surface temperatures, specifically the Persian Gulf and the Red Sea. The hot-humid cycle will be used as a design condition only for systems intended for use or likely to be used in these limited areas. Areas reporting these highest worldwide dew points may also experience hot-dry conditions at other times. Tests against hot-humid cycle conditions should be required only for systems that are specified for use in these designated areas.

(2) *Temperature, humidity, solar radiation.*

*(a) Operational conditions.* On days with extremely high dew points (high absolute humidity), a cycle such as that in table 3–4 may occur, along with wind speeds between 8 and 17 fps (2.4 and 5.2 mps) and a maximum ground surface temperature of 130°F (54°C).

*(b) Storage and transit conditions.* Induced storage temperatures are presumed to be the same as those for the hot-dry cycle although relative humilities in the enclosed space are considerably higher.

**Table 3–4**
**Hot climatic design type B3: Hot-humid daily cycle**

| Local Time | OPERATIONAL CONDITIONS (Natural Environment) Ambient Air Temperature C | Ambient Air Temperature F | Solar Radiation W/m² | Solar Radiation Bph | RH Percent | Dew Point Temperature C | Dew Point Temperature F | STORAGE AND TRANSIT CONDITIONS Induced Air Temperature C | Induced Air Temperature F | RH Percent |
|---|---|---|---|---|---|---|---|---|---|---|
| 0100 | 31 | 88 | 0 | 0 | 88 | 29 | 84 | 35 | 95 | 67 |
| 0200 | 31 | 88 | 0 | 0 | 88 | 29 | 84 | 34 | 94 | 72 |
| 0300 | 31 | 88 | 0 | 0 | 88 | 29 | 84 | 34 | 94 | 75 |
| 0400 | 31 | 88 | 0 | 0 | 88 | 29 | 84 | 34 | 93 | 77 |
| 0500 | 31 | 88 | 0 | 0 | 88 | 29 | 84 | 33 | 92 | 79 |

**Table 3–4**
**Hot climatic design type B3: Hot-humid daily cycle—Continued**

| | OPERATIONAL CONDITIONS (Natural Environment) | | | | | | | STORAGE AND TRANSIT CONDITIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Time | Ambient Air Temperature | | Solar Radiation | | RH | Dew Point Temperature | | Induced Air Temperature | | RH |
| | C | F | W/m$^2$ | Bph | Percent | C | F | C | F | Percent |
| 0600 | 32 | 90 | 45 | 15 | 85 | 29 | 85 | 33 | 91 | 80 |
| 0700 | 34 | 93 | 315 | 100 | 80 | 30 | 86 | 36 | 97 | 70 |
| 0800 | 36 | 96 | 560 | 177 | 76 | 31 | 87 | 40 | 104 | 54 |
| 0900 | 37 | 98 | 790 | 251 | 73 | 31 | 88 | 44 | 111 | 42 |
| 1000 | 38 | 100 | 950 | 302 | 69 | 31 | 88 | 51 | 124 | 31 |
| 1100 | 39 | 102 | 1035 | 328 | 65 | 31 | 88 | 57 | 135 | 24 |
| 1200 | 40 | 104 | 1080 | 343 | 62 | 31 | 88 | 62 | 144 | 17 |
| 1300 | 41 | 105 | 1000 | 317 | 59 | 31 | 88 | 66 | 151 | 16 |
| 1400 | 41 | 105 | 885 | 280 | 59 | 31 | 88 | 69 | 156 | 15 |
| 1500 | 41 | 105 | 710 | 225 | 59 | 31 | 88 | 71 | 160 | 14 |
| 1600 | 41 | 105 | 465 | 147 | 59 | 31 | 88 | 69 | 156 | 16 |
| 1700 | 39 | 102 | 210 | 66 | 65 | 31 | 88 | 66 | 151 | 18 |
| 1800 | 37 | 99 | 15 | 4 | 69 | 31 | 87 | 63 | 145 | 21 |
| 1900 | 36 | 97 | 0 | 0 | 73 | 31 | 87 | 58 | 136 | 29 |
| 2000 | 34 | 94 | 0 | 0 | 79 | 30 | 86 | 50 | 122 | 41 |
| 2100 | 33 | 91 | 0 | 0 | 85 | 30 | 86 | 41 | 105 | 53 |
| 2200 | 32 | 90 | 0 | 0 | 85 | 29 | 85 | 39 | 103 | 58 |
| 2300 | 32 | 89 | 0 | 0 | 88 | 29 | 85 | 37 | 99 | 62 |
| 2400 | 31 | 88 | 0 | 0 | 88 | 29 | 84 | 35 | 95 | 63 |

## 3–5. Basic climatic design type

Four daily cycles represent conditions that may be found in areas where the basic climatic design type prevails. Two of these cycles represent high humidity conditions and two represent the extreme temperatures of the basic set of design values.

*a. High humidity daily cycles.*

(1) *Location.* Basic high humidity conditions are found most often in tropical areas, although they occur briefly or seasonally in the mid-latitudes. One of the two high humidity cycles (constant high humidity) represents conditions in the heavily forested areas where nearly constant conditions may prevail during rainy and wet seasons. The other daily cycle (variable high humidity) represents conditions found in the open in tropical areas. In the first cycle, exposed materiel is likely to be constantly wet or damp for many days at a time. In the second cycle, exposed items are subject to alternate wetting and drying. Both conditions promote severe deterioration in materiel. The one that is most important, as shown in table 3–5, depends on the nature of the equipment involved.

**Table 3–5**
**Materials and high humidity deterioration**

| Type Material | Type of Site with the Highest Deterioration Rates |
|---|---|
| Elastomers | Open |
| Polymers | Open |

**Table 3–5**
**Materials and high humidity deterioration—Continued**

| Type Material | Type of Site with the Highest Deterioration Rates |
|---|---|
| Textiles | Forest |
| Metals | Coastal swamp (mangrove) and forest |

(2) *Temperature, humidity, solar radiation (constant high humidity cycle).*

*(a) Operational conditions.* RH above 95 percent in association with a nearly constant temperature at 75°F (24°C) persists for periods of several days (see table 3–6).

*(b) Storage and transit conditions.* RH above 95 percent in association with a nearly constant 80°F (27°C) temperature occurs for periods of a day or more.

**Table 3–6**
**Basic climatic design type B1: Constant high humidity daily cycle**

| | OPERATIONAL CONDITIONS (Natural Environment) | | | | | | | STORAGE AND TRANSIT CONDITIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Time | Ambient Air Temperature | | Solar Radiation | | RH | Dew Point Temperature | | Induced Air Temperature | | RH |
| | C | F | Bph | W/m$^2$ | Percent | C | F | C | F | Percent |
| 0100 | Nearly constant at 24°C (75°F) throughout the 24 hours. | | Negligible | | 100 | 24 | 75 | Nearly constant at 27°C (80°F) Throughout the 24 hours. | | Same as operational conditions. |
| 0200 | | | | | 100 | 24 | 75 | | | |
| 0300 | | | | | 100 | 24 | 75 | | | |
| 0400 | | | | | 100 | 24 | 75 | | | |
| 0500 | | | | | 100 | 24 | 75 | | | |
| 0600 | | | | | 100 | 24 | 75 | | | |
| 0700 | | | | | 98 | 23 | 74 | | | |
| 0800 | | | | | 97 | 23 | 74 | | | |
| 0900 | | | | | 95 | 23 | 74 | | | |
| 1000 | | | | | 95 | 23 | 74 | | | |
| 1100 | | | | | 95 | 23 | 74 | | | |
| 1200 | | | | | 95 | 23 | 74 | | | |
| 1300 | | | | | 95 | 23 | 74 | | | |
| 1400 | | | | | 95 | 23 | 74 | | | |
| 1500 | | | | | 95 | 23 | 74 | | | |
| 1600 | | | | | 95 | 23 | 74 | | | |
| 1700 | | | | | 95 | 23 | 74 | | | |
| 1800 | | | | | 95 | 23 | 74 | | | |
| 1900 | | | | | 97 | 23 | 74 | | | |
| 2000 | | | | | 98 | 23 | 74 | | | |
| 2100 | | | | | 100 | 24 | 75 | | | |
| 2200 | | | | | 100 | 24 | 75 | | | |
| 2300 | | | | | 100 | 24 | 75 | | | |
| 2400 | | | | | 100 | 24 | 75 | | | |

(3) *Temperature, humidity, solar radiation (variable high humidity cycle).*

*(a) Operational conditions.* The daily cycle outlined in table 3–7 has a maximum ambient air temperature of 95°F (35°C) for 2 hours. The maximum solar radiation load of 307 Bph (970 W/m$^2$) for not more than 2 hours, is accompanied by wind speeds of less than 7 fps (2 mps) and a maximum ground surface temperature of 130°F (54°C).

*(b) Storage and transit conditions.* See storage and transit conditions associated with the hot-humid daily cycle of the hot climatic design type.

**Table 3–7**
**Basic climatic design type B2: Variable high humidity daily cycle**

| | OPERATIONAL CONDITIONS (Natural Environment) | | | | | | | STORAGE AND TRANSIT CONDITIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Time | Ambient Air Temperature | | Solar Radiation | | RH | Dew Point Temperature | | Induced Air Temperature | | RH |
| | C | F | W/m$^2$ | Bph | Percent | C | F | C | F | Percent |
| 0100 | 27 | 80 | 0 | 0 | 100 | 27 | 80 | 33 | 91 | 69 |
| 0200 | 26 | 79 | 0 | 0 | 100 | 26 | 79 | 32 | 90 | 70 |
| 0300 | 26 | 79 | 0 | 0 | 100 | 26 | 79 | 32 | 90 | 71 |
| 0400 | 26 | 79 | 0 | 0 | 100 | 26 | 79 | 31 | 88 | 72 |
| 0500 | 26 | 78 | 0 | 0 | 100 | 26 | 78 | 30 | 86 | 74 |
| 0600 | 26 | 78 | 45 | 15 | 100 | 26 | 78 | 31 | 88 | 75 |
| 0700 | 27 | 81 | 230 | 73 | 94 | 26 | 79 | 34 | 93 | 64 |
| 0800 | 29 | 84 | 435 | 138 | 88 | 27 | 80 | 38 | 101 | 54 |
| 0900 | 31 | 87 | 630 | 200 | 82 | 27 | 81 | 42 | 107 | 43 |
| 1000 | 32 | 89 | 795 | 252 | 79 | 28 | 82 | 45 | 113 | 36 |
| 1100 | 33 | 92 | 900 | 286 | 77 | 28 | 83 | 51 | 124 | 29 |
| 1200 | 34 | 94 | 970 | 307 | 75 | 29 | 84 | 57 | 134 | 22 |
| 1300 | 34 | 94 | 970 | 307 | 74 | 29 | 84 | 61 | 142 | 21 |
| 1400 | 35 | 95 | 900 | 286 | 74 | 29 | 85 | 63 | 145 | 20 |
| 1500 | 35 | 95 | 795 | 252 | 74 | 30 | 86 | 63 | 145 | 19 |
| 1600 | 34 | 93 | 630 | 200 | 76 | 29 | 85 | 62 | 144 | 20 |
| 1700 | 33 | 92 | 435 | 138 | 79 | 29 | 84 | 60 | 140 | 21 |
| 1800 | 32 | 90 | 230 | 73 | 82 | 29 | 84 | 57 | 134 | 22 |
| 1900 | 31 | 88 | 45 | 15 | 86 | 28 | 83 | 50 | 122 | 32 |
| 2000 | 29 | 85 | 0 | 0 | 91 | 28 | 83 | 44 | 111 | 43 |
| 2100 | 28 | 83 | 0 | 0 | 95 | 28 | 82 | 38 | 101 | 54 |
| 2200 | 28 | 82 | 0 | 0 | 96 | 27 | 81 | 35 | 95 | 59 |
| 2300 | 27 | 81 | 0 | 0 | 100 | 27 | 81 | 34 | 93 | 63 |
| 2400 | 27 | 80 | 0 | 0 | 100 | 27 | 80 | 33 | 91 | 68 |

(4) *High humidity chamber testing.* Climate chamber tests can be used to determine whether materiel is likely to resist fungus growth and the mechanical effects of moisture. They cannot be expected to produce the overall effects on materiel that will result from tropical field testing.

*b. Basic hot daily cycle.*

(1) *Location.* Basic hot conditions exist in many parts of the world extending outward from the areas of hot-dry conditions in the United States, Mexico, Africa, Asia, and Australia. They also occur in southern Africa, South America, southern Spain, and in southwest Asia.

(2) *Temperature, humidity, solar radiation.*

*(a) Operational conditions.* Design criteria are 8 continuous hours with an ambient air temperature above 105°F (41°C) with an extreme temperature of 110°F (43°C) for not more than 3 hours, a maximum ground surface temperature of 140°F (60°C), solar radiation (horizontal surface) at a rate of 355 Bph (1120 W/m$^2$) for not more than 2 hours (not concurrent with the extreme temperature), a wind speed between 10 and 16 fps (3 and 5 mps) during the period with temperature above 105°F (41°C), and an RH of approximately 14 percent concurrent with the high temperatures (see table 3–8). For elevations of 3,000 ft to 10,000 ft (914 to 3048 m), the ground surface temperature and wind remain the same. Ambient air temperatures, however, decrease 5°F per 1,000 ft (9.1°C per 1,000 m), and solar radiation increases at a rate of 4 Bph per 1,000 ft (43 W/m$^2$ per 1,000 m).

*(b) Storage and transit conditions.* Design criteria are 4 continuous hours with an induced air temperature above 140°F (60°C) with RH less than 8 percent, and an air temperature extreme of 145°F (63°C) for not more than 2 hours without the benefit of solar radiation and with negligible wind (see table 3–8).

**Table 3–8**
**Basic climatic design type A2: Basic hot daily cycle**

| | OPERATIONAL CONDITIONS (Natural Environment) | | | | | | | STORAGE AND TRANSIT CONDITIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Local Time | Ambient Air Temperature | | Solar Radiation | | RH | Dew Point Temperature | | Induced Air Temperature | | RH |
| | C | F | W/m$^2$ | Bph | Percent | C | F | C | F | Percent |
| 0100 | 33 | 91 | 0 | 0 | 36 | 15 | 61 | 33 | 91 | 36 |
| 0200 | 32 | 90 | 0 | 0 | 38 | 16 | 60 | 32 | 90 | 38 |
| 0300 | 32 | 90 | 0 | 0 | 41 | 17 | 63 | 32 | 90 | 41 |
| 0400 | 31 | 88 | 0 | 0 | 44 | 17 | 62 | 31 | 88 | 44 |
| 0500 | 30 | 86 | 0 | 0 | 44 | 17 | 62 | 30 | 86 | 44 |
| 0600 | 30 | 86 | 55 | 18 | 44 | 17 | 62 | 31 | 88 | 43 |
| 0700 | 31 | 88 | 270 | 85 | 41 | 16 | 61 | 34 | 93 | 37 |
| 0800 | 34 | 93 | 505 | 160 | 34 | 16 | 61 | 38 | 101 | 30 |
| 0900 | 37 | 99 | 730 | 231 | 29 | 17 | 62 | 42 | 107 | 23 |
| 1000 | 39 | 102 | 915 | 291 | 24 | 14 | 58 | 45 | 113 | 17 |
| 1100 | 41 | 106 | 1040 | 330 | 21 | 14 | 58 | 51 | 124 | 14 |
| 1200 | 42 | 107 | 1120 | 355 | 18 | 13 | 55 | 57 | 134 | 8 |
| 1300 | 43 | 109 | 1120 | 355 | 16 | 11 | 52 | 61 | 142 | 6 |
| 1400 | 43 | 110 | 1040 | 330 | 15 | 11 | 52 | 63 | 145 | 6 |
| 1500 | 43 | 110 | 915 | 291 | 14 | 10 | 50 | 63 | 145 | 5 |
| 1600 | 43 | 110 | 730 | 231 | 14 | 10 | 50 | 62 | 144 | 6 |
| 1700 | 43 | 109 | 505 | 160 | 14 | 9 | 49 | 60 | 140 | 6 |
| 1800 | 42 | 107 | 270 | 85 | 15 | 9 | 49 | 57 | 134 | 6 |
| 1900 | 40 | 104 | 55 | 18 | 17 | 10 | 50 | 50 | 122 | 10 |
| 2000 | 38 | 100 | 0 | 0 | 20 | 11 | 51 | 44 | 111 | 14 |
| 2100 | 36 | 97 | 0 | 0 | 22 | 11 | 51 | 38 | 101 | 19 |
| 2200 | 35 | 95 | 0 | 0 | 25 | 12 | 54 | 35 | 95 | 25 |
| 2300 | 34 | 93 | 0 | 0 | 28 | 12 | 54 | 34 | 93 | 28 |
| 2400 | 33 | 91 | 0 | 0 | 33 | 14 | 58 | 33 | 91 | 33 |

*c. Basic cold daily cycle.*

(1) *Location.* Basic cold conditions are found only in the Northern Hemisphere south of the coldest areas and on high-latitude coasts (for example, the southern coast of Alaska) where maritime effects prevent occurrence of very low temperatures. Small areas of basic cold weather conditions may be found at high elevations in lower latitudes.

(2) *Temperature, humidity, solar radiation.*

*(a) Operational conditions.* Design conditions are 5 continuous hours with an ambient air temperature of −25°F (−31°C), a minimum ground surface temperature of −35°F (−37°C), wind speed less than 16 fps (5 mps), negligible solar radiation (horizontal surface), and humidity tending toward saturation (see table 3–7). Saturation is the result of the extremely low temperatures. The absolute humidity and vapor pressure are very low when these temperatures prevail. Although not typical, wind speeds greater than 16 fps (5 mps) may be associated with temperatures of −25°F (−31°C).

*(b) Storage and transit conditions.* Design criteria are five continuous hours with an induced air temperature of −28°F (−33°C) with no wind or solar radiation and humidity tending toward saturation (see table 3–9).

**Table 3–9**
**Basic climatic design type C1; Cold daily cycle**

| | OPERATIONAL CONDITIONS (Natural Environment) | | | | | STORAGE AND TRANSIT CONDITIONS | | |
|---|---|---|---|---|---|---|---|---|
| Local Time | Ambient Air Temperature | | Solar Radiation | | RH | Induced Air Temperature | | RH |
| | C | F | W/m | Bph | Percent | C | F | Percent |
| 0100 | −31 | −24 | Negligible During Low Temperature Periods | | Tending Towards Saturation | −33 | −27 | Tending Toward Saturation |
| 0200 | −32 | −25 | | | | −33 | −28 | |
| 0300 | −32 | −25 | | | | −33 | −28 | |
| 0400 | −32 | −25 | | | | −33 | −28 | |
| 0500 | −32 | −25 | | | | −33 | −28 | |
| 0600 | −32 | −25 | | | | −33 | −28 | |
| 0700 | −30 | −22 | | | | −33 | −27 | |
| 0800 | −28 | −18 | | | | −33 | −27 | |
| 0900 | −26 | −15 | | | | −32 | −26 | |
| 1000 | −24 | −12 | | | | −31 | −24 | |
| 1100 | −22 | −8 | | | | −30 | −22 | |
| 1200 | −21 | −5 | | | | −28 | −19 | |
| 1300 | −21 | −5 | | | | −27 | −17 | |
| 1400 | −21 | −6 | | | | −26 | −15 | |
| 1500 | −21 | −6 | | | | −25 | −13 | |
| 1600 | −22 | −8 | | | | −26 | −15 | |
| 1700 | −24 | −11 | | | | −28 | −18 | |
| 1800 | −25 | −13 | | | | −29 | −20 | |
| 1900 | −26 | −15 | | | | −30 | −22 | |
| 2000 | −27 | −17 | | | | −31 | −24 | |
| 2100 | −28 | −19 | | | | −32 | −26 | |
| 2200 | −29 | −21 | | | | −33 | −27 | |
| 2300 | −30 | −22 | | | | −33 | −27 | |
| 2400 | −31 | −24 | | | | −33 | −27 | |

## 3–6. Cold climatic design type

*a. Location.* Cold conditions are found in the Northern Hemisphere in Canada, Alaska, Greenland, northern Scandinavia, northern Asia, and Tibet. Very small areas of the cold type may be found at higher elevations in both the Northern and Southern Hemisphere (for example, Alps, Himalayas, and the Andes).

*b. Temperature, humidity, solar radiation.*

(1) *Operational conditions.* Design conditions are 6 continuous hours with an ambient air temperature of −50°F (−46°C), a minimum snow surface temperature of −50°F (−46°C), wind speed less than 16 fps (5 mps), negligible solar radiation (horizontal surface), and RH tending towards saturation (see table 3–10).

(2) *Storage and transit conditions.* Same as operational conditions (see table 3–10).

**Table 3–10**
**Cold climatic design type C2: Daily cycle**

| Local | OPERATIONAL CONDITIONS (Natural Environment) | | | | | STORAGE AND TRANSIT CONDITIONS | | |
|---|---|---|---|---|---|---|---|---|
| | Ambient Air Temperature | | Solar Radiation | | RH | Induced Air Temperature | | RH |
| Time | C | F | Bph | W/m$^2$ | Percent | C | F | Percent |
| 0100 | −46 | −51 | Negligible | | Tending Towards Saturation | −46 | −51 | Tending Towards Saturation |
| 0200 | −46 | −51 | | | | −46 | −51 | |
| 0300 | −46 | −51 | | | | −46 | −51 | |
| 0400 | −46 | −51 | | | | −46 | −51 | |
| 0500 | −46 | −51 | | | | −46 | −51 | |
| 0600 | −46 | −51 | | | | −46 | −51 | |
| 0700 | −45 | −49 | | | | −45 | −49 | |
| 0800 | −44 | −47 | | | | −44 | −47 | |
| 0900 | −43 | −45 | | | | −43 | −45 | |
| 1000 | −41 | −42 | | | | −41 | −42 | |
| 1100 | −39 | −38 | | | | −39 | −38 | |
| 1200 | −37 | −35 | | | | −37 | −35 | |
| 1300 | −37 | −35 | | | | −37 | −35 | |
| 1400 | −37 | −35 | | | | −37 | −35 | |
| 1500 | −37 | −35 | | | | −37 | −35 | |
| 1600 | −38 | −36 | | | | −38 | −36 | |
| 1700 | −39 | −38 | | | | −39 | −38 | |
| 1800 | −39 | −38 | | | | −39 | −38 | |
| 1900 | −41 | −42 | | | | −41 | −42 | |
| 2000 | −42 | −44 | | | | −42 | −44 | |
| 2100 | −43 | −45 | | | | −43 | −45 | |
| 2200 | −44 | −47 | | | | −44 | −47 | |
| 2300 | −44 | −47 | | | | −44 | −47 | |
| 2400 | −45 | −49 | | | | −45 | −49 | |

## 3–7. Severe cold climatic design type

*a. Location.* Severe cold conditions are found in the Northern Hemisphere in the interior of Alaska extending into the Yukon in Canada. They also exist in the interior of the northern islands of the Canadian Archipelago, on the Greenland icecap, and in northern Asia.

*b. Temperature, humidity, solar radiation.*

(1) *Operational conditions.* The design condition is a minimum temperature of −60°F (−51°C). (For testing purposes, this is a cold soak temperature.) Solar radiation (horizontal surface) is negligible and RH toward saturation (because of low temperature, not high absolute humidity or vapor pressure). Wind speeds are less than 16 fps (5 mps). In rare cases where materiel is designed to operate solely in areas where the cold climatic design type applies, the reverse season, or expected maximum, temperature is 95°F (35°C).

(2) *Storage and transit conditions.* Same as paragraph 3–7*b*(1).

(3) *Daily Cycle.* No cycle is given because temperature, humidity, and solar radiation remain nearly constant throughout the 24–hour period.

## 3–8. Additional environmental elements

Several additional climatic or other environmental elements are known to have effects on some kinds of military materiel. The elements are discussed in the following paragraphs, and where possible, operational extremes are given.

*a. Rain.* The world's highest rainfall intensities are in areas that experience the constant high humidity conditions of the basic climates, particularly Southeast Asia. The operational value is an instantaneous (1 minute) rate of 0.03 inches per minute (in./min) (0.80 millimeters per minute (mm/min)). Based on data from Southeast Asia, this is the value exceeded only 0.5 percent of the hours in the rainiest month. For certain classes of materiel (for example, missiles and aircraft) that might be subject to erosion from the more extreme rainfall intensities, a design value of 0.07 in./min (1.80 mm/min), derived from the same area should be considered. This is the intensity that is exceeded only 0.1 percent of the hours in the most extreme month. Much higher rainfall intensities can occur, but they are normally of short duration and usually are restricted to small areas. The highest rainfall intensity ever officially recorded is 1.23 in./min (31 mm/min).

(1) A nominal drop-size spectrum for the 0.5 percent extreme is shown in table 3–11.

**Table 3–11**
**Rainfall intensities—Drop diameter range (mm)**

| Number per $m^3$ | 0.5–1.4 | 1.5–2.4 | 2.5–3.4 | 3.5–4.4 | 4.5–5.4 | 5.5–6.4 |
|---|---|---|---|---|---|---|
| | 2626 | 342 | 45 | 6 | 1 | <1 |

(2) The rainfall intensities shown in table 3–11 may be accompanied by intermittent winds up to 60 fps (18 mps). Higher wind speeds occur in hurricanes and typhoons (up to 148 fps or 45 mps), along with intense rain that falls almost horizontally penetrating cracks around doors, hatches, and other vertical openings. Rain affects the performance of electro-optical systems because of its attenuation of electromagnetic radiation in the atmosphere.

*b. Snow.* Three aspects of snow are discussed in relation to equipment design. Falling snow also affects the performance of electro-optical systems because of the attenuation and degradation of electromagnetic radiation in the atmosphere.

(1) *Snowfall rate.* No operational extreme is given for rate of snowfall accumulation because conditions are more severe when snow is windblown. (See para 3–8*b*(2)). The greatest snowfall accumulation during a 24–hour period ever recorded in the United States, the snowier sections of which receive as much snow as any part of the world, was 76 inches (in.) (1930 millimeters (mm)), a rate of about 3 inches per hour (76 mm/hour). Crystal sizes of snow particles range from 0.05 to 20 mm diameter with a median range of 0.1 to 1.0 mm. Larger sizes are associated with temperatures near freezing and light winds.

(2) *Blowing snow.* Operational extremes for blowing snow are given in terms of horizontal mass flux of snow particles, that is, the mass of snow moving horizontally across a unit area per unit time. Mass flux decreases significantly with increasing height; highest fluxes are found below 2 in. (0.05 m). Therefore, extremes of blowing snow are given for height intervals up to 33 ft (10 m). Design values should be based on the height of the equipment. The horizontal mass fluxes for operational extremes, with a wind speed of 44 fps (13 mps) at a height above ground or snow surface of 10 ft (3 m), are shown in table 3–12. When blown by strong winds, snow crystals are broken and abraded into roughly equal size grains with rounded or sub-angular corners. More particles occur in the size range of 7.87 × 10–4 to 1.57 × 10–3 in. (0.02 to 0.4 mm), where the size is the effective diameter as shown in figure 3–4, in the plane of measurement. Smaller sizes tend to occur at lower temperatures. Within the basic cold regions, the typical temperature range during periods of blowing snow is 14°F to −4°F (−10°C to −20°C). Within the cold and severe cold regions, snowfall is common at temperatures between −10°F and −20°F (−23°C to −29°C). Blowing snow may occur at temperatures as low as −40°F (−40°C).

**Table 3–12**
**Horizontal mass fluxes for blowing snow—Continued**

| Height | | Mass Flux | |
|---|---|---|---|
| **Feet** | **Meters** | **lbs./ft·/sec** | **kg/m²/sec** |
| 33.0 | 10.0 | $0.45 \times 10^{-3}$ | $2.2 \times 10^{-3}$ |
| 25.0 | 7.5 | $0.68 \times 10^{-3}$ | $3.3 \times 10^{-3}$ |
| 16.0 | 5.0 | $0.82 \times 10^{-3}$ | $4.0 \times 10^{-3}$ |
| 8.2 | 2.5 | $1.4 \times 10^{-3}$ | $6.9 \times 10^{-3}$ |
| 3.3 | 1.0 | $3.3 \times 10^{-3}$ | $16.0 \times 10^{-3}$ |
| 2.5 | 0.75 | $4.5 \times 10^{-3}$ | $22.0 \times 10^{-3}$ |
| 1.6 | 0.5 | $6.6 \times 10^{-3}$ | $32.0 \times 10^{-3}$ |
| 0.82 | 0.25 | $14.0 \times 10^{-3}$ | $66.0 \times 10^{-3}$ |
| 0.33 | 0.1 | $41.0 \times 10^{-3}$ | $200.0 \times 10^{-3}$ |
| 0.16 | 0.05 | $109.0 \times 10^{-3}$ | $530.0 \times 10^{-3}$ |

$$\sqrt{\text{length} \times \text{breadth}}$$

**Figure 3–4. Blown snow crystal diameter formula**

(3) *Snow load.* A third important effect of snow is the structural load imposed by accumulated snow upon buildings, shelters, vehicles, or other relatively large military items. Snow load extremes are not applicable to operations; however, designers of the above equipment may wish to consider the following extremes, which are for snow loads on the ground. Snow loads on military equipment would usually be less than on the nearby ground.

*(a)* Portable equipment usually involves small items, such as tentage, which may be moved daily. This equipment generally will shed snow; but in instances where it does not, distortion will be noticeable and daily cleaning mandatory. The design criterion for this equipment is based on 24–hour snowfalls. The snow load value is 10 lb/ft$^2$ (48.9 kg/m$^2$), which is equivalent to a depth of 20 in. (508 mm) of snow with a specific gravity of 0.1.

*(b)* Temporary equipment usually involves large items on which snow can collect, rigid shelters, portable hangars, and so forth, which can be cleared of snow between storms. This equipment will not sag much due to the snow loading but may collapse when its limits are exceeded. The design criterion for this equipment is based on snowfalls associated with storms lasting longer than one day. The snow load value is 20 lb/ft$^2$ (97.7 kg/m$^2$), which is equivalent to a snow depth of 40 in. (1016 mm) with a specific gravity of 0.1.

*(c)* Semi permanently installed equipment is usually demountable and not very mobile. Snow is not removed between snowfalls. The design criterion for this equipment is based on seasonal accumulation of snow. The snow load value is 48 lb/ft$^2$ (235 kg/m$^2$), which is equivalent to a snow depth of 96 in. (2438 mm) with a specific gravity of 0.1.

*c. Icing phenomena.* Icing phenomena include glaze (freezing rain), hoarfrost, and rime, which cause problems of ice accretion on aircraft and other materiel, and ice fog, which interferes with visibility. Although reliable and systematic data on ice accumulation are scarce, fairly large areas of the United States and Europe can expect to endure seven or more ice storms per year. The effects of the storms may last from a few hours to several days. In the same areas, probably one storm per year on the average is severe enough to cause some damage. In perhaps one year out of two or three, ice accumulation will probably be a half-inch or more. Therefore, if all-weather operation of materiel is desired within the areas where icing may occur, the operational design value should be for one-half inch of glaze with specific gravity of 0.9. This includes the colder sections within the basic design type and all the cold and severe cold areas. If equipment failure during the time of icing can be tolerated, the question of withstanding more severe storms without permanent damage becomes important. For withstanding, the values as given in MIL–HDBK–310 are as follows:

(1) 3 in. (76 mm) glaze, specific gravity 0.9.

(2) 6 in. (152 mm) glaze and rime mixed, specific gravity 0.5.

(3) 6 in. (152 mm) rime near the surface increasing linearly to 20 in. (508mm) at 400 ft (122 m), specific gravity 0.2.

(4) Deposits of hoarfrost, the only type of ice accretion that occurs when air temperatures are well below 32°F (O°C), may be several inches thick but will have a specific gravity of less than 0.2.

(5) Ice fog consists of suspended ice crystals averaging 1.97 × 10–4 to 7.87 × 10–4 in. (5 to 20 micrometers (µm)) in diameter. In areas where sufficient water vapor is present, ice fog occurs mainly at temperatures below −20°F (−37°C); ice fog may be very dense, limiting visibility of a few feet. Ice fog is often locally induced by the operation of motor vehicles, power plants, and weapon systems. It is usually high in concentration of contaminants from the burning of hydrocarbon fuels and explosive fuels. It affects the performance of electro-optical systems because of its attenuation and degradation of electromagnetic radiation in the atmosphere.

*d. Hail.* Hail occurs too infrequently to warrant specification of an operational extreme. When hail-caused equipment failure would endanger life or limb, designers should consider the possibility of encountering hailstones up to 2 in. (51 mm) in diameter. The largest hailstone ever recorded measures 5.6 in. (142 mm) in diameter.

*e. Wind.* Wind is probably the most complex of all climatic elements affecting materiel. Wind effects are difficult to analyze because wind is a vector quantity subject to rapid temporal and areal changes in speed and direction. In addition to parameters of average speed and direction, a complete description of wind includes the random motions of widely different scales and periods called atmospheric turbulence or eddies. The wind forces on a structure result from differential pressures, positive and negative, caused by an obstruction to the free flow of the wind. Thus, these forces are functions of the velocity and turbulence of the wind and of the orientation, area, and shape of the elements of the structure.

(1) For operations, the following extremes, as given in MIL–HDBK–310, are a steady wind speed of 73 fps (22 mps) and a gust of 95 fps (29 mps).

(2) The above operational wind speeds are for a height of 10 ft (3 m). Multiplication factors for obtaining speeds at the height of equipment are shown in table 3–13.

**Table 3–13**
**Wind speed multiplication factors at selected heights**

| Height | | Operational | |
|---|---|---|---|
| Meters | Feet | Steady winds | Gusts |
| 1.5 | 0.5 | 0.917 | 0.946 |
| 3 | 10 | 1.000 | 1.000 |
| 6 | 20 | 1.090 | 1.057 |
| 9 | 30 | 1.147 | 1.092 |
| 12 | 40 | 1.189 | 1.117 |
| 15 | 50 | 1.222 | 1.137 |
| 23 | 75 | 1.286 | 1.175 |
| 30 | 100 | 1.334 | 1.202 |
| 61 | 200 | 1.454 | 1.271 |
| 91 | 300 | 1.510 | 1.313 |
| 122 | 400 | 1.586 | 1.343 |
| 152 | 500 | 1.631 | 1.368 |
| 305 | 1000 | 1.778 | 1.445 |

*f. Sand and dust.* Sand and dust are usually differentiated on the basis of particle size, although there are no generally accepted specific size limits for the two kinds of particles. For most military applications, it is important to distinguish between the smaller particles (dust) and the larger particles (sand) because of their different effects on equipment. Dust can penetrate small openings, causing undue wear to moving parts, and interfere with electrical contacts. Engine and electronic cooling system ingestion of particulate materials require evaluation; complex chemical compositions can create engine deposits or a conductive electrical path. Blowing sand, which may be too large to penetrate the smaller openings, can erode and abrade the outside of equipment. Sand and dust present in the air affect the performance of electro-optical systems because of their attenuation and degradation of electromagnetic radiation in the atmosphere. Airborne particulate materials from natural and induced sources can create degraded visual environments (brownout) with near zero visibility for rotary/fixed wing aircraft and ground operations. Particles vary in diameter from 3.94 × 10–6 to 3.94 × 10–2 in. (0.1 to 1,000 µm), but most airborne particles are less than 2.91 × 10–3 in. (74 µm).

(1) Three operational levels are given; selection of the appropriate one depends on intended use of the materiel under consideration. Items likely to be used in close proximity to aircraft operating over unpaved surfaces should be designed for particle concentrations of about 1.32 × 10–4 lb/ft$^3$ (2.19 × 10–3 kg/m$^3$) in multidirectional strong winds (downwash from helicopter rotors). The extinction coefficient for this particle concentration is estimated to be 161 miles$^{-1}$ (100 kilometers (km)$^{-1}$) for visible wavelengths through the middle infrared (4.72 × 10–4 in (12 µm)). Such particles range in size up to 1.97 × 10–2 in. (500 µm) in diameter. Items never used or never exposed in close proximity to operating aircraft but which may be found near operating surface vehicles, should be designed for particle concentrations of 6.61 × 10–5 lb/ft$^3$ (106 × 10–3 kg/m$^3$) with wind speeds up to 59 fps (18 mps) at a height of 10 ft (3 m). Particle sizes will range from less than 2.91 × 10–3 in. (74 µm) in diameter to 3.94 × 10–2 in. (1,000 µm), with the bulk of the particles ranging in size from 13.8 × 10–3 in. (74 to 350 µm).

(2) The above two categories are likely to include most military items. However, items that are ensured of being subjected only to natural conditions should be designed for particle concentrations of 1.10 × 10–5 lb/ft$^3$ (0.177 × 10–3 kg/m$^3$) with wind speeds of 59 fps (18 mps) at a height of 10 ft (3 m). Under these conditions, the bulk of the particle sizes are likely to be less than 5.90 × 10–3 in. (150 µm) except that some large particles (up to 3.94 × 10–2 in., 1,000 µm) may be in motion within several feet of the ground. In all categories, temperatures are typically above 70°F (21°C), and relative humidity is less than 30 percent. For testing purposes, particle sizes up to 5.90 × 10–3 in. (150 µm) should be used if the primary concern is with the penetration of fine particles. If the abrasion effect of blowing sand is the primary concern, particle sizes up to 3.94 × 10–2 in. (1,000 µm) should be used, but the bulk of the particles should be between 5.90 × 10–3 and 1.97 × 10–2 in. (150 and 500 µm). Many items, such as rifles, vehicles, and helicopters, may be exposed to particles up to 3.94 × 10–2 in. (1,000 µm) that can penetrate the space between moving parts.

*g. Ozone concentration.* For operations, a value of 1.37 × 10–8 lb/ft$^3$ (220 × 10–3 kg/m$^3$) is recommended.

*h. Atmospheric pressure.* Atmospheric pressure usually is not considered in the design and testing of military equipment. Ambient pressure, however, may be important for a few types of equipment, for example, items that require oxygen for combustion and sealed units, which might explode or collapse under abnormally low or high pressure.

(1) *High pressure.* The operational extreme high pressure is 1,080 mbar (31.89 inches of mercury (inHg)).

(2) *Low pressure.* The operational extreme low pressure is estimated to be 508 mbar (15.00 inHg) at 15,000 ft (4,572 m), the highest elevation at which Army equipment is likely to be used. At sea level, the operational extreme is 877 mbar (25.90 inHg).

### 3–9. Combined environmental effects

The climatic design types in this regulation are based primarily on temperature extremes and secondly on humidity extremes. The climatic elements discussed in paragraph 3–8; however, may interact concurrently with temperature and humidity and with each other to produce effects on materiel either different or more severe than the sum of the effects caused by the separate elements acting independently. These are known as combined or synergistic environmental effects. The fact that these synergistic effects exist is one of the prime arguments for conducting field tests because it is extremely difficult or impossible to reproduce the interacting environmental factors concurrently in a test chamber.

## Chapter 4
## Global Operating Environments

### 4–1. Geographic classification framework

GOE and OE framework builds on Bailey's ecoregions method of geographical classification (*Ecosystem Geography, Bailey*, R.G., 1996) to address atmospheric, terrestrial, and biological consideration for the design and performance of material worldwide. The Bailey classification system is used both nationally and internationally, including being used to manage DoD and other federal lands. This standardized geographical classification system provides—

*a.* Direct connectivity to a large volume of existing environmental information.

*b.* The ability to classify an area of interest anywhere in the world so that direct analogs in more accessible areas can be identified for RDTE activities.

*c.* Identifying environmental factors that have a high possibility of affecting performance of equipment, materials, or personnel during operations in these areas.

## 4–2. Global operational environments

*a.* Each climatic region comprises land areas characterized by broad similarities in mean annual temperature, precipitation, and evapotranspiration. Three of the regions are humid and differentiated on the basis of temperature regime—

(1) Polar—low temperatures, severe winters, and small amounts of precipitation.

(2) Humid temperate—rainy with mild to severe winters.

(3) Humid tropical—rainy with no winter season.

(4) Dry—defined on the basis of moisture deficit and covers land areas that transect the otherwise humid climates.

*b.* The geographic distribution of these four regions is described below.

(1) *The polar region.* This region occupies approximately 26 percent of the earth's land area, including Antarctica, and is located at high latitudes with climate controlled by polar and Arctic air masses. This area is generally cool with severely low temperatures in the winter. Annual precipitation is low with most of it occurring in the summer. Because of the low air and soil temperatures, total annual evaporation is also limited. Traditionally, the Army has established an operational lower limit at −50°F (−46°C) with storage at −60°F (−51°C). The Antarctic Treaty of 1959 limits military activity in Antarctica to scientific research and other peaceful purposes.

(2) *The humid temperate region.* This region lies in the mid-latitudes between 30° and 60° north and 30° and 60° south latitude, covers approximately 16 percent of the earth's land area, generally consists of coniferous and broad-leafed forests, and is concentrated in North America, Central Europe, southern China, eastern South America, coastal Southeastern Australia, and New Zealand. This area is diverse in climatic characteristics, including pronounced seasonal temperature variation, a high frequency of precipitation, and periodic freeze-thaw cycles. Most of the world's industrialized nations lie within this region.

(3) *The humid tropical region.* This region covers approximately 26 percent of the Earth's land surface, lying between the Tropic of Cancer and Tropic of Capricorn in Central and South America, Africa, and southeastern Asia. This region is characterized by mean monthly temperatures above 64°F (18°C), variable to constant high humidity, and no winter season. Average annual rainfall is abundant but can be seasonal. The world's tropic rainforests and major watersheds are found in these regions.

(4) *The dry region.* This region encompasses semi-arid and arid areas, covering approximately 32 percent of the Earth's land area, including western and southwestern North America, the Atacama and Patagonia regions of South America, the interior of Australia, Central Asia, Southwest Asia, and Northern Africa. This region is defined on the basis of atmospheric moisture balance, where potential evapotranspiration exceeds precipitation. The area includes regions that vary from dry deserts to high-altitude steppes. Aridity can be constant throughout the year or seasonal. This region includes the world's hottest areas where ambient temperatures can exceed 120°F (49°C) during the hot season. The GOEs are illustrated in figure 4–1.

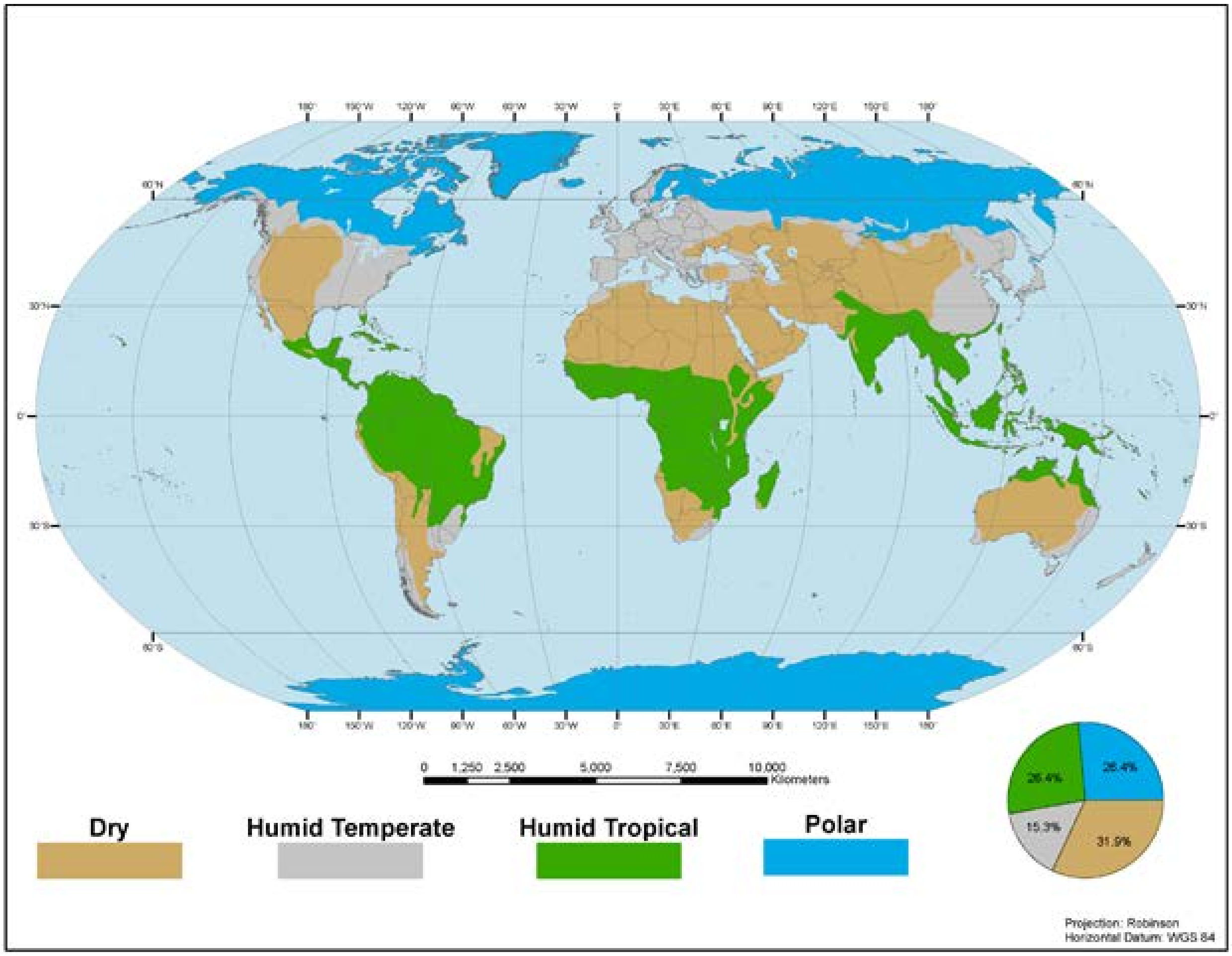


Figure 4–1. Operational environments (after Bailey 1998)

## 4–3. Operational environments descriptions

OEs are 15 subdivisions of the GOEs plus 4 special environments that are selected for their demonstrated effects on operations of military equipment. Table 4–1 depicts the distribution of the GOEs and the associated OEs by percentage of global land area. Figure 4–2 illustrates the OEs that are subdivisions of the GOEs. All OEs are described below along with identification of the environmental factors of greatest concern. Figure 4–2 depicts the distribution of the GOEs and the associated OEs by percentage of global land mass.

**Table 4–1**
**Distribution of global operational environments and operational environments by percentage of global land area**

| Global Operational Environment | Global Land Area (%) | OE | % of Global Land Area |
|---|---|---|---|
| **Polar (Cold) (Antarctic Only)** | 9 | Ice cap (Antarctic) | 9 |
| **Polar (Cold) (Excluding Antarctica)** | 17 | Ice cap | 1 |
| | | Tundra | 4 |
| | | Subarctic | 12 |
| **Humid Temperate** | 16 | Warm Continental | 2 |
| | | Hot Continental | 2 |

**Table 4–1**
**Distribution of global operational environments and operational environments by percentage of global land area—Continued**

| Global Operational Environment | Global Land Area (%) | OE | % of Global Land Area |
|---|---|---|---|
| | | Subtropical | 4 |
| | | Marine | 2 |
| | | Prairie | 4 |
| | | Mediterranean | 2 |
| **Dry** | 32 | Tropical/Subtropical Steppe | 10 |
| | | Tropical/Subtropical Desert | 14 |
| | | Temperate Steppe | 4 |
| | | Temperate Desert | 4 |
| **Humid Tropical** | 26 | Savanna | 17 |
| | | Rainforest | 9 |

*Note*. This does not include special environments such as hot-humid costal desert, littoral, mountain, and sea environments.

*a. Polar region.* This region is divided into three OEs: icecap, tundra, and subarctic. Throughout this region, the environmental factors of greatest concern are low temperatures, high winds, ice fog/whiteout, frozen soil, surface snow/ice, precipitation (snow, freezing rain, hail, and rain, depending on season and temperature), the difficulty of movement over thawed ground, and landforms such as mountain ranges and watersheds that inhibit movement. In the subarctic OE, there are additional concerns over movement due to longer thawed season, larger rivers that are unfrozen for longer periods, more vegetation, and wider distribution of mountain ranges. Temperature inversions are another atmospheric factor that are very prevalent in the polar regions. These occur when the temperature is colder at the bottom of the layer and warms with height, versus normally cooling with height. This will cause mountains to warm with height to an extent depending on how deep the inversion is. These inversions are normally formed when stagnant conditions become present with calm winds and clear skies, which allows optimal radiational cooling to occur. This is then exacerbated even further due to the limited amount of solar radiation that is experienced during the winter months. It then builds a very stable layer at the surface and continues to build in depth with further cooling, which can be as high as several hundred meters and have a temperature gradient of 59°F (15°C) or warmer at the top of the inversion. It is then this stable layer that traps the pollutants and water vapor in the lower levels, which reduces visibility. These temperature inversions also cause sound and shockwaves to travel much farther near the surface, due to the refraction of the inversion. This refraction of light and sound can also affect other materiel, including targeting systems and communication systems.

(1) *Icecap.* The icecap includes the large ice sheets, such as those found in Greenland, Antarctica, and on small islands in the high northern latitudes. Mean annual temperatures are constantly below freezing, with low amounts of annual precipitation occurring as snow, and landscapes generally devoid of vegetation and soils.

(2) *Tundra.* Located in the northern continental fringes of North America, Iceland, coastal Greenland, and the Arctic coast of Eurasia, this OE has long, severe winters and very short, cool summers. The mean monthly temperature of the warmest month is between 32°F and 50°F (0°C and 10°C). Annual precipitation is less than 8 in. (200 mm), but low rates of evaporation make the climate humid. Vegetation consists of low-growing forbs, grasses, lichens, mosses, and brush with treeless plains. Soils are poorly developed and have a permanently frozen sub layer (permafrost) that may seasonally thaw at the surface. Surface and subsurface drainage is poor, creating muddy summertime conditions. Tundra is predominately composed of coastal plains, low-interior and high-interior plains, and lesser areas of low- and high-relief mountains.

(3) *Subarctic.* The subarctic OE is found only in the northern hemisphere and at least 1 month of the year has a mean monthly temperature above 50°F (10°C). The boundaries of this OE are ecosystem defined and not latitude defined. Precipitation is concentrated in the three summer months. Vegetation consists primarily of needle-leaf forests and open woodlands. Soils are acidic, seasonally frozen, and contain discontinuous permafrost. Numerous lakes, ponds, peat bogs, and swamps exist because of poor subsurface drainage. Subarctic is composed of coastal plains, high-relief and low-relief mountains, lesser areas composed of low and high-interior plains, and extensive areas of rock and non-cohesive sand.

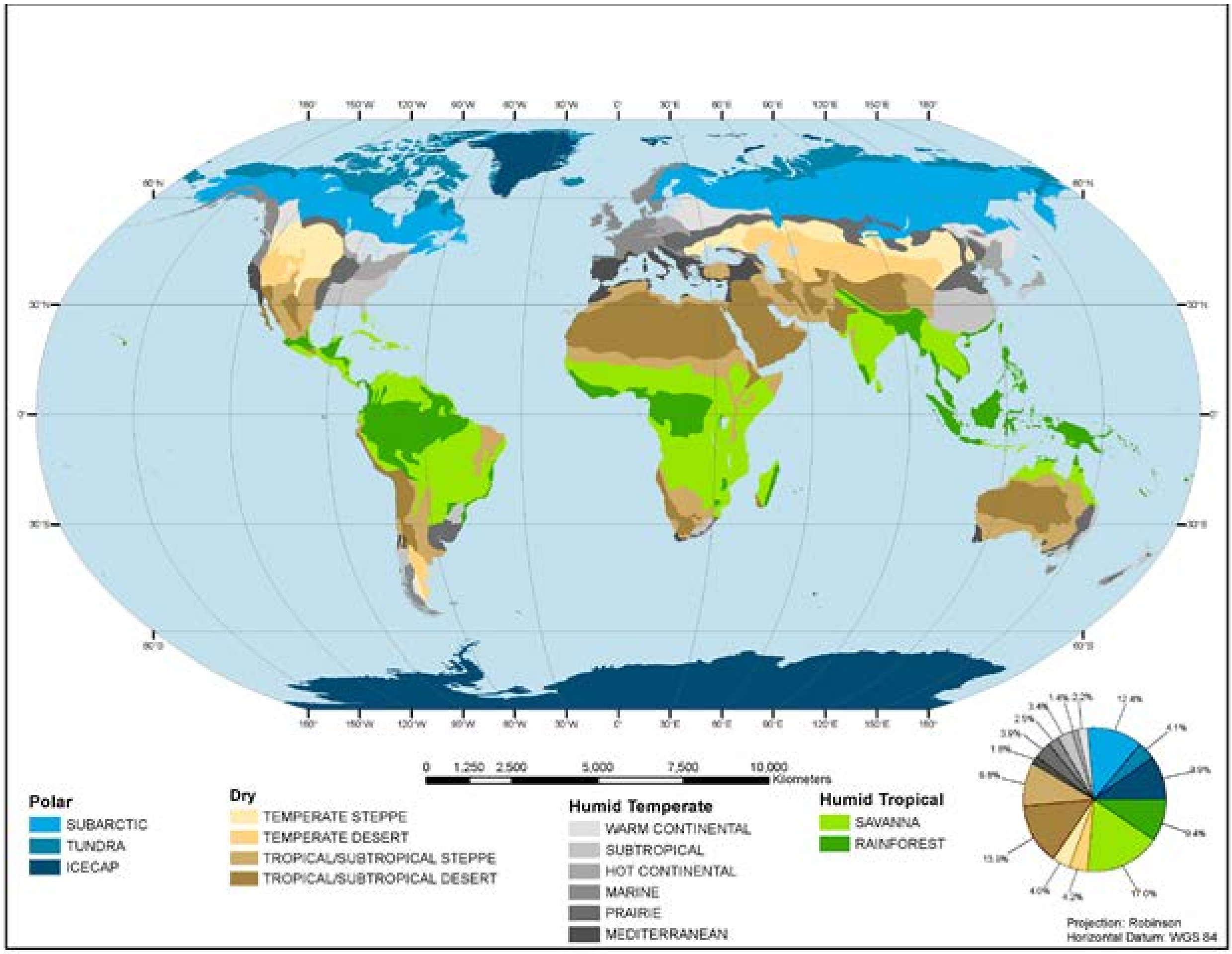



**Figure 4–2. Global operational environments subdivided to the operational environments level**

*b. The humid temperate region.* This region is divided into six OEs: warm continental, hot continental, subtropical, marine, prairie, and Mediterranean. By definition, temperate zones do not contain climatic extremes. However, the seasonal variations can be wide ranging. These variations introduce frequent rains, mud, and on a seasonal basis, severe winters with temperatures well below freezing. The forests, rivers, and low to moderate altitude mountain ranges can inhibit military movements. This regulation does not consider the effects of widespread urbanization, but drafters of capability requirements documents and specifications must.

(1) *Warm continental.* This OE occurs in the northern hemisphere, specifically the northeastern United States; southeastern Canada; southeastern Siberia; northern Japan; and eastern Europe, including the Balkans and Russia as far east as the Ural Mountains. It is characterized by very cold, snowy winters, warm summers, and no dry season. These areas have 4 to 7 months when mean monthly temperatures exceed 50°F (0°C). The mean temperature during the coldest month is below 32°F (0°C), and absolute minimum temperatures may be below −25°F (−32°C). Snow and freeze-thaw cycles are common during the winter. Precipitation occurs throughout the year but is substantially greater during the summer. Vegetation consists of mixed coniferous and deciduous forests. Soils have a rich organic layer (humus) and are generally acidic. Hydrologic features include perennial streams, lakes, bogs, and wetlands. Warm continental is predominately composed of low- and high-relief mountains, with lesser areas of basin and range, and plateaus.

(2) *Hot continental.* This OE is located in central and eastern parts of the United States, northern China, Korea, northern Japan, and Central and Eastern Europe. It has hot, humid summers with the mean temperatures in the warmest month exceeding 72°F (22°C) and cool winters with the mean temperature in the coldest month less than 32°F (0°C). These climatic characteristics are similar to but more moderate than those found in the warm continental OE. The natural vegetation is deciduous forest, dominated by tall broadleaf trees. Soils are rich in humus. Human occupancy and agriculture have largely modified these locations, resulting in second- and third-growth forests. Hot continental includes low-interior plains, high-interior plains, and high-relief mountains.

(3) *Subtropical.* This OE includes the southeastern United States, southern China, Taiwan, Uruguay, southern Brazil and Argentina, the eastern coast of Australia, and the North Island of New Zealand. The subtropical OE is rainy and characterized by mild winters, with mean monthly temperatures that are greater than 32°F (0°C), and hot summers with high humidity. The mean temperature of the warmest month is above 72°F (22°C). Rainfall is ample throughout the year but greatest during the summer months due to atmospheric cyclonic activity. Rivers and streams flow continuously. The dominant vegetation is forest, including broadleaf evergreen and pine. Soils are strongly leached, with concentrations of aluminum and iron oxides. Subtropical includes high-relief mountains, high-interior plains, and plateaus.

(4) *Marine.* The marine OE is located on continental west coasts and islands in latitudes between 40° and 60°. These locations are characterized by a damp, humid climate with abundant cloud cover, rainy and mild winters, and warm summers. Mean monthly temperatures exceed 32°F (0°C), and precipitation is abundant but markedly reduced during the summer months. Dominant vegetation is needle-leaf coniferous forest including redwoods, firs, and cedars. Mosses and ferns dominate the forest floor. Soils are strongly leached and acidic with heavy surface organic deposits. Marine includes high-interior plains, low-interior plains, coastal plains, high- and low-relief mountains, and major basins.

(5) *Prairie.* The prairie OE is a transition zone in the mid-latitudes between forest and desert. Prairie locations include mid-North America from Texas to southern Alberta and Saskatchewan, the Pampas in Argentina, Uruguay and southern Brazil, the Puszta of Hungary, the northern Russian steppes, South Africa, Manchuria, and Australia. Mean temperatures exceed 72°F (22°C) during the warmest month and are less than 32°F (0°C) in the coldest months. Precipitation occurs primarily in the summer months. Vegetation consists of both forests and tall grasslands. Soils have rich, organic surface horizons that are extremely fertile. Human settlement and agriculture have largely modified these locations. In addition, the prairie OE can be located on coastal plains and plateaus and may be dissected by mountains.

(6) *Mediterranean.* The Mediterranean OE is situated along the western margins of continents mainly in the northern hemisphere between 30° and 45° north latitude, including southern California, Chile, southern South Africa, segments of coastal Australia, and coastlines of the Mediterranean Sea. This OE is characterized by dry, hot summers that often experience severe drought and rainy, warm winters. Mean monthly temperatures exceed 72°F (22°C) during the warmest month and are less than 64°F (18°C) in the coldest months. Natural vegetation consists of hard-leafed evergreen trees and shrubs. Soils are typical of semi-arid grasslands. Topography ranges between coastal lowlands to high mountain ranges inland that often produce high-energy streams and deposition of alluvial fans in low-lying areas. Mediterranean includes high-relief mountains, high-interior plains, low-interior plains, low-relief mountains, and sand sea/dunes.

*c. The humid tropical region.* This region is divided into two OEs: savanna and rainforest. Environmental factors of greatest concern are heavy/frequent precipitation, constant high humidity, and constant warm temperatures. These combine to produce dense vegetation; destructive combinations of micro- and macro-organisms; and in coastal regions, extremely rapid corrosion of materials and equipment. Mobility is constrained in rainforest areas because of dense vegetation, soft soils, and frequent watercourses.

(1) *Savanna.* This OE is the transition zone between Rainforest and more arid locations. Large areas of savanna surround rainforest locations in Brazil and central Africa and exist in India and northern Australia. Mean temperatures during all months exceed 64°F (18°C) with an annual variation less than 22°F (12°C). The savanna is characterized by distinct wet summer (heavy rainfall) and dry winter seasons (both more than two months in length). Dominant vegetation includes tall grasslands that contain drought-tolerant shrubs and trees. Dense tropical forests occur along streams. Rivers and streams experience high seasonal fluctuations. Plains and plateaus are common surface features. Soils are characterized by heavy leaching. Savanna includes low-interior plains and plateaus.

(2) *Rainforest.* This OE exists in equatorial locations from 10° north to 10° south latitude, including the central African Congo, South American Amazon, parts of southeastern Asia, and the Indonesian Islands. The rainforest has a wet equatorial climate and no distinct dry season, and all months exceed 3 in.(60 mm) of rainfall. Mean monthly temperatures during all months exceed 64°F (18°C) with an annual variation less than 5°F (3°C). Undisturbed natural vegetation is rainforest consisting of triple canopy in some places. Soils are rich in hydroxides of iron, magnesium, and aluminum. The stream flow is constant throughout the year. The rainforest OE may include major river basins, plateaus, low-interior plains, high-interior plains, and coastal plains.

*d. The dry region.* This region is divided into four distinct OEs: tropical/subtropical steppes, tropical/subtropical deserts, temperate steppes, and temperate deserts. Environmental factors shared by all dry region OEs are extreme dust conditions on at least a seasonal basis. Movement can be inhibited by rough or steep terrain, sand dunes, and loose soils. Rains are infrequent but are generally severe when they occur, resulting in flash floods. Snow, ice, and extreme cold temperatures can occur in the colder, high-altitude deserts. Within the dry regions, the tropical/subtropical deserts provide the world's highest ambient temperatures, which may exceed 120°F (49°C); highest levels of solar radiation; and solar-induced internal and external (surface) temperatures for equipment and personnel. These are the world's driest areas; consequently, dust is a constant problem made worse by winds and/or military operations.

(1) *Tropical/subtropical steppe.* This OE is the semi-arid transition zone between tropical deserts to the north and south and more humid savanna OE toward the equator. Major locations include the southwestern United States, Kalahari Desert of South Africa, northeastern Brazil, and large portions of Australia. Potential annual evaporation rates exceed precipitation, and all months have monthly mean temperatures above 32°F (0°C) with mean maximum monthly temperatures above 64°F (18°C). Rainfall varies greatly, ranging between 10 to 30 in. (250 and 750 mm) annually. Vegetation consists of grasslands with localized shrubs and woodlands. Tropical/subtropical steppe includes major river basins, low-interior plains, coastal plains, and mountains.

(2) *Tropical/subtropical desert.* This OE includes the vast desert belt of the Sahara in North Africa, Arabia, the Thar Desert in Iran and Pakistan, the Tibetan plateau, the Sonoran Desert of the southwestern United States and northern Mexico, and the Great Australian Desert. Except where modified by high altitude (for example, the Tibetan plateau) these locations are characterized by extremely arid conditions with high air and soil temperatures throughout the year. Mean monthly temperatures exceed 64°F (18°C) in all months of the year. Direct solar radiation is very high, and extreme temperature variations occur between day and night. Annual rainfall is less than 8 in. (200 mm). Vegetation consists of drought-adapted plants that provide negligible ground cover. Soils are sandy and rocky, may have significant bedrock exposure at the surface, and are sources of natural and induced atmospheric dust. Stream channels (arroyos and wadis) are incised, intermittent, and subject to flash flooding. Tropical/subtropical desert includes sand sea/dunes, low-interior plains, plateaus, and major river basins.

(3) *Temperate steppe.* This OE includes the Columbia Plateau and northern Great Plains of the central United States and southern Canada, the Steppes of Central Asia, the Pampas of South America, and the Veldt of Africa. This OE is characterized by a semi-arid continental climate with cold winters and warm to hot summers. The coldest month has a mean temperature below 32°F (0°C), and the warmest month has mean temperatures above 64°F (18°C). Maximum rainfall occurs in the summer with mean annual precipitation of 1 to 10 in. (30 to 250 mm), but overall annual evaporation exceeds precipitation. Vegetation is typically short-grass prairie and shrubs (sagebrush). Soils have little organic content and contain clay horizons and salt accumulations. Temperate steppe includes sand sea/dunes, basin and range, and high-relief mountains and plateaus.

(4) *Temperate desert.* This OE includes the Great Basin of North America, the Turkestan and Gobi regions of Central Asia, and the Patagonia in Argentina. These locations are interior to continents. They are arid with hot summers, cold winters, and limited rainfall. These locations have the highest percentage of possible sunshine of all mid-latitude climates. At least one month has a mean monthly temperature below 32°F (0°C), and some precipitation occurs as snow. Vegetation consists of sparse shrubs. Soils are low in humus and have high calcium carbonate content. Temperate desert includes sand sea/dunes and low-relief mountains.

*e. Special environments.* There are some special environments or conditions that introduce specific challenges to the operation, storage, and transport of military equipment intended for worldwide use. These are added to the list of OEs to ensure consideration during RDTE of materiel and include the following:

(1) *Hot-humid coastal desert.* The hot-humid coastal desert exists only along a very narrow coastal strip bordering bodies of water with high surface temperatures (that is, the Persian Gulf and the Red Sea). High humidity, high temperatures, and high concentrations of salt aerosols combine to produce extremely high corrosion rates that degrade materials and equipment.

(2) *Littoral.* Littoral environments are found along the coasts of all oceans and along the banks of rivers and lakes. The proximity of water bodies results in particular types of landforms, such as sand dunes, steep cliffs, lagoons, bays, and estuaries. Coastal littoral OEs are subject to salt spray and salt fall. Biologically, the availability of water and increased humidity creates a microclimate that enables a variety of unique plant and animal life. The shallow water of these areas often creates muddy waters that can affect military operations (for example, infiltration by sea).

(3) *Mountains.* Mountain ranges are found within all OEs and cover approximately 22 percent of the earth's land surface. Lower mountain environments, those below 10,000 ft (3,048 m) in elevation, generally exhibit the climatic characteristics associated with adjacent lowlands. As elevation increases, the pattern of climate and vegetation modifies significantly, which greatly increases the complexity of military operations and negatively affects personnel and equipment. Higher mountains, those over 10,000 ft (3,048 m), can introduce seasonal or nighttime microclimates equivalent to those found in the subarctic military operating environment. For example, although the Tibetan Plateau (comprising 1 percent of the earth's land mass) is part of the tropical/subtropical desert OE, it exhibits temperatures more closely identified with the subarctic OE. Mountain environments can affect aviation operations (for example, lift of helicopters). The operational extreme low pressure is estimated to be 508 mbar (15.00 in Hg) at 15,000 ft (4,572 m) at 32°F (0°C), the highest elevation at which Army equipment is likely to be used. Figure 4–3 depicts the mountain environments within the OEs.

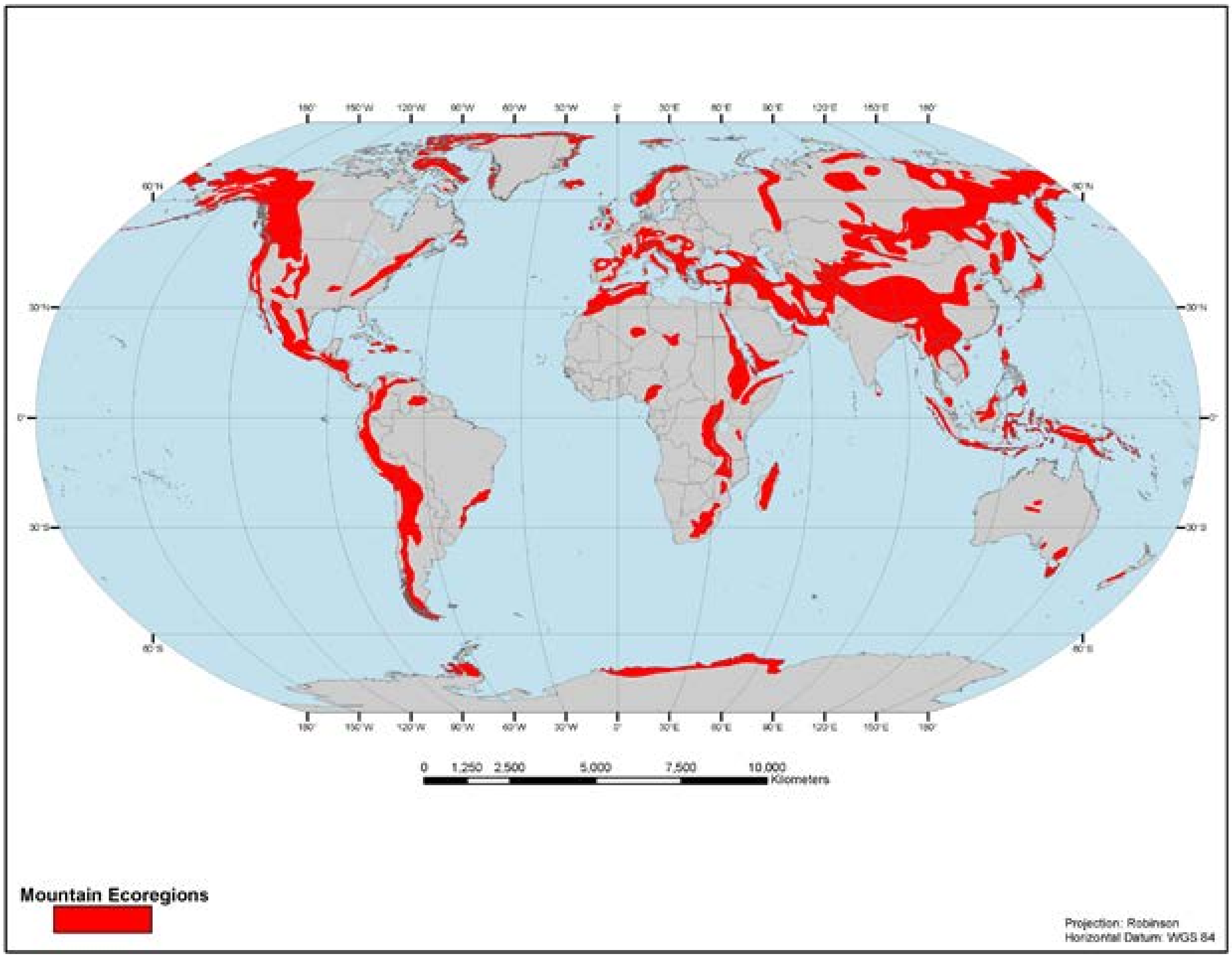



**Figure 4–3. Mountain environments within the operating environments framework**

(4) *Sea environment.* The sea environment is not within the scope of this document, though salt fog and salt spray effects on materiel items are briefly discussed. Logistics may be affected by cold sea environments (for example, superstructure sea spray icing when loading and shipping equipment). See AECTP–230 for additional information.

## Chapter 5
## Environmental Factors and Their Effects on Military Equipment

### 5–1. Environmental factors

*a.* Table 5–1 contains specific environmental factors classified as either atmospheric, terrain, or biological. These environmental factors can be described in terms of daily cycles, annual or monthly extremes, annual or monthly averages, total yearly values, or the frequency of occurrence. Such data and additional details on the factors and their effects on military equipment have been compiled in several military publications, including MIL–HDBK–310.

*b.* Some effects, like reduced visibility, can be the result of one or several environmental factors. These effects are addressed under the appropriate environmental factors.

**Table 5–1**
**Environmental factors classified as atmospheric, terrain, or biological**

| | **Environmental Factors** |
|---|---|
| **Atmospheric** | Temperature<br>Precipitation—Rain, Snow<br>Humidity |

**Table 5–1**
**Environmental factors classified as atmospheric, terrain, or biological—Continued**

| | Environmental Factors |
|---|---|
| | Fog / Ice Fog / Whiteout<br>Wind<br>Salt / Salt Fog<br>Solar Radiation<br>High Elevation (low pressure) |
| **Terrain** | Landforms (topography, slope, relief)<br>Exposed Rock<br>Sand<br>Mud<br>Dust<br>Surface Water<br>Frozen Soil<br>Surface Snow and Ice |
| **Biological** | Vegetation<br>Microbiota<br>Macrobiota |

## 5–2. Atmospheric factors

Atmospheric factors considered in this regulation consist of temperature, humidity, precipitation, fog, wind, salt spray, solar radiation, and high elevation.

*a. High temperature.*

(1) The highest temperatures in the world are found seasonally in low-altitude tropical/subtropical desert OEs, such as the northern and western Sahara Desert, desert areas in the southwestern United States, the low-lying desert areas of the Persian Gulf, the deserts of central and eastern Australia, and parts of eastern Pakistan. During the warmest summer month in these areas, daily maximum temperatures exceed 100°F (38°C) 99 percent of the days and exceed 120°F (49°C) less than 1 percent of the days. Direct exposure to solar radiation can significantly increase exposed surface and ground temperatures above the ambient air temperature and approach 160°F (71°C) in closed storage conditions (see MIL–HDBK–310). Environmental data from Operation Desert Storm indicates that temperatures in solar-loaded storage locations can reach nearly 190°F (88°C). The ground surface can attain temperatures 59°F to 86°F (15°C to 30°C) higher than the free air temperature, depending on radiation, conduction, wind, and turbulence. Figure 5–1 depicts global distribution of maximum temperatures.

(2) High temperatures can detrimentally affect Soldier performance so that operations in hot deserts require careful monitoring of Soldier physical condition. High temperatures cause differential expansion of dissimilar materials, an increased rate of chemical reactions, lowered lubricant viscosity, electronic circuit instability, outgassing, deterioration of desired functional characteristics, and other effects. The increased rate of chemical reaction will cause batteries to deteriorate rapidly. Coatings on equipment may efficiently absorb direct sunlight. When coupled, materials with low thermal conductivity and low thermal mass (that is, composites) can cause the temperature of objects to rise significantly above the ambient temperature. High temperatures are particularly damaging to energetic materials (explosives, propellants, and primers) along with adhesives. Planning of tests must consider maximum induced high temperatures to verify storage/service life requirements for ammunition.

*b. Low temperature.*

(1) The lowest worldwide temperatures are found in the polar regions and the interior continental areas north of the Arctic Circle (for example, northeastern Asia, interior Alaska extending into Canada, and on the Greenland Ice Cap). During January in these areas, 10 to 50 percent of the month has temperatures below −25°F (−32°C) with as much as 95 percent of the month colder than −25°F (−32°C) in continental northeastern Asia. Figure 5–2 presents the global distribution of minimum temperatures.

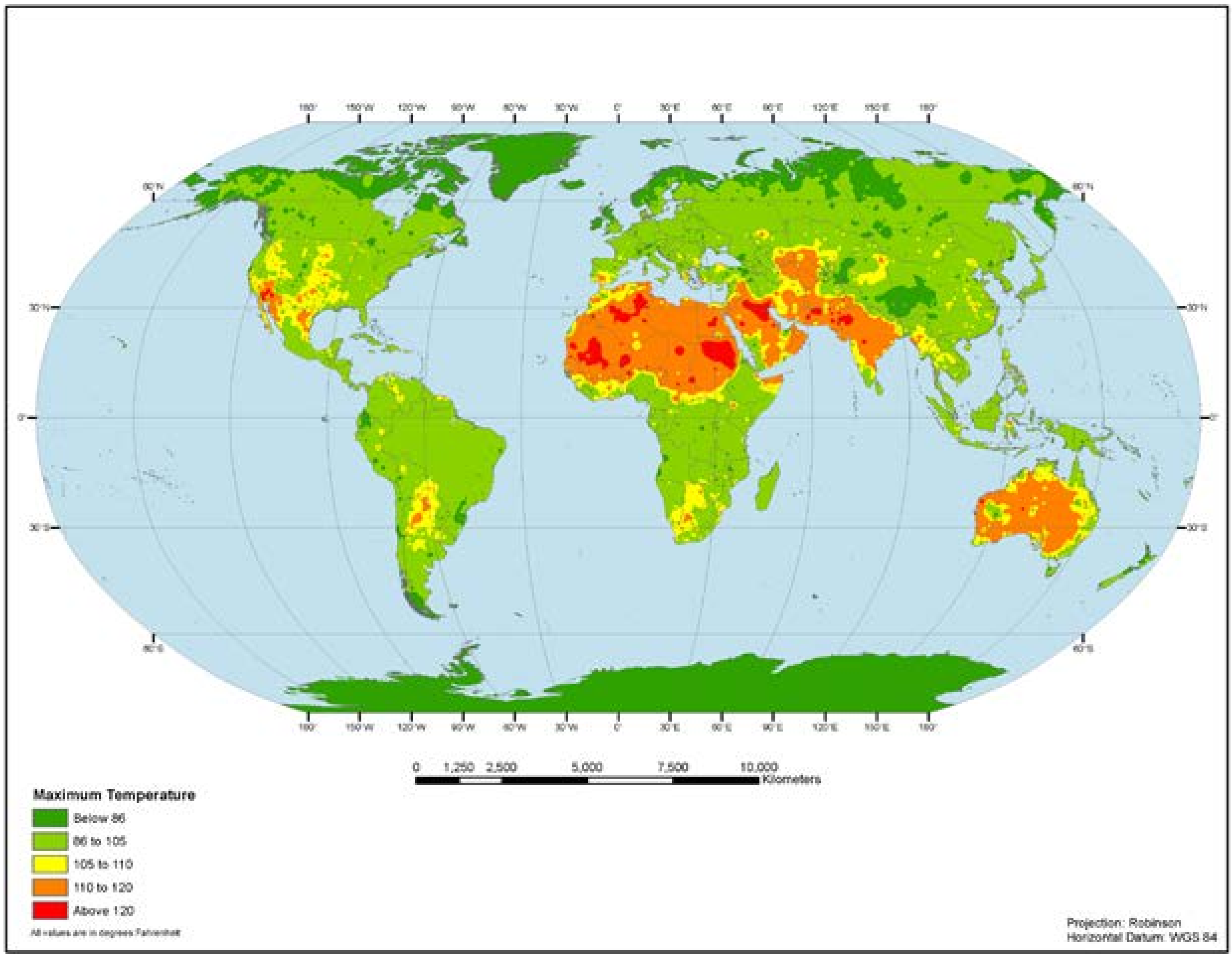



**Figure 5–1. Global distribution of absolute maximum temperatures**

(2) Cold environments are particularly difficult for soldiers because of the increased need for protective clothing and shelter, which makes movement and maneuver difficult. Low temperatures may also impair equipment operation, either temporarily or permanently, by changing the physical properties of materials. Hardening and brittleness of material, differential contraction of dissimilar materials, increased viscosity of lubricants, changes in electronic components, stiffening of shock mounts, condensation, and freezing of water are just a few of the potential problems.

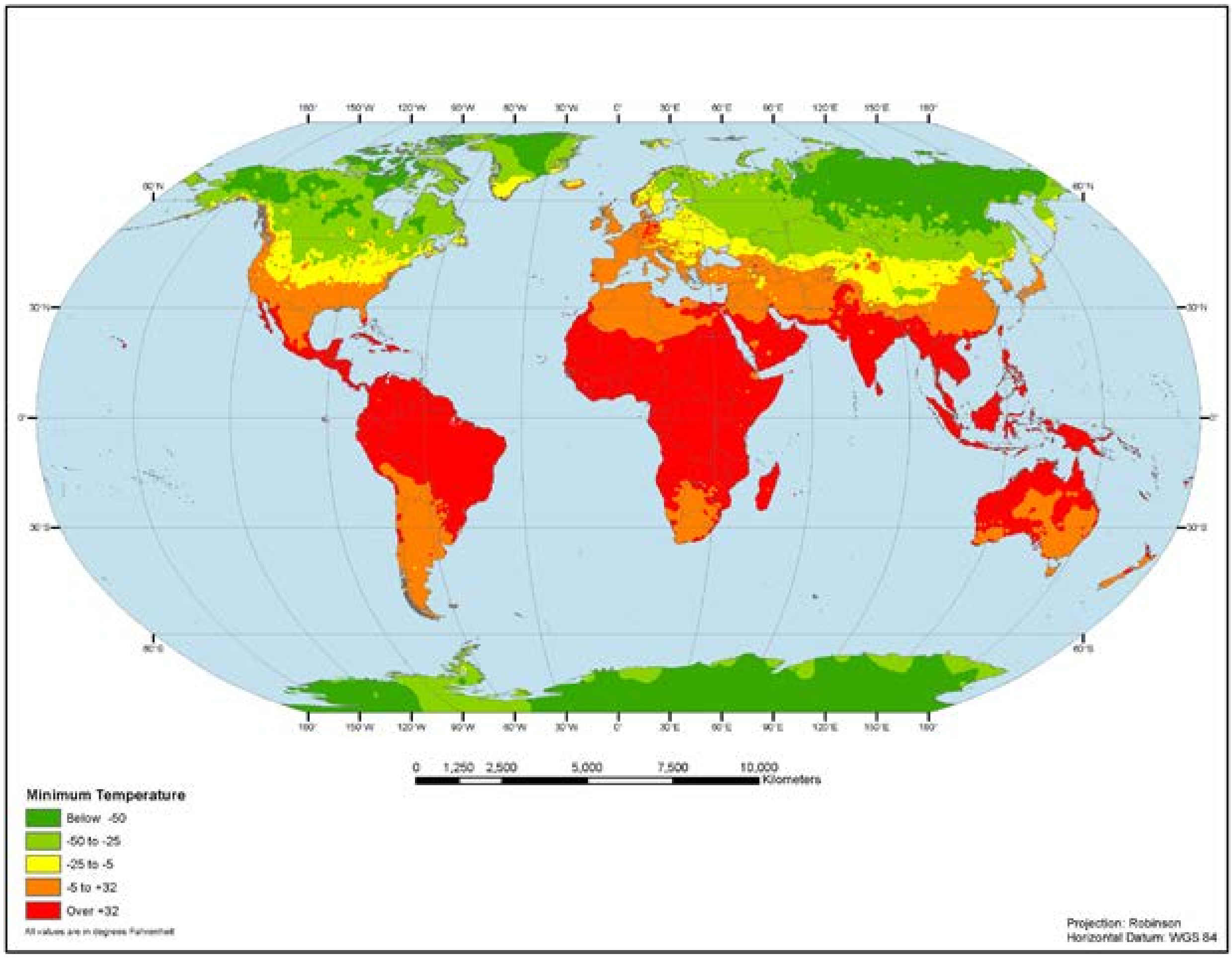



**Figure 5–2. Global distribution of absolute minimum temperatures**

*c. Precipitation—rain.*

(1) The world's highest rainfall amounts and intensities occur in areas that experience the constant high humidity conditions of the humid tropics. The highest rainfall rates are associated with thunderstorms and tropical cyclones. In southeastern Asia, rainfall intensity can be as high as 0.08 to 0.12 in./min (0.2 to 0.3 cm/min). Similar intensities, although of shorter duration, can occur in the areas of the humid temperate region. The record rainfall associated with thunderstorms is 1.2 in.(3.1 cm) in 1 minute and 12 in. (30.5 cm) in 42 minutes. Records for longer rainfalls occur in tropical cyclones and are 53.1 in. (135 cm) for a 12–hour period, 74 in. (188 cm) in 24 hours, and 169.3 in. (430 cm) in 5 days.

(2) In addition to its erosive effects, rainfall is an agent of moisture infiltration into parts, corrosion, and the attenuation of electromagnetic radiation in the atmosphere, thus affecting the performance of some electro-optical systems (for example, visible and infrared sights). Rainfall can create wet soil conditions that may affect off-road mobility. It also degrades the performance of personnel and their equipment during exposed activities.

*d. Precipitation—snow, freezing rain, and hail.*

(1) Snow is the primary precipitation in winter months of the polar region and common during the winter months of the warm continental and prairie OEs of the humid temperate region. Annual snowfall in these regions varies from as little as 10 in. (25.4 cm) to more than 800 in. (20.3 m). Some of the highest annual snowfall is associated with high altitudes and coastal locations. Lesser annual snowfall occurs in mid-continental areas. Mean rates of global precipitation (which include both rain and snow as water equivalent) are presented in figure 5–3.

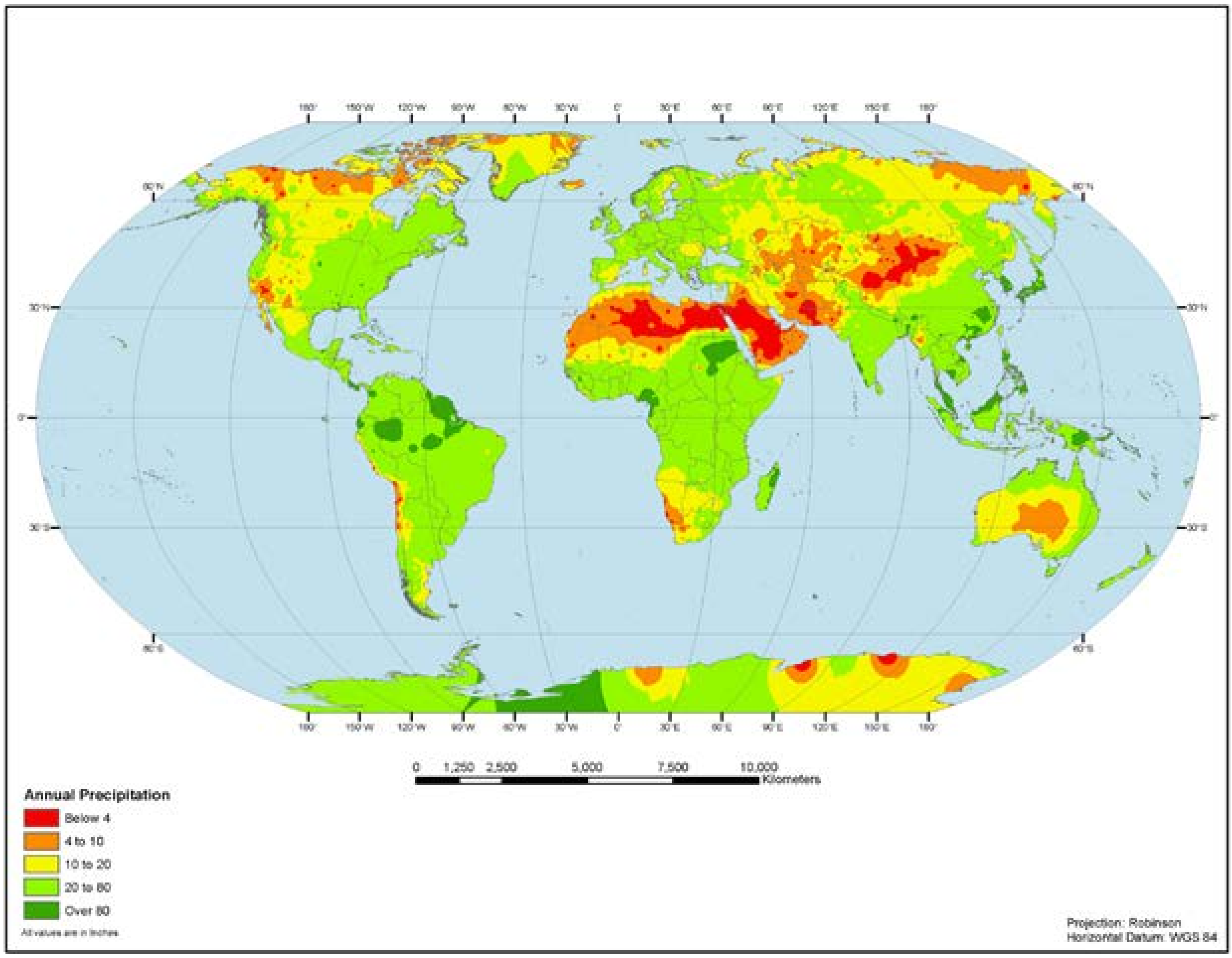



**Figure 5–3. Global distribution of annual precipitation**

(2) Icing phenomena, such as freezing rain, hoarfrost, and rime, can cause ice accretion and interfere with visibility. Icing can occur in areas that experience temperatures below freezing, where sufficient water vapor or freezing precipitation events occur (for example, the polar region or northern coastal areas or continental areas of the humid temperate region subjected to winter storms). Hail occurs in the mid-latitude continental areas where there is intense thunderstorm activity during the summer months. Ice accumulation on structures and equipment can cause damage and interfere with communication, visibility, and mobility. Aircraft such as helicopters and unmanned aircraft systems are especially vulnerable to icing, which can eliminate these key assets from operation. The primary effect of hail is damage.

(3) Falling snow attenuates electromagnetic signals (for example, optical and infrared sights) and is a natural battlefield obscurant. Accumulated snow also affects performance of electromagnetic sensors and additionally imposes a structural load on buildings, shelters, vehicles, and other equipment. Snow accumulation on the ground affects the mobility of vehicles. These effects can be made more severe when the snow is windblown or when the temperature of the snow is close to freezing.

(4) Freeze-thaw cycles occur on any day that the temperature crosses the freezing point and is described by the number of days in which they occur. The maximum number of freeze-thaw days in non-mountainous areas occurs in the humid temperate region. These mid-latitude areas also have great variance in average number of freeze-thaw days. In general, sites that have the most months with mean monthly temperatures at or near 0°C (32°F) will have the greatest annual number of freeze-thaw days. The effects on materiel are caused by expansion and contraction as any moisture present freezes and thaws. These effects can exert great stress on susceptible components of materiel. For the above reason, freeze-thaw is of greatest potential concern in areas where abundant moisture is present immediately before or during the occurrence of the freeze-thaw cycle. Freezing and thawing of off-road surfaces can impede mobility, creating ice-covered and muddy surfaces.

*e. Humidity—high constant, high cyclic, and low.*

(1) High RH is a characteristic of the humid tropics, where daily RH may vary from 88 percent to near saturation (100 percent) in heavily forested areas and from 74 percent to near saturation in open areas (see MIL–HDBK–310). High and cyclic RHs are also present seasonally in parts of the humid temperate region.

(2) High humidity complicates the effect of the ambient temperatures; and temperature/humidity variations can trigger condensation inside and on materiel, initiate fogging, cause oxidation or corrosion, increase chemical reactions, change materiel properties, degrade optical and infrared properties, modify lubricant behavior, and change elasticity or plasticity. Exposed material is likely to remain wet or damp for days in the humid tropics, which in combination with high temperature quickly produces corrosion, wood rot, and fabric deterioration. A global distribution of average RH map is presented in figure 5–4.

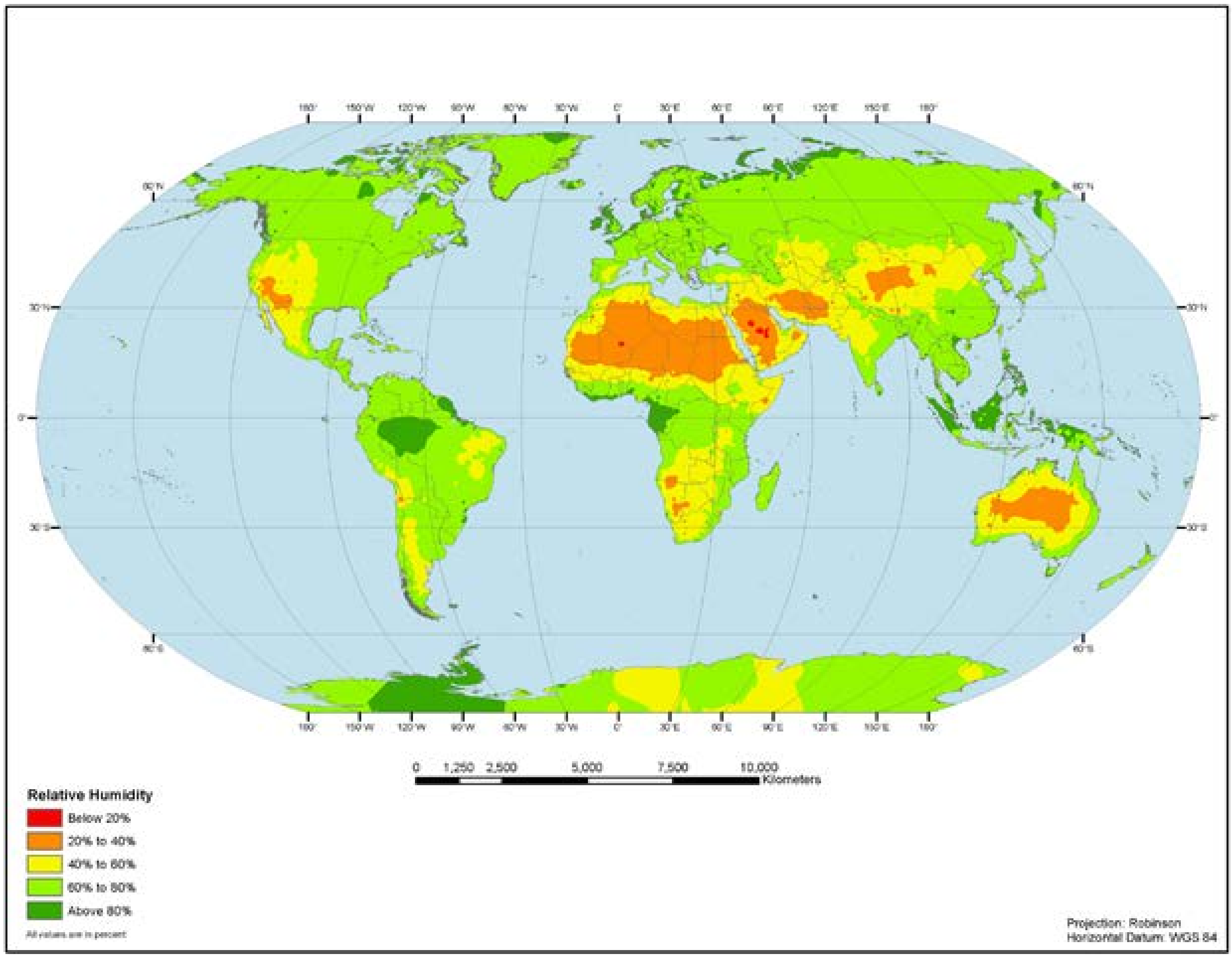



**Figure 5–4. Global distribution of average relative humidity**

*f. Fog/ice fog/whiteout.*

(1) *Fog.* Fog is created by the presence of minute water droplets in the atmosphere at or near the earth's surface. It forms when the air cools to a point where water vapor begins to condense into droplets of water that are sufficiently small to remain suspended in the air. Fog typically occurs in coastal areas in mid-north latitude areas or in mountain valleys in the winter. Fog is an obscurant that reduces the transmission of electromagnetic signals, affecting visibility, mobility, communication systems, and sensors. Reduced visibility can severely restrict operation of both air and ground vehicles. Fog also degrades laser range finding and target acquisition systems.

(2) *Ice fog.* Ice fog occurs naturally in temperatures below −40°F (−40°C) when water vapor freezes into ice crystals that remain suspended in air. It occurs at temperatures below approximately −22°F (−30°C) when particulate matter and water vapor are provided by vehicle exhaust, combustion, or explosive processes. Ice fog can be extremely dense and persistent. It impacts electromagnetic signal transmission and visibility and may also provide a signature of human activity. Sudden drops in visibility will occur due to artillery fire in these conditions. Visibility may be reduced to as little as 10 ft

(3 m). Vertical and horizontal scattering of light by ice crystals can make estimating distance almost impossible. Ice fog is an environmental factor that can be induced by military equipment operating in cold weather. In addition to vehicles and living/working areas, weapons firing can produce ice fog that obscures the vision of the operator and provides the enemy an easy to spot location signature. Ice fog is also greatly increased in populated areas due to the increased amount of water vapor being introduced into the atmosphere.

(3) *Whiteout.* Whiteout is an optical condition resulting from a variety of weather conditions, such as blowing snow, low clouds, snowfall, or fog, in which objects do not cast shadows, the horizon is not discernible, and light-colored objects are difficult to see. The senses of depth and orientation are lost. Like fog, whiteout reduces visibility and can restrict operation of both air and ground vehicles.

*g. Wind.*

(1) Wind is a complex atmospheric phenomenon that occurs at multiple scales, from local air movement lasting minutes to persistent global winds. When considering surface winds, the area having the highest wind gusts in the world (excluding mountain peaks and tornado tracks) is the typhoon belt of the western North Pacific Ocean, an area of the humid tropics that otherwise has relatively low wind speeds. Generally, average wind speed in the humid tropics is less than 3 miles per hour (mph) (5 km/hour) and seldom exceeds 8 mph (13 km/hour). Average wind speeds of 3.7 to 6.8 mph (6 to 11 km/hour) are representative of most desert locations. However, some desert areas have strong winds (greater than 30 mph (48 km/hour)) associated with sand or dust storms. These storms occur with a frequency of 3 or 4 per year in the deserts of southwestern North America and as many as 20 per year in North Africa.

(2) Excessively strong winds can be damaging to structures and operations. The wind is also often combined with precipitation and/or cold temperature, causing blowing rain or snow, obscuration, reduced visibility, and increased moisture penetration. In dry regions, strong winds can generate severe dust storms, which have serious consequences on humans and all classes of materiel. While surface winds are of most concern to Army land operations, high-altitude winds affect the flight of aircraft, unmanned aircraft systems, tethered surveillance systems, and long-range projectiles.

*h. Salt/salt fog.*

(1) Salt and salt spray are phenomena that affect coastal regions throughout the world. In these areas, yearly salt-fall from all sources varies from a minimum of 25 to more than 300 lb/acre/year (336 kg/hectare/year). Daily salt-fall during maximum periods may be as high as 20 lb/acre/day (22 kg/hectare/year). A belt of decreasing salt-fall extends from the coast to a point 50 to 1000 miles (80 to 1609 km) inland where salt-fall is reduced to a minimum. In this inland area, salt-fall varies from a minimum of about 3 to a maximum of 25 lb/acre/year (28 kg/hectare/year).

(2) The principle effect of salt, salt fog, and salt water on materials is the acceleration of metallic corrosion, resulting in loss of mechanical and structural strength, alteration of electrical properties, and surface deterioration.

*i. Solar radiation.*

(1) The important characteristics of solar radiation that impact military operations are the intensity of the radiation and the differential interaction of spectrum within the atmosphere and with the surface. Radiation intensity is primarily determined by the solar geometry relative to the surface and is a function of latitude, time of day, and time of year. Radiation is modified during transmission to the surface through scattering and absorption by clouds, atmospheric gases, aerosols, and other particles. At the surface, reflection and absorption by terrain and surface materials further attenuate or enhance the intensity.

(2) Solar radiation produces a variety of effects that influence performance of materiel, including photochemical degradation of materials, heating of materiel and the environment, personnel performance degradation, optical sensor degradation, and decreased covertness.

*j. High elevation.*

(1) As Army operations move from low to high elevations, there are significant impacts on equipment and material primarily caused by the decrease in atmospheric pressure and changes in other environmental factors. As the elevation increases, the temperature and dew point temperature normally decrease, the wind speed increases, the solar radiation increases (especially in the ultraviolet region), reduced atmospheric pressure results in less oxygen intake, and precipitation increases on the windward side of mountains.

(2) The transport of equipment and materiel from low to high altitude reduces outside air pressure relative to internal higher pressure. This difference in pressure can cause seals to rupture or containers to distort, especially if pressure reduction is rapid (for example, inside an aircraft cargo space, which is not pressurized). When pressure changes, liquids can leak from containers and control systems, the lubrication capability of oil and grease decreases, electrical breakdowns can occur, heat transfer is less efficient, and liquids vaporize at lower temperatures. Additionally, combustion processes are less efficient at lower pressures. Helicopter lift is reduced in the “thinner air” or lower pressure at higher elevations, especially in high desert mountains with relatively high temperatures.

## 5–3. Terrain factors

In addition to the conditions of the lower atmosphere, the earth surface landscape is also important to military operations. In this regulation, the term *terrain* is defined as all of the physical components of the land surface, including topography, soil type, surface cover, and water features (for example, rivers, lakes, swamps, marshes, and so forth). These terrain elements are important because they can affect troop movement and supply, mobility, sensor operations, and defensive and offensive operations. Mobility is often the prime factor of success in military operations, and terrain character determines the degree and magnitude of trafficability, off-road mobility, and river crossing problems. The effect of terrain on mobility and on other operations is usually the result of the combined influence of several terrain elements; therefore, it is necessary to plan for each of them.

*a. Topography—landforms, slope, relief, and roughness.*

(1) Landforms are conspicuous topographic features on the surface of the earth. Eleven landform types are mapped in Figure 5–5 (*Global Physiographic and Climatic Maps to Support Revision of Environmental Testing Guidelines*, McDonald, et al., 2009).

(2) Figure 5–5 depicts the landforms on a global scale. Each physiographic class exhibits unique topographic attributes that are characterized by its relief (that is, flat versus steep and smooth versus. rough) and soil conditions. These classes also extend across the different ecoregions of the world as defined by Bailey (*Ecoregions Map of North America: Explanatory Note*, Bailey, R.G., 1998). The land surface of the earth can also be subdivided on the basis of the drainage networks (that is, watersheds) of the world's major rivers. These drainage networks can crosscut the landforms shown in figure 5–5 and the ecoregions described in chapter 4. The drainage networks can present additional obstacles to military mobility and maneuver over-and-above that caused by local landform character.

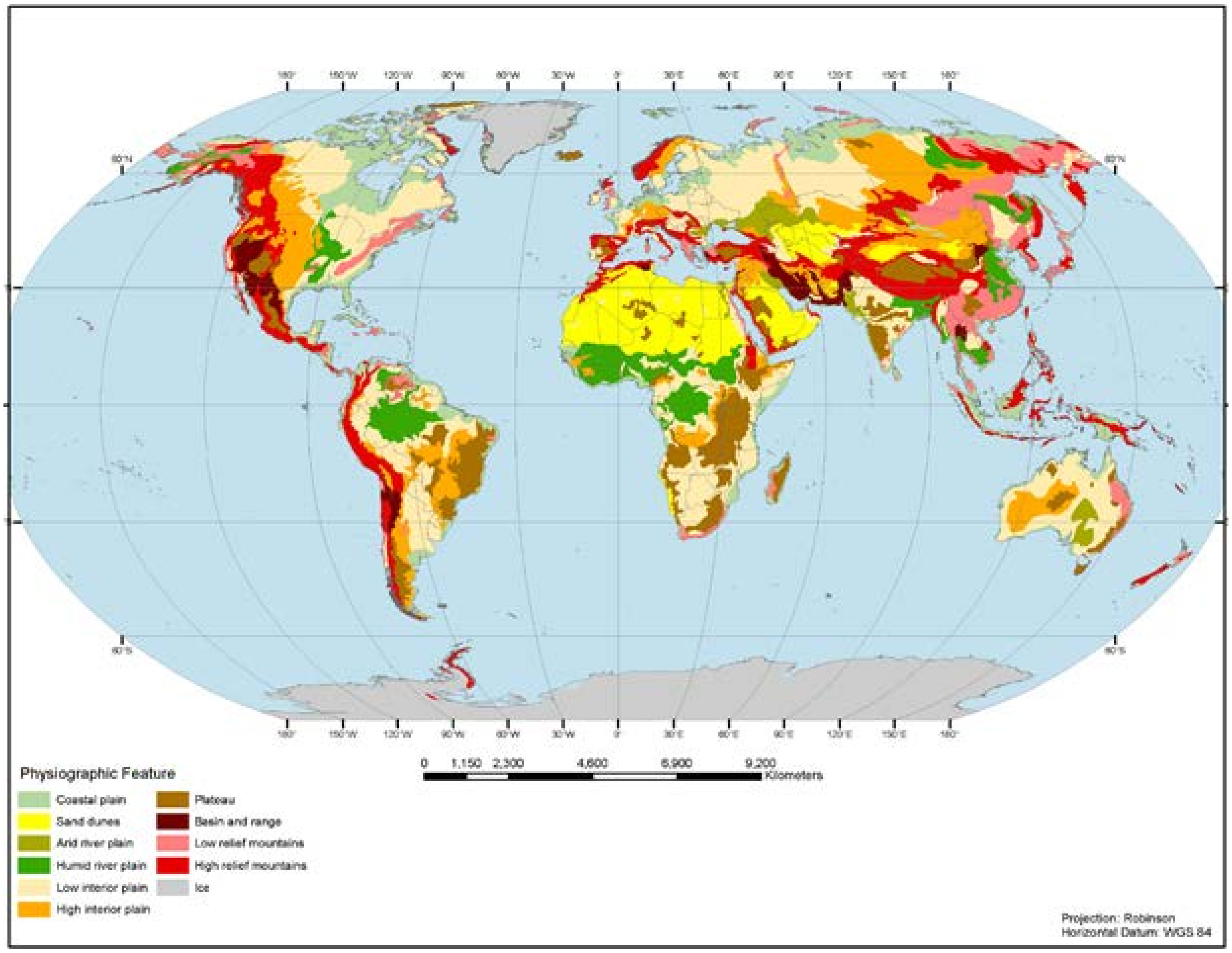



**Figure 5–5. Generalized global physiography**

(3) Topography is of primary concern for cross-country mobility of both soldiers and equipment. It may also affect sensors, artillery effectiveness, communications, concealment, and detectability.

*b. Soil.*

(1) The Army is principally a ground force. As a result, soil properties in large part control the ease with which an Army moves. Soil is the interface between the lithosphere (rocky part of the earth) and the atmosphere and is a multicomponent, dynamic system composed of weathered rock and chemical precipitates, organic matter, water, and gas. Soil depth can vary from centimeters to many meters. The composition and physical properties of a soil profile at a location depend on many factors acting in concert, including—

*(a)* Climate/energy and moisture exchanges with the atmosphere.

*(b)* Flora and fauna.

*(c)* Topography.

*(d)* Bedrock composition.

*(e)* Length of time material has been exposed to climate, vegetation, and fauna.

(2) Soil changes as climate, geology, vegetation, and topography vary with location. Classification schemes to describe soil are related to its texture, such as sand, silt, and clay composition; soil structure or morphology, which is related to its developmental history as rated by the U.S. Department of Agriculture and the United Nations Food and Agriculture Organization; or according to engineering and geological properties, such as mobility as used by the USACE in the Unified Soil Classification System (USCS).

(3) The USCS scheme is most useful for military operations because it considers texture, plasticity, and moisture content with no regard for agricultural properties. The composition and physical properties of soils and related surface cover features are important to mobility, sensor performance, engineering construction considerations, and health physics. Soil bearing strength and shear strength, for example, are controlled by soil composition and soil moisture. Dry clay supports

more weight than wet clay; and moist, frozen sand will allow better mobility because of its higher bearing strength and resistance to shear forces than thawed, dry sand. Particle size and depth of a soil are important factors on which cohesiveness, sound wave transmission, and moisture-holding capacity depend. Fine sand, silt, and clay-sized fraction of soils may become mud when wet, whereas with little moisture, the same soil composition and particle size fraction has high dust potential.

*c. Exposed rock.* Exposed rock can be present where the underlying bedrock has not been eroded or where soil has been removed over time by climate factors. Exposed rock is abrasive on tires and tracks, impedes mobility, and creates additional shock and vibration that causes mechanical damage to suspensions. Rocky surfaces can be slippery and present challenges for Soldier movement and cause increased wear to boots and equipment.

*d. Sand.* Deep, dry sand degrades mobility because it provides poor traction for vehicles. Sand is abrasive, causing excessive wear on brakes, tires, and other components that are in contact with a sandy surface.

*e. Mud.* A combination of silt and clay soil constituents and water produce mud, which impedes mobility of both the Soldier and vehicles. Operations under muddy conditions also affect durability; for example, there is increased abrasion and damage to seals.

*f. Airborne sand and dust.* Soil type and moisture content are the major inputs into dust potential throughout the world (see fig 5–6). Few areas are exempt from dust problems. However, the highest dust potential is in the dry regions of the world.

(1) Dust potential is a result of soil conditions, vegetation conditions, atmospheric humidity, and wind or human activity. Sand and dust are terms used to designate small soil particles, usually of mineral origin. Sand and dust are distinguished on the basis of size (dust particles are smaller), but there are no generally accepted specific size limits for the two kinds of particles. Important characteristics are size, hardness, shape, and atmospheric concentrations. Particles vary in diameter from 3.94 × 10–6 to 3.94 × 10–2 in. (0.1 to 1,000 µm), but most airborne particles are less than approximately 2.95 × 10–3 in. (75 µm in diameter). Hardness also varies widely (from 1 to 9 on the Mohs scale), depending largely on mineral composition. Quartz, typically the most common mineral in larger particles, has a hardness of 7. The greatest airborne particle concentrations are found near helicopters hovering over dry loose surfaces. Lesser concentrations are found near ground vehicles operating on unpaved surfaces and roads. Smaller concentrations are associated with natural dust storms although the spatial extent of such storms may be larger.

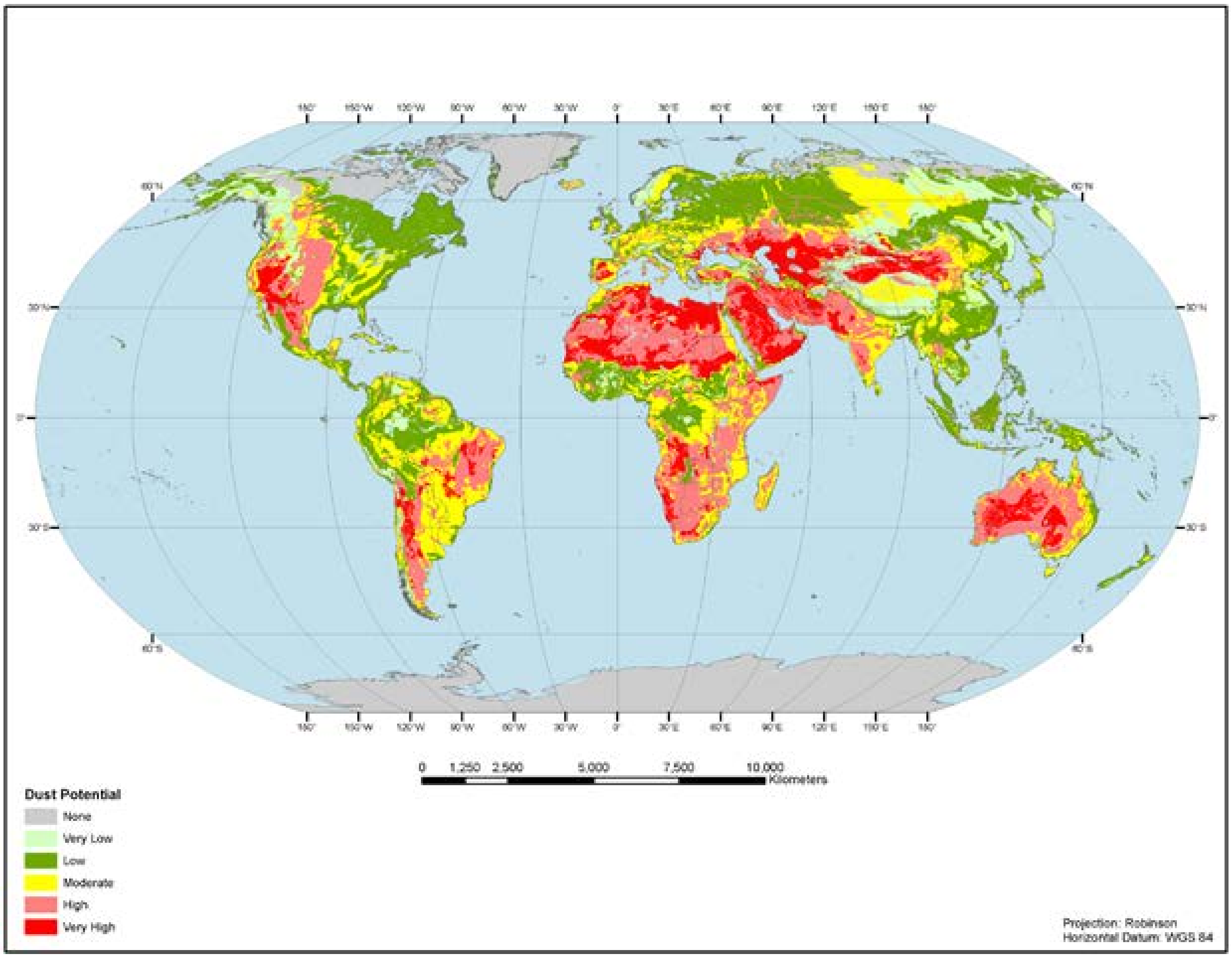



**Figure 5–6. Global dust potential**

(2) Airborne sand and dust are atmospheric obscurants, can be damaging to equipment, and present a health hazard when inhaled. Airborne dust is primarily damaging because of its penetration into mechanical equipment, air filters, and other materiel and its adhesion to oil-bearing surfaces (for example, lubricated weapons). Airborne sand is primarily damaging because of its erosion and abrasion effects on equipment (for example, helicopter blades).

(3) Emerging data indicates that the chemical composition of dust in some operational areas must be considered in addition to particle size distribution and hardness. Complex dust mixtures can contain carbonates, corrosive salts, and potentially harmful microorganisms.

*g. Surface water.* Surface waters of concern are those that form obstructions or obstacles during military operations (for example, rivers, lakes, bays, estuaries, or marshes). Information of interest for military purposes includes parameters such as bank height relative to the water surface, side slopes, water depth, water width, and water velocity, which indicate the fordability of a river.

*h. Frozen soil.*

(1) In areas that are subjected to seasonal frost, the depth of frost penetration varies depending on the number of days below freezing, soil moisture conditions, and the ground cover condition. Permafrost, which occurs in the polar region, is frozen ground that never thaws. In summer, a thaw layer that is commonly saturated and poorly drained forms over permafrost and creates muddy or boggy conditions.

(2) Freezing typically increases the load-carrying capacity of soils and improves cross-country mobility. However, soil with high moisture content is very hard and resists the penetration of tent stakes and howitzer spades. Also, frozen soil, while it improves mobility, in combination with low temperatures may increase damage to suspensions.

*i. Surface snow and ice.*

(1) Accumulation of seasonal snow cover is a function of the seasonal volume of precipitation and temperature cycles. In the polar regions, melting seldom occurs during the 6 to 8 months of winter. The major difference between recorded

annual snowfall and snow on the ground is due to settling, consolidation, and sublimation, not to melting. Snow accumulation in warmer areas, such as the warm continental region, may also be reduced by frequent winter thaws. High winds may clear exposed areas of snow and deposit it in protected areas to depths several times the normal snowfall for a locality.

(2) The depth of snow on the ground imposes a physical barrier to mobility. Freezing and thawing of off-road surfaces can impede mobility, creating ice-covered and muddy surfaces. Designs must consider the snow load (that is, weight of snow on a surface or structure).

## 5–4. Biological factors

*a. Dense vegetation.*

(1) Land cover is often characterized by land use (for example, urban or cropland) or by the dominant vegetation structure (for example, forest or shrub land) as shown in figure 5–7, which is based on the U.S. Geological Survey Land Cover Characteristics Database. For RDTE purposes, dense vegetation is best described in terms of its structural characteristics that have direct effect on military operational requirements to move, shoot, and communicate. These characteristics include stem density, stem diameter, plant height, and plant canopy.

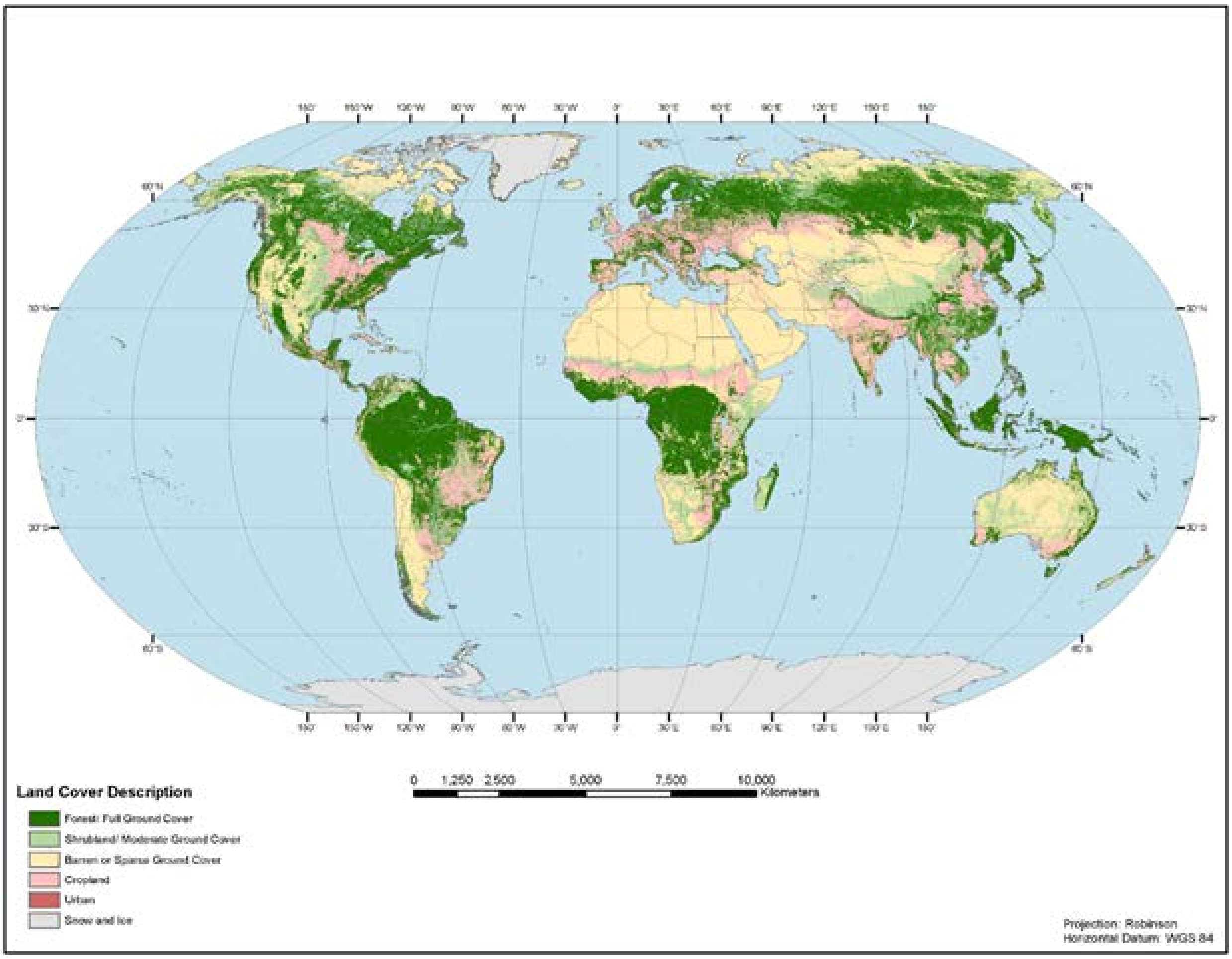



**Figure 5–7. Global land cover map**

(2) Stem diameter and density affect mobility and cover; plant height and canopy affect cover and communications. Seasonal change in dense vegetation, especially deciduous broadleaf forests in temperate and tropic regions, can have significant effects on operational factors, such as cover and communications. Tropical rainforests and other forms of dense vegetation are significant to military operations because they often restrict mobility, visibility, and communications. Conversely, they may provide cover and concealment critical to tactical advantage on the battlefield and in covert operations.

*b. Macro- and microorganisms.*

(1) Macroorganisms include all life forms except microorganisms (or microbes). Microbes exist throughout the environment in water, soil, and air. Moisture and temperature are the critical growth factors for microbes. Areas in the humid temperate region and particularly the humid tropics have the temperature and moisture to support large microbial and macrobiological populations. In the dry region, because of the lack of moisture, macro-organisms such as insects exist but generally do not create significant problems. Likewise, the lack of moisture for microbial growth prevents biodegradation by microorganisms.

(2) Both microbes and macroorganisms present potential problems to military operations, including human injury and disease, spoilage of perishable items, fouling of equipment, and bio-deterioration of materiel. Materiel damage by macro-organisms ranges from nuisance to destructive through direct contact (chewing, eating, moving, nesting, and burrowing). For example, termites are an important group of macro-organisms capable of the physical and chemical breakdown of plant material; and as such, they are a factor in the degradation of cellulose-containing test materials. Microbes are the major agent of biodegradation; and microbe species have evolved that attack all naturally occurring compounds and many, though not all, synthetic materials. Microbes may oxidize metal pipes, causing corrosion, or foul lubricating grease in equipment, causing excessive wear. Canvas and other cloth items and optics or sensors may be damaged by the growth of algae or fungi on fabrics, plastics, glass, or coatings.

## 5–5. Summary

Tables 5–2 through 5–6 summarize the environmental characteristics of each OE.

*a.* Because the special environments of hot-humid coastal desert and mountains are presented in table 5–6, climate information for those areas was excluded from the OEs that they transected.

*b.* Information on atmospheric factors, terrain factors, and surface snow cover were developed from work done in support of this revision by McDonald, et al., 2009.

*c.* Information on biological factors, surface cover, surface water, and frozen soil was derived from information presented in *Ecosystem Geography* (Bailey, R.G., 1996).

*d.* Climate information was calculated using the last 30 years of worldwide meteorological data. The 5 percent extreme values were used for high temperatures, low temperatures, wind gusts, and maximum sustained winds for each OE and a 1 percent extreme for the maximum 6–hour precipitation.

*e.* Information on atmospheric factors, terrain factors, and surface snow cover were developed from work done in support of this revision by McDonald, et al., 2009.

*f.* Information on biological factors, surface cover, surface water, and frozen soil was derived from information presented in *Ecosystem Geography* (Bailey, R.G., 1996).

**Table 5–2**
**Environmental factors for operational environments within the polar region excluding Antarctica**

| Environmental Factors | | Operational Environments[1] | | |
|---|---|---|---|---|
| | | Icecap | Tundra | Subarctic |
| Atmospheric Factors | Low Temp °C (°F) (5% extreme)[2] | −54 (−65) | −53 (−63) | −54 (−62) |
| | High Temp °C (°F) (5% extreme)[2] | 19 (66) | 29 (84) | 36 (96) |
| | Yearly avg. Precipitation mm (in.)[2, 4] | 343 (13.5) | 224 (8.8) | 429 (16.9) |
| | 6–hour Max (1% extreme) Precip. mm (in.)[2, 4] | 25 (1.0) | 25 (1.0) | 61 (2.4) |
| | Yearly avg. snow mm (in.)[2] | 1299 (51.1) | 643 (25.3) | 973 (38.3) |
| | Mean RH % / Mean Dew Point °C (°F)[2] | 75% / −12 (10) | 80% / −11 (13) | 74% / −4 (25) |
| | Fog / Ice Fog / Whiteout Mean (days)[2] | 19 | 32 | 19 |
| | Visibility Mean (miles)[2] | 17 | 13 | 16 |
| | Wind: Gusts/Max Sustained (knots) (5% extreme)[2] | 71 / 50 | 71 / 59 | 78 / 43 |
| Terrain Factors | Landforms (Physiography); greater than 15% total area (% area)[2] | Icecap (97%) | Low-interior plain(40%), coastal plain (18%), high-interior plain (16%) | Coastal plain (37%), low-relief mountains (18%), |

**Table 5–2**
**Environmental factors for operational environments within the polar region excluding Antarctica—Continued**

| Environmental Factors | | Operational Environments[1] | | |
|---|---|---|---|---|
| | | **Icecap** | **Tundra** | **Subarctic** |
| | | | | high-relief mountains (16%) |
| | Predominate National Resources Conservation Service (NRCS) soil order; greater than 15% total area Soil Order (% Area)[2,5] | Ice (97%) | Inceptisols (30%); Gelisols (26%) | Gelisols (84%) |
| | Extensive areas of exposed bedrock/limited soil cover (High, Moderate, Low)[2] | Low | Moderate | High |
| | Extensive areas of non-cohesive (Sand and Gravel)[2] | Low | Moderate | Moderate |
| | Extensive areas of non-cohesive Silt and Clay (mud and mud potential)[2] | Low | High | Moderate |
| | Potential for generating dust; greater than 15% total area; Rating (% Area)[2] | None (96%) | Low (50%); moderate (31%); very low (19%) | Very low (39%); low (34%) |
| | Surface Water (Hydrography)[3] | Limited | Poor drainage, 50% covered in summer. Lakes, swamps, bogs | Poor drainage, spring flooding |
| | Frozen Soil[3] | Continuous Permafrost | Continuous Permafrost | Discontinuous Permafrost, and deep seasonal frost |
| **Surface Cover** | Snow Cover[3] | Permanent | Persistent | Persistent |
| | Surface Ice Cover[3] | Year-round ice | 50% in winter | Associated with wet areas, little freeze-thaw |
| **Biological Factors** | Vegetation Structure[3] | Algae, lichen, moss | Grass, sedges, brush | Needle-leaf, mixed deciduous |
| | Microbiology[3] | Limited activity | Limited activity | Limited activity |
| | Macrobiology[3] | Limited | Abundant insects, birds seasonally | Abundant insects and birds seasonally; rodents and other mammals all year |

*Notes.*

[1] The Antarctic continent is excluded from these areas. The special cases of mountains and hot/humid coastal desert and salt/salt spray/salt fog and solar radiation are not addressed.

[2] Based on summaries of meteorological and physiographic data (McDonald, et al., 2009).

[3] Information was derived from Ecosystem Geography (Bailey, R.G., 1996).

[4] Precipitation includes water equivalent snow.

[5] Although the USCS is the preferred soil classification system used by the Army, worldwide available data is predominantly classified using the NRCS system. The National Geospatial-Intelligence Agency (NGA) has long-term plans to classify soil worldwide using USCS, but it is not available for this regulation.

**Table 5–3**
**Environmental factors for operational environments within the humid temperate region**

| | Environmental Factors | Operational Environments[1] | | |
|---|---|---|---|---|
| | | Warm Continental | Hot Continental | Subtropical |
| Atmospheric Factors | Low Temp °C (°F) (5% extreme)[2] | −42 (−44) | −37 (−34) | −15 (4) |
| | High Temp °C (°F) (5% extreme)[2] | 33 (92) | 35 (95) | 46 (115) |
| | Yearly avg. Precipitation mm (in.)[2, 4] | 599 (23.6) | 665 (26.2) | 1016 (40.0) |
| | 6-hour Max(1% extreme) Precip mm (in.)[2,4] | 69 (2.7) | 51 (2.0) | 155 (6.1) |
| | Yearly avg. snow mm (in.)[2] | 640 (25.2) | 549 (21.6) | 109 (4.3) |
| | Mean RH % / Mean Dew Point °C (°F)[2] | 75% / 2 (35) | 71% / 4 (40) | 71% / 12 (53) |
| | Fog/Ice fog/Whiteout Mean (days)[2] | 35 | 47 | 44 |
| | Visibility Mean (miles)[2] | 10 | 9 | 9 |
| | Wind: Gusts/Max Sustained (knots) (5% extreme)[2] | 60 / 41 | 70 / 45 | 75 / 59 |
| Terrain Factors | Landforms (Physiography); greater than 15% total area (% area)[2] | High-relief mtns 22%, low-relief mountains 20% | Low-interior plain 39%, high-interior plain 28%, high-relief mnts15% | High-relief mtns 34%, high-interior plain 19%, plateau 17% |
| | Predominate NRCS soil order; greater than 15% total area Soil Order (% Area)[2,5] | Entisols 27%; Aridisols 24% Inceptisols 19%; Ultisols 18% | Mollisols 33%; Inceptisols 27%; | Gelisols 22%; Entisols 19%; Aridisols 17%; Inceptisols 15% |
| Terrain Factors | Extensive areas of exposed bed-rock/limited soil cover (High, Moderate, Low)[2] | High | Moderate | Moderate |
| | Extensive areas of non-cohesive (Sand and Gravel)[2] | Low | Moderate | Low |
| | Extensive areas of non-cohesive Silt and Clay (mud and mud potential)[2] | Low | Moderate | Moderate |
| | Potential for generating dust; greater than 15% total area; Rating (Percent Area)[2] | Low (37%); very high (26%); moderate (24%) | Moderate (36%); low (32%); very low (16%); high (15%) | Moderate (26%); high (25%); very low 22%; low (16%) |
| | Surface Water (Hydrography)[3] | Seasonally frozen | Seasonally frozen | Rivers streams flow year-round |
| | Frozen Soil[3] | Seasonal frost | Seasonal frost | None |
| Surface Cover | Snow Cover[3] | Intermittent | Intermittent | None |
| | Surface Ice Cover[3] | Freeze-thaw | Freeze-thaw | None |
| Biological Factors | Vegetation Structure[3] | Mixed boreal and deciduous forests | Deciduous forests | Broad-leafed and evergreen forests |
| | Microbiology[3] | Limited activity during winter | | |

**Table 5–3**
**Environmental factors for operational environments within the humid temperate region—Continued**

| | Environmental Factors | Operational Environments[1] | | |
|---|---|---|---|---|
| | | **Warm Continental** | **Hot Continental** | **Subtropical** |
| | Macrobiology[3] | Abundant insects, birds, rodents, and other small mammals | Abundant insects, birds, rodents, and other small mammals | Abundant insects, birds, rodents, and other small mammals |

*Notes.*

[1] The Antarctic continent is excluded from these areas. The special cases of mountains and hot/humid coastal desert and salt/salt spray/salt fog and solar radiation are not addressed.

[2] Based on summaries of meteorological and physiographic data (McDonald, et al., 2009).

[3] Information was derived from Ecosystem Geography (Bailey, R.G., 1996).

[4] Precipitation includes water equivalent snow.

[5] Although the USCS is the preferred soil classification system used by the Army, worldwide available data is predominantly classified using the NRCS system. The NGA has long-term plans to classify soil worldwide using USCS, but it is not available for this regulation.

**Table 5–4**
**Environmental factors for operational environments within the dry region**

| Environmental Factors | | Operational Environments[1] | | | |
|---|---|---|---|---|---|
| | | **Tropic / subtropical Steppe** | **Tropic / subtropical Desert** | **Temperate Steppe** | **Temperate Desert** |
| **Atmospheric Factors** | Low Temp °C (°F) (5% extreme)[2] | −25 (−14) | −15 (5) | −38 (−36) | −36 (−32) |
| | High Temp °C (°F) (5% extreme)[2] | 44 (112) | 54 (129) | 41 (105) | 42 (108) |
| | Yearly avg. Precipitation mm (in.)[2, 4] | 333 (13.1) | 155 (6.1) | 302 (11.9) | 157 (6.2) |
| | 6-hour Max(1% extreme) Precip mm (in.)[2, 4] | 127 (5.0) | 201 (7.9) | 51 (2.0) | 71 (2.8) |
| | Yearly avg. snow mm (in.)[2] | 71 (2.8) | 10 (0.4) | 378 (14.9) | 290 (11.4) |
| | Mean RH %/ Mean Dew Point °C (°F)[2] | 56% / 9 (48) | 42% / 8 (46) | 67% / 1 (34) | 53% / −1 (30) |
| | Fog/ice fog/Whiteout Mean (days)[2] | 12 | 3 | 25 | 12 |
| | Visibility Mean (miles)[2] | 14 | 12 | 12 | 17 |
| | Wind: Gusts/Max Sustained (knots) (5% extreme)[2] | 68 / 40 | 90 / 46 | 78 / 66 | 66 / 47 |
| **Terrain Factors** | Landforms (Physiography); greater than 15% total area (% area)[2] | Major river basin (36%), low-interior plain (17%), coastal plain (16%) | Sand sea (31%), low-interior plain (16%), plateau (15%) | Sand sea (33%), basin and range (16%) | Sand sea (68%) |
| | Predominate NRCS soil order; greater than 15% total area Soil Order (% Area)[2] | Entisols (22%); Alfisols (19%); Ultisols (19%) | Entisols (31%); Ultisols (16%) | Aridisols (35%); Entisols (34%) | Entisols (46%); Aridisols (18%); Shifting Sand(16%) |

**Table 5–4**
**Environmental factors for operational environments within the dry region—Continued**

| Environmental Factors | | Operational Environments[1] | | | |
|---|---|---|---|---|---|
| | | **Tropic / subtropical Steppe** | **Tropic / subtropical Desert** | **Temperate Steppe** | **Temperate Desert** |
| | Extensive areas of exposed bedrock/limited soil cover (High, Moderate, Low)[2] | Moderate | Moderate | High | High |
| | Extensive areas of non-cohesive (Sand and Gravel)[2] | Moderate | High | High | High |
| | Extensive areas of non- cohesive Silt and Clay (mud and mud potential)[2] | High | Low | Moderate | Low |
| | Potential for generating dust; greater than 15% total area; Rating (% Area)[2] | Moderate (46%); low (32%); high (20%) | High (35%); moderate (27%); low (20%); very high (17%) | High (40%); very high (39%) | High (46%); very high (32%) |
| | Surface Water (Hydrography)[3] | Dry stream beds | Often dry stream beds, subterranean water | Few perennial streams with low velocity and braiding | Abundant water from mountains |
| | Frozen Soil[3] | May be present at high altitude | May be present at high altitude | May be present at high altitude | May be present at high altitude |
| **Surface Cover** | Snow Cover[3] | May be present at high altitude | May be present at high altitude | May be present at high altitude | May be present at high altitude |
| | Surface Ice Cover[3] | May be present at high altitude | May be present at high altitude | May be present at high altitude | May be present at high altitude |
| **Biological Factors** | Vegetation Structure[3] | Short grass, shrubs | Shrubs, sparse grass, barren | Short grass, shrubs | Shrubs, sparse grass, barren |
| | Microbiology[3] | Slow decomposition | Slow decomposition | Slow decomposition | Slow decomposition |
| | Macrobiology[3] | Insect, rodent, and reptile populations present all year | Insect, rodent, and reptile populations present all year | Insect, rodent, and reptile populations present all year | Insect, rodent, and reptile populations present all year |

*Notes.*

[1] The Antarctic continent is excluded from these areas. The special cases of mountains and hot/humid coastal desert and salt/salt spray/salt fog and solar radiation are not addressed.

[2] Based on summaries of meteorological and physiographic data (McDonald, et al., 2009).

[3] Information was derived from Ecosystem Geography (Bailey, R.G., 1996).

[4] Precipitation includes water equivalent snow.

[5] Although the USCS is the preferred soil classification system used by the Army, worldwide available data is predominantly classified using the NRCS system. The NGA has long-term plans to classify soil worldwide using USCS, but it is not available for this regulation.

**Table 5–5**
**Environmental factors within the humid tropic region**

| | Environmental Factors | Operational Environments[1] | |
|---|---|---|---|
| | | Savanna | Rainforest |
| Atmospheric Factors | Low Temp °C (°F) (5% extreme)[2] | −5 (23) | 3 (37) |
| | High Temp °C (°F) (5% extreme)[2] | 46 (114) | 43 (109) |
| | Yearly avg. Precipitation mm (in.)[2, 4] | 662.9 (26.1) | 1001 (39.4) |
| | 6-hour Max(1% extreme) Precip mm (in.)[2, 4] | 201 (7.9) | 221 (8.7) |
| | Yearly avg. snow mm (in.) [2] | 5 (0.2) | 8 (0.3) |
| | Mean RH %/ Mean Dew Point °C (°F)[2] | 67% / 18 (64) | 78% / 22 (71) |
| | Fog/Ice fog/Whiteout Mean (days)[2] | 6 | 10 |
| | Visibility Mean (miles)[2] | 10 | 9 |
| | Wind: Gusts/Max Sustained (knots) (5% extreme)[2] | 90 / 90 | 78 / 51 |
| Terrain Factors | Landforms (Physiography); greater than 15% total area (% area)[2] | Low-interior plain (46%), plateau (15%) | Major river basin (31%), plateau (23%) |
| | Predominate NRCS soil order; greater than 15% total area Soil Order (% Area)[2, 5] | Aridisols (25%); Entisols (24%); Alfisols (15%) | Oxisols (41%); Ultisols (20); Entisols (23%) |
| | Extensive areas of exposed bedrock/limited soil cover (High, Moderate, Low)[2] | Moderate | Low |
| | Extensive areas of non-cohesive (Sand and Gravel)[2] | Moderate | Low |
| | Extensive areas of non-cohesive Silt and Clay (mud and mud potential)[2] | Moderate | High |
| | Potential for generating dust; greater than 15% total area; Rating (Percent Area)[2] | High (49%); moderate (31%) | Low (42%); moderate (36%); high (20%) |
| | Surface Water (Hydrography)[3] | Perennial small- to medium-width streams | Streams with nominal velocities |
| | Frozen Soil[3] | Not applicable | Not applicable |
| Surface Cover | Snow Cover[3] | Not applicable | Not applicable |
| | Surface Ice Cover[3] | Not applicable | Not applicable |
| Biological Factors | Vegetation Structure[3] | Open woodlands, grasslands | Evergreen tropical rainforest (dense forest, heavy undergrowth) |
| | Microbiology[3] | Diverse and active decomposer population | Diverse and active decomposer population |
| | Macrobiology[3] | Abundant insects, birds, rodents, and other small mammals all year | Abundant insects, birds, rodents. and other small mammals all year |

*Notes.*

[1] The Antarctic continent is excluded from these areas. The special cases of mountains and hot/humid coastal desert and salt/salt spray/salt fog and solar radiation are not addressed.

[2] Based on summaries of meteorological and physiographic data (McDonald, et al., 2009).

[3] Information was derived from Ecosystem Geography (Bailey, R.G., 1996).

[4] Precipitation includes water equivalent snow.

[5] Although the USCS is the preferred soil classification system used by the Army, worldwide available data is predominantly classified using the NRCS system. NGA has long-term plans to classify soil worldwide using USCS, but it is not available for this regulation.

**Table 5–6**
**Environmental factors within the Special Environments**

| Environmental Factors | Operational Environments[1, 6] | |
|---|---|---|
| | Hot-Humid Coastal Desert | Mountains |
| Low Temp °C (°F) (5% extreme)[2] | 6 (43) | −54 (−66) |
| High Temp °C (°F) (5% extreme)[2] | 45 (113) | 47 (117) |

**Table 5–6**
**Environmental factors within the Special Environments—Continued**

| Environmental Factors | Operational Environments[1, 6] | |
|---|---|---|
| | Hot-Humid Coastal Desert | Mountains |
| Yearly avg. Precipitation mm (in.)[2,4] | 25 (1.0) | 180 (7.1) |
| 6–hour Max(1% extreme) Precip mm (in.)[2,4] | 208 (8.5) | 480 (18.9) |
| Yearly avg. snow mm (in.)[2] | 3 (0.1) | 475 (18.7) |
| Mean RH %/Mean Dew Point °C (°F)[2] | 61% / 19 (67) | 68% / 4 (39) |
| Fog/Ice fog/Whiteout Mean (days)[2] | 6 | 22 |
| Visibility Mean (miles)[2] | 7 | 13 |
| Wind: Gusts/Max Sustained (knots) (5% extreme)[2] | 58 / 58 | 98 / 76 |

*Notes.*

[1] The Antarctic continent is excluded from these areas. The special cases of mountains and hot/humid coastal desert and salt/salt spray/salt fog and solar radiation are not addressed.

[2] Based on summaries of meteorological and physiographic data (McDonald, et al., 2009).

[3] Information was derived from Ecosystem Geography (Bailey, R.G., 1996).

[4] Precipitation includes water equivalent snow.

[5] Although the USCS is the preferred soil classification system used by the Army, worldwide available data is predominantly classified using the NRCS system. The National Geospatial-Intelligence Agency has long-term plans to classify soil worldwide using USCS, but it is not available for this regulation.

[6] Only atmospheric factors are considered for these special environments. The sea and littoral OEs are not addressed here.

## Appendix A

## References

### Section I

### Required Publications

**AR 70–1**
Army Acquisition Policy (Cited in para 1–6*a*.)

**DoDI 6055.01**
DoD Safety and Occupational Health (SOH) Program (Cited in para 1–6*d*.) (Available at https://www.esd.whs.mil/Directives/.)

### Section II

### Related Publications

A related publication is a source of additional information. The user does not have to read a related publication to understand this regulation.

**AECTP–100**
Environmental Guidelines for Defence Materiel (Available at http://www.everyspec.com.)

**AECTP–200**
Environmental Conditions (Available at http://www.everyspec.com.)

**AECTP–230**
Climatic Conditions. (Available at http://www2.fhi.nl/plot2012/archief/2010/images/aectp-230.pdf.)

**Antarctic Treaty**
The Antarctic Treaty of 1959. (Available at https://www.state.gov/t/avc/trty/193967.htm.)

**AR 11–2**
Managers' Internal Control Program

**AR 25–30**
Army Publishing Program

**AR 71–9**
Warfighting Capabilities Determination

**AR 73–1**
Test and Evaluation Policy

**AR 385–10**
The Army Safety Program

**DA Pam 73–1**
Test and Evaluation in Support of Systems Acquisition

**DoDI 5000.67**
Prevention and Mitigation of Corrosion on DoD Military Equipment and Infrastructure (Available at https://www.esd.whs.mil/Directives/.)

**Ecoregions Map of North America: Explanatory Note, Bailey, R. G., (1998)**
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McDonald, E. V., Bacon, S. N., Bassett, S. D., and Jenkins, S. E. (2009) DRI/DEES/TAP–2009–R43–FINAL, U.S. Army Yuma Proving Ground, Natural Environments Test Office, Yuma, AZ. (Available at https://apps.dtic.mil/dtic/tr/fulltext/u2/a508853.pdf.)

**MIL–HDBK–310**
Global Climatic Data for Developing Military Products (Available at https://quicksearch.dla.mil/qsSearch.aspx.)

**MIL–STD–331D**
Fuzes, Ignition Safety Devices and Other Related Components, Environmental and Performance Tests For (Available at https://quicksearch.dla.mil/qsSearch.aspx.)

**MIL–STD–810H**
Environmental Engineering Considerations and Laboratory Tests (Available at https://quicksearch.dla.mil/qsSearch.aspx.)

**MIL–STD–882E**
System Safety (Available at https://quicksearch.dla.mil/qsSearch.aspx.)

**NATO STANAG 4370**
Environmental Testing (Available at https://standards.globalspec.com/.)

## Section III

## Prescribed Forms

This section contains no entries.

## Section IV

## Referenced Forms

Unless otherwise indicated, DA forms are available on the Army Publishing Directorate website: https://armypubs.army.mil/.

**DA Form 11–2**
Internal Control Evaluation Certification

**DA Form 2028**
Recommended Changes to Publications and Blank Forms

## Appendix B

## Internal Control Evaluation

### B–1. Function

The function covered by this evaluation is research, development, test, and evaluation of materiel for worldwide deployment by the U.S. military services into multiple areas of operation with varying environmental effects.

### B–2. Purpose

The purpose of this evaluation is to assist the RDTE community, requirements developers, and program managers in evaluating the key internal controls listed. It is intended as a guide and does not cover all controls.

### B–3. Instructions

Answers must be based upon the actual testing of controls (for example, document analysis, direct observation, sampling, simulation, and/or others). Answers that indicate deficiencies must be explained and the corrective action indicated in the supporting documentation. These management controls must be evaluated at least once every 5 years. Certification that this evaluation has been conducted must be accomplished on DA Form 11–2 (Internal Control Evaluation Certification). Responses may be directed to the Commander, U.S. Army Corps of Engineers (CERD) 441 G Street NW, Washington, DC 20314–1000.

### B–4. Test questions

*a.* Does the US Army Corps of Engineers retain the subject matter expertise as the proponent of this regulation?

*b.* Have environmental parameters for subject OEs been properly evaluated and addressed?

*c.* Are the range of temperatures, OEs, and environmental effects appropriate for RDTE of materiel and equipment?

*d.* Are testing policies found within the regulation adequate, relevant, and appropriate with current science, technology, and engineering practices, that is, composite materials expansion/contraction?

*e.* Are RDTE policies for worldwide use of materials found within the regulation adequate, relevant, and appropriate with current ASA (ALT) acquisition policy?

*f.* Are performance criteria listed within the regulation adequate for RDTE processes?

### B–5. Supersession

This evaluation replaces any previously published evaluations in AR 70–38.

### B–5. Comments

Help to make this a better tool for evaluating internal controls. Submit comments to the Assistant Secretary of the Army (Financial Management and Comptroller) (SAFM–FOA), 109 Army Pentagon, Washington, DC 20310–0109.

# Glossary

## Section I

## Abbreviations

**AECTP**
Allied Environmental Conditions and Test Publication

**AMC**
U.S. Army Materiel Command

**AR**
Army regulation

**ARIMS**
Army Records Information Management System

**ASA (ALT)**
Assistant Secretary of the Army (Acquisition, Logistics and Technology)

**ASA (IE&E)**

Assistant Secretary of the Army (Installations, Energy and Environment)

**ATEC**
U.S. Army Test and Evaluation Command

**Bph**
British Thermal Units per square foot per hour

**C**
Celsius

**CG**
commanding general

**DA**
Department of the Army

**DCS**
Deputy Chief of Staff

**DoD**
Department of Defense

**DoDI**
Department of Defense instruction

**DUSA**
Deputy Under Secretary of the Army

**F**
Fahrenheit

**fps**
feet per second

**ft.**
feet

**GOE**
global operational environment

**HQDA**
Headquarters, Department of the Army

**in.**
inches

**in./min**
inches per minute

**inHg**
inches of mercury

**kg**
kilogram

**km**
kilometers

**lb**
pound

**m**
meter

**mbar**
millibars

**MIL–HDBK**
Military Handbook

**MIL–STD**
Military Standard

**mm**
millimeters

**mm/min**
millimeters per minute

**mph**
miles per hour

**mps**
meters per second

**NATO STANAG**
North Atlantic Treaty Organization Standardization Agreement

**NGA**
National Geospatial-Intelligence Agency

**NRCS**
National Resources Conservation Service

**OE**
operational environment

**OMS/MP**
operation mode summary/mission profile

**RDTE**
research, development, test, and evaluation

**RH**
relative humidity

**sec**
second

**SOH**
safety and occupational health

**T&E**
test and evaluation

**TRADOC**
U.S. Army Training and Doctrine Command

**USACE**
U.S. Army Corps of Engineers

**USCS**
Unified Soil Classification System

## Section II

## Terms

**Environment**
The combination of natural and induced conditions occurring or encountered at any time or place. This document focuses on the naturally occurring conditions of environment.

**Global operational environments**
A framework build on Bailey's ecoregions method of geographical classification (Bailey, R.G., 1996) to address atmospheric, terrestrial, and biological consideration for the design and performance of material worldwide. GOEs identify four climate regions: polar, humid temperate, humid tropical, and dry. Each climatic region comprises land areas characterized by broad similarities in mean annual temperature, precipitation, and evapotranspiration.

**Natural environmental factors**
Includes atmospheric factors, terrain factors, and biological factors. Other factors are considered induced.

**Operational environments**
More detailed geographic classification system than the GOE system. Under this OE system, the world is subdivided into nineteen subgroups. These are further discussed in chapter 3.

## Section III

## Special Abbreviations and Terms

This section contains no entries.