Army Regulation 70–38

RESEARCH, DEVELOPMENT, AND ACQUISITION

RESEARCH, DEVELOPMENT, TEST AND EVALUATION OF MATERIEL FOR EXTREME CLIMATIC CONDITIONS

Headquarters
Department of the Army
Washington, DC
15 September 1979

UNCLASSIFIED

SUMMARY of CHANGE

AR 70–38
RESEARCH, DEVELOPMENT, TEST AND EVALUATION OF MATERIEL FOR EXTREME CLIMATIC CONDITIONS

This Change 1--

- o Is issued to correct printing errors of the basic.
- o Replaces old pages 2-19 and 2-20. This corresponds to electronic paras 2-8f through 2-11b.
- o This revision--
- o Is a complete revision of AR 70-38.
- o Reflects changes in policy, guidance, and climatic criteria, and conforms to MIL-STD-210B, Climatic Extremes for Military Equipment, 15 December 1973.

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Effective 15 September 1979

RESEARCH, DEVELOPMENT, AND ACQUISITION

RESEARCH, DEVELOPMENT, TEST AND EVALUATION OF MATERIEL FOR EXTREME CLIMATIC CONDITIONS

By Order of the Secretary of the Army:

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Major General, United States Army
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History. This publication was originally printed on 1 August 1979. It was authenticated by E. C. Meyer, General, United States Army Chief of Staff, and J. C. Pennington, Major General, United States Army, The Adjutant General. This electronic edition publishes the basic 1 August 1979 edition and incorporates Change 1. Change 1 to this regulation was printed on 15 September 1979. Change 1 was authenticated by E. C. Meyer, General, United States Army Chief of Staff, and J. C. Pennington, Major General, United States Army, The Adjutant General.

Summary. This regulation prescribes policies, responsibilities, and planning guidance for realistic consideration of climatic conditions in the research, development, test, and evaluation (RDTE) of material used in combat by the Army.

Applicability. This regulation applies to items of materiel developed by the Army. It also applies to items of materiel developed by another Service to meet Army's requirements and Army (a) approves the requirements documents, (b) has budget responsibility and (c) is the user.

Proponent and exception authority. The proponent agency of this regulation is the Office of the Chief of Engineers.

Army management control process. Not applicable.

Supplementation. Local supplementation of this regulation is prohibited, except upon approval of the Chief of Engineers.

Interim changes. Interim changes to this regulation are not official unless they are authenticated by The Adjutant General. Users will destroy interim changes on their expiration dates unless superseded or rescinded.

Suggested Improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) direct to HQDA (DAEN-RD) WASH DC 20314.

Distribution. To be distributed in accordance with DA Form 12-9A requirements for AR, Research and Development.
Active Army: C
ARNG: NONE
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Contents (Listed by paragraph and page number)

*This regulation supersedes AR 70-38, 5 May 1969.

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Chapter 1
GENERAL POLICIES AND PROCEDURES

1–1. Purpose.
This regulation prescribes policies, responsibilities, and planning guidance for realistic consideration of climatic conditions in the research, development, test, and evaluation (RDTE) of material used in combat by the Army. The principal classes of materiel used in combat are—

a. Mechanical assemblies for ground use (e.g., tank).

b. Mechanical assemblies for air use (e.g., helicopter).

c. Electrical and electronic equipment (e.g., radio).

d. Optical equipment (e.g., rangefinder).

e. Weapons (e.g., missile).

f. Ammunition (e.g., artillery shell).

g. Hydrocarbon fuels and lubricants.

h. Construction materials and equipment.

1–2. Applicability.
a. This regulation applies to items of materiel—

(1) Developed by the Army.

(2) Developed by another Service to meet Army's requirements and Army—

(a) Approves the requirements documents.

(b) Has budget responsibility.

(c) Is the user.

b. For materiel developed for the sole use of another service, the policy of the using service will apply.

c. This regulation does not apply to the Army National Guard or the Army Reserve.

d. It defines the climatic conditions materiel may be exposed to and gives guidance in the selection of appropriate test levels for some test procedures. It does not define test procedures, because there may be valid reasons for performing tests under conditions that are not entirely realistic. Four climatic design types, differentiated by temperature characteristics, are in chapter 2. These design types give guidance in preparing requirements documents and other documents covering RDTE and procurement of Army materiel. A map showing locations of the four types of design criteria is included (fig. 2-1).

e. This regulation is concerned primarily with the mechanical operation or functioning of materiel under the extremes of climate to which it is likely to be exposed. It is recognized that some environmental elements or conditions (smoke, haze, fog, shimmer, and clouds, for example) may affect the ability of some materiel, particularly Electro-optical equipment, to perform its mission. Unfortunately, the effects of these environmental factors on the operation of electro-optical devices cannot be reliably quantified at this time. Therefore, design criteria for visibility requirements are not given in this regulation.

f. Although climate is the most important element of the total natural environment as far as military equipment design is concerned, other environmental elements such as vegetation, soils, landforms, and biological agents also affect the performance of materiel. In some cases, these factors may be more responsible for deterioration and failure than climate. No attempt is made to specify criteria for these non-climatic elements in this regulation. It is recommended that, wherever appropriate, they be stated in requirement documents.

g. Provisions of this publication are the subjects of international standardization agreements (QSTAG 360 and STANAG 2831). When amendment, revision, or cancellation of this publication is proposed that will affect or violate the international agreements concerned, the proponent will take appropriate reconciliation action through international standardization channels.

1–3. Explanation of terms.
The following terms apply to this regulation.

a. Climatic design types. Four climatic design types are differentiated on the basis of worldwide temperature regimes. They are—

(1) Hot climatic design type.

(2) Basic climatic design type.

(3) Cold climatic design type.

(4) Severe cold climatic design type.

Areas of the world where these types apply are shown in figure 2-1.

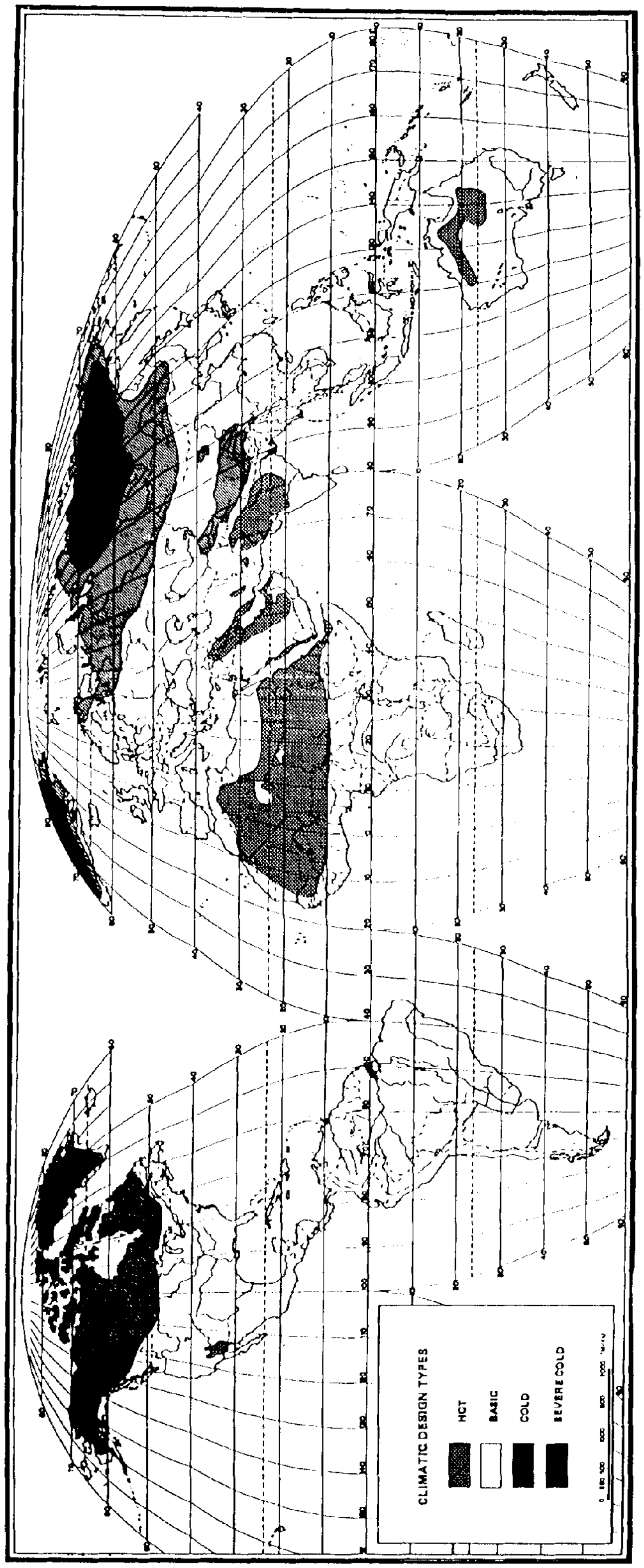

Figure 2-1. Areas of Occurrence of Climatic Design Types

The climatic values included in the design types represent the extreme conditions materiel is likely to encounter in the field, with allowance for some risk (see 1-5b and app A).

b. Daily weather cycles. Each of the climatic design types is characterized by one or more daily weather cycles, which show the interactions and daily patterns of temperature, humidity, and solar radiation (where applicable).

(1) Four cycles represent the basic design type.

(a) One for the hottest days and one for the coldest days likely to be found in the basic design areas.

(b) Two cycle represent areas where high humidities are a major problem.

Materiel that can operate satisfactorily under all four of these daily weather cycles should be capable of satisfactory performance throughout the areas of the basic design type.

(2) The hot climatic design type is characterized by two daily weather cycles, one representing the highest temperatures likely to be found anywhere in the world, and the other representing extremely high dewpoints.

(3) The cold climatic design type and the severe cold climatic design type are each represented by one daily weather cycle, the latter representing the lowest temperatures in which materiel operation is required.

Details of the daily weather cycles that make up the climatic design types are given in section II, chapter 2.

c. Operational, and storage and transit conditions. In each of the eight daily weather cycles, a distinction is made between operational temperature and humidity conditions, and storage and transit temperature and humidity conditions.

(1) *Operational conditions.* These are climatic conditions in the open to which materiel might be subjected during operations or standby for operations. Ambient temperature and humidity conditions are those measured under standard conditions of ventilation and radiation shielding in a meteorological shelter at a height of 4 to 6 feet (1.2 to 1.8 meters) above the ground and determined according to the risk policy in paragraph 1-5b. Solar radiation, which might be experienced concurrently with the temperature and humidity, is also stated for many of the climatic conditions. Although the standard conditions measured in meteorological shelters are usually not exactly the same as the operational environment for materiel, it is necessary to state operational conditions in standard terms so—

(a) Measurements have the same meaning in all parts of the world.

(b) The great range of variations in response of different materiel to a given climatic condition is not a complicating factor in setting design criteria.

For example, the temperature of the materiel itself may vary considerably from the operational air temperature because of the effects of incoming solar radiation, internal sources of heat, the thermal mass, and the heat transfer characteristics of the materials. Most items exposed to the sun will attain higher temperatures than the air temperature. The exact temperature can be obtained through actual or simulated exposure to the appropriate daily cycle, or through the development and use of suitable mathematical models.

(2) *Storage and transit conditions.* These are temperature and humidity conditions materiel might be subjected to in storage and transit situations. Examples of these situations are—

(a) Inside an unventilated field storage shelter.

(b) In a railway boxcar.

Because of great differences in temperature and humidity in varying storage modes, the severity of the exposure depends upon the choice of storage mode as much as the storage location. This is very important in areas of extreme solar radiation and high humilities. Storage and transit air temperature and humidity may differ from operational temperature and humidity because of the induced effects of heat gains or losses of air in confined spaces. Where a large thermal mass is involved (e.g., in food storage), the temperature of the stores may be much lower than the storage air temperature stated, and may have little daily variation. Temperature for such a thermal mass is derived by using data from previous similar storage conditions or is determined by actual measurement under current conditions.

1–4. Objective.

It is intended that this and related regulations will help the Army achieve the objective of developing materiel that will perform adequately under the environmental conditions likely to be found in the areas of intended use.

1–5. Design and test policy.

a. Areas of potential use for Army materiel include all parts of the world except the Antarctic continent. Standard general-purpose materiel will be designed for safe and effective use under the specified conditions of the basic climatic design type (defined in chap. 2). Materiel for use under the conditions of extreme climatic design types (hot, cold, and severe cold) will be provided by designing—

(1) Special materiel capable of such use.

(2) Special materiel solely for such use.

(3) Modification kits which adapt new standard materiel or previously type-classified standard materiel.

The approach chosen will be that which gives satisfactory results most economically, considering the extent of deployment in each area ofpotential use, the current technology level, and the time required for development. For example, if certain materiel is to be used only in areas where cold conditions prevail, materiel should be designed solely for the conditions of those areas.

b. Climatic requirements as well as performance standards for operations, storage, and transit will be stated in requirement documents. Because climatic requirements can have a substantial impact on acquisition and support costs, materiel will be designed, developed, and tested to operate under conditions less severe than the absolute extremes that may occur within the areas of intended use. This implies there is some risk of failure to operate at times. (See app A for discussion of risk levels.) The four climatic design types outlined in chapter 2 all contain some element of risk. Also because of cost considerations, it is general policy to accept reduced performance under the hot, cold, and severe cold conditions as compared to performance under the basic conditions.

c. Army materiel will be designed to be compatible with user personnel fully clothed and equipped for protection against conditions of potential use.

d. Testing in climatic chambers will be fully and creatively exploited before testing in the natural environment. Test results from climatic chambers, however, cannot be interpreted as a total substitute for tests conducted in natural environments.

e. Sites for field testing will be selected, if possible, to induce representative deterioration rates and performance challenges from all environmental effects that the newly developed materiel will be expected to encounter under tactical operational conditions. When time and fund constraints permit sites with the highest materiel deterioration rates or most severe conditions may be selected.

f. DA will support research to develop information about the areal and temporal distribution of climatic and terrain conditions that influence RDTE of materiel.

g. The interaction of equipment with the environment should be considered in all phases of RDTE because the induced conditions may be quite different from those of the natural environment. Sheltered materiel must be designed to operate under the conditions within the shelter during operation in the stipulated areas.

h. For materiel that is sheltered, in limited use, or composed of materials that will be subject to change (structural, irreversible, or destructive) as a result of exposure to natural or induced climatic extremes during test, shipment, or storage, the developing agency will—

(1) Develop protective devices that will permit shipment, storage, and operational use of such materiel in the climatic conditions for which it is intended.

(2) Indicate by distinct markings and by warning statements from appropriate standards the actual climatic stress limits that should not be exceeded.

i. Potentially dangerous items (e.g., ammunition) will be designed to meet safety requirements for all climatic design values despite their chance of being used or the requirement to operate in those climates. An item developed for the basic climatic design type may fail in the more severe climatic conditions of the hot, cold, or severe cold types, and in some cases produce catastrophic or extremely hazardous results.

1–6. Major responsibilities.

General responsibilities for research and development are contained in AR 70-1. Specific responsibilities for RDTE of materiel to ensure its usefulness under extreme climatic conditions are as follows:

a. The Deputy Chief of Staff for Research, Development, and Acquisition will—

(1) Establish policy on climatic conditions to be included in the RDTE of Army materiel.

(2) Approve permanent sites for testing materiel in the natural environment.

b. The Deputy Chief of Staff for Operations and Plans will ensure that climatic requirements are defined in requirements documents.

c. The Chief of Engineers will—

(1) Develop climatic criteria for the RDTE of materiel and recommend their inclusion in DA guidance documents.

(2) Conduct special climatic studies and prepare reports as a guide for RDTE of materiel to be used at a particular place or in a known limited area. (See para 1-7a.)

(3) Provide consulting services for interpretation of climatic conditions for the RDTE of materiel. When questions arise on the use or interpretation of this regulation, consultation with environmental scientists is encouraged. The agency listed below is the point of contact for providing environmental consultation services or directing developers to appropriate sources of information.

Commander and Director
US Army Engineer Topographic Laboratories
ATTN: ETL-GS-A

Fort Belvoir, VA 22060

d. CG, US Army Materiel Development and Readiness Command, The Surgeon General, The Chief of Engineers, and other commanders designated as materiel developers in AR 70-1 will—

(1) Incorporate known climatic parameters in the RDTE of materiel.

(2) Plan and conduct tests of materiel designed to satisfy climatic requirements (AR 70-10).

(3) Recommend to the Deputy Chief of Staff for Research, Development, and Acquisition permanent sites for climatic testing of materiel in the natural environment.

(4) Implement the policy regarding standard and special materiel and modification kits contained in paragraph 1-5a.(3).

(5) Determine when severe consequences may result if the materiel fails under extreme climatic conditions and get a special study of necessary modifications of criteria in chapter 2 in such a case (c(2) above).

(6) Request special studies (c(2) above) when compatibility with climatic criteria (chap. 2) is not possible or is undesirable because of the nature of the materiel or its use (e.g., operated only during winter).

e. CG, US Army Training and Doctrine Command and CG, US Army Communications Command will—

(1) Include in materiel requirement document—

(a) A statement of the areas or conditions in which the materiel may be operated, stored, or transported according to climatic conditions in chapter 2.

(b) A description of the shelters, if any, in which the materiel will be operated.

(c) A list of operational constraints (para 1-2e and f) imposed by meteorological and terrain elements other than those considered in chapter 2.

(2) Request a special study when compatibility with climatic criteria in chapter 2 is not possible or is undesirable because of the nature of the materiel or its use.

1–7. Limitations.

The climatic information in chapter 2 is not to be used—

a. In the RDTE of materiel to be used at a specific place or in a known limited area. This materiel should be designed to withstand climatic conditions at the specific place. In these situations, the climatic requirements should be outlined by the combat user in a special study prepared by designated Army environmental specialists (para 1-6c(2)).

b. In the RDTE of materiel that has inherent limitations, such as food items or medical supplies that must always be kept in controlled environments. Also excluded are most individual clothing items, which, by themselves, are not capable of protecting the soldier from a wide range of climatic conditions. The total range of climatic conditions cited in chapter 2, however, can and should be used as the guide for developing the required number of clothing ensembles to protect personnel against all conditions they may encounter.

c. To authorize the issue of materiel.

1–8. Application of design values.

The general design values in chapter 2 represent a conservative design approach; that is, there is little risk that the design values will be exceeded in the areas to which they apply. Because there is some risk, the design values should be modified for some materiel items. In certain cases, failure of an item may be so critical that more severe climatic criteria should be applied to ensure against environment-related failure. In other cases, the consequences of failure may be slight, so that the cost of designing to the given values may be unwarranted. Special study may be required in these cases to determine the most appropriate design values (1-6c(3)). The type of failure is also an important consideration. Two categories of failure that may cause different design decisions are identified as follows:

a. Reversible failure. For the duration of climatic extremes, the materiel may continue to function, but its performance or safety is reduced, or it may cease to function. When the extreme climatic conditions cease, the materiel will return to normal function.

b. Irreversible failure. The materiel suffers a failure so damaging during climatic extremes that it will not return to normal function when the extreme climatic conditions cease.

1–9. Climatic testing.

Materiel under development is always tested in climatic chambers and usually undergoes additional natural (or field) environmental tests.

a. Chamber climatic test.

(1) *Simulated climatic tests.* The use of simulated climatic tests is encouraged, especially under combined (e.g., temperature and humidity) and sequential conditions, that supports efforts aimed at better simulation through improved test procedures and facilities. In certain cases, it will not be practical or necessary to duplicate exact conditions of the applicable climatic design values in these tests. The materiel, however, will be tested to meet the guidelines of the requirements document. Developers doing simulated climatic tests will use the daily cycles normally found in nature as their models, rather than chamber testing only at the extreme condition. This daily cycling gives more realistic moisture

condensation and temperature response patterns. Test planners and environmental specialists will consult with each other on how the climatic design values apply to testing. (See para, 1-6c(3).)

(2) *Accelerated and aggravated tests.* Accelerated tests approximate conditions, which may occur in nature, but with a greater frequency or duration than would be expected naturally. Aggravated tests involve subject materiel to more extreme conditions than are found in nature. The results of accelerated and aggravated tests are evaluated in terms of what they imply for future service performance. Specifically, they give rapid feedback on problems requiring corrective action as well as statistical data on the margin of safety provided by the design. Comparing results of these tests with results of field climatic tests of service performance will give a better interpretation of results. It also increases confidence in the use of such techniques in subsequent similar situations. In chamber tests, developers are cautioned that subjecting materiel to more extreme conditions than are found in nature may introduce problems that will not occur when testing is conducted in the natural environment. (An example is the liquification of TNT, which does not occur at temperatures below 150° or 66°C.) This is overtesting. On the other hand, the successful conclusion of chamber tests does not guarantee than an item of equipment will operate satisfactorily in the natural environment, because nature involves complex, synergistic effects that cannot presently be induced in chambers (para 2-9). Such factors must be considered by the developer when evaluating results obtained in chambers. Test planners and environmental specialists will consult with each other to determine the extreme combinations of conditions that occur in nature. (See para 1-6c(3).)

b. Natural climatic test. Although climatic conditions during a field day test are not likely to be as extreme as the values specified in chapter 2, there are distinct advantages to conducting tests in a real world environment where the combined effects of several climatic factors can cause difficulties not revealed by chamber testing. (See para 2-8 and 2-9.) On the other hand, when tests are conducted under less than the specified extreme conditions, the adequacy of the natural tests must be reviewed particularly when test results are marginal. Consideration should then be given to results obtained under simulated extreme conditions. Data describing climatic conditions prevailing during field tests at the test site will be recorded to provide a basis for future evaluation.

Chapter 2
CLIMATIC CRITERIA

Section I
GENERAL

2–1. Climatic design types.

a. Hot. The world's highest air temperatures occur in the areas identified with the hot climatic design type in figure 2-1. These are primarily low latitude deserts, which, in addition to very high air temperatures, concurrently experience very low relative humidities (except in the hot-humid areas) and intense solar radiation. Two daily cycles, described in paragraphs 2-4a and b, make up the hot design type—

(1) Hot-dry.

(2) Hot-humid.

b. Basic. The humid tropics and the midlatitudes (basic design type) are characterized by temperatures more moderate than the extremes of the other design types. Areas where the basic type applies are more widespread than the hot and cold design types combined. They also include most of the densely populated, highly industrialized sectors of the world. All general purpose Army materiel is expected to perform satisfactorily under all conditions formally identified as extremes in the basic design type, according to paragraph 1-5a. Since microbial deterioration is a function of temperature and humidity and is an inseparable condition of hothumid tropics and the midlatitudes, it must be considered in the design of all standard general-purpose materiel. Four daily cycles, described in paragraphs 2-5a-c, are recognized for the basic design types—

(1) Constant high humidity.

(2) Variable high humidity.

(3) Basic hot.

(4) Basic cold.

c. Cold. The cold climatic design type areas in figure 2-1, which are confined to the Northern Hemisphere, have temperatures much lower than the basic cold areas but not as low as the severe cold areas. The cold cycle is described in paragraph 2-6.

d. Severe cold. The severe cold climatic design type areas in figure 2-1 have the lowest temperatures on the surface of the earth, except Antarctica, which is not considered in this regulation. These low temperatures are found in the northern continental interiors and the Arctic. The severe cold condition is described in paragraph 2-7.

2–2. Summary of daily cycles.

Table 2-1 is a summary table of the daily extremes (highest and lowest values in a 24-hour cycle) of temperature, solar radiation, and relative humidity 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. 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.

Climatic Design Type	Daily Cycle (QSTAG 360 Equivalents)*	Operational Conditions			Storage and Transit Conditions	
		Ambient Air Temperature °F (°C)	Solar Radiation Bph (W/m²)	Ambient Relative Humidity %	Induced Air Temperature °F (°C)	Induced Relative Humidity %
Hot	Hot-Dry (A1)	90 to 120 (32 to 49)	0 to 355 (0 to 1120)	3 to 8	91 to 160 (33 to 71)	1 to 7
	Hot-Humid (B3)	88 to 105 (31 to 41)	0 to 343 (0 to 1080)	59 to 88	91 to 160 (33 to 71)	14 to 80
Basic	Constant High Humidity (B1)	Nearly Constant 75 (24)	Negligible	95 to 100	Nearly Constant 80 (27)	95 to 100
	Variable High Humidity (B2)	78 to 95 (26 to 35)	0 to 307 (0 to 970)	74 to 100	86 to 145 (30 to 63)	19 to 75
	Basic Hot (A2)	86 to 110 (30 to 43)	0 to 355 (0 to 1120)	14 to 44	86 to 145 (30 to 63)	5 to 44
	Basic Cold (C1)	−5 to −25 (−21 to −32)	Negligible	Tending toward saturation	−13 to −28 (−25 to −33)	Tending toward saturation
Cold	Cold (C2)	−35 to −50 (−37 to −46)	Negligible	Tending toward saturation	−35 to −50 (−37 to −46)	Tending toward saturation
Severe Cold	Severe Cold (C3)	−60 (Cold soak) (−51)	Negligible	Tending toward saturation	−60 (−51)	Tending toward saturation

*Designations in parentheses refer to corresponding climatic categories in Quadripartite Standardization Agreement 360 *Climatic Environmental Conditions Affecting the Design of Military Materiel.* Two of the QSTAG 360 categories, C0 and C4, are not used by the United States.

NOTE: The numbers shown for 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, 120°F is the maximum daytime temperature and 90°F is the minimum nighttime (or early morning temperature). Details of the cycles are provided in tables 2-2 through 2-8.

Figure TABLE 2-1. Summary of Temperature, Solar Radiation, and Relative Humidity Daily Cycles.

2–3. 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 feet (4,572 meters) apply.

b. For materiel subject to shipment by air (elevations as high as 50,000 feet or 15,240 meters), the low air pressure and temperature shown below could result from failure of cabin pressure and temperature regulation.

Height or Elevation		Pressure	Temperature	
ft	(m)	millibars (mb)	°F	(°C)
10,000	(3,048)	660	-42	(-41)
15,000	(4,572)	520	-53	(-47)
20,000	(6,096)	410	-68	(-56)
30,000	(9,144)	255	-87	(-66)
40,000	(12,192)	160	-98	(-72)
50,000	(15,240)	100	-105	(-76)

Figure 2-1B. Elevation, Pressure and Temperature

Section II
CLIMATIC DESIGN TYPES

2–4. 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 (fig. 2-1).

(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 tables 2-2. Nominal accompanying windspeeds at the time of high temperatures are 13 fps (4 mps). The maximum ground surface temperature is 146°F (63°C. At ground elevations above 3,000 feet (915 m), maximum air temperatures will be lower by approximately 5°F per 1,000 feet 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 feet (43 W/ m^2 per 1,000 m) to 15,000 feet.

Local Time	Operational Conditions							Storage & Transit Conditions		
	Ambient Air		Solar Radiation		R.H.	Dewpoint		Induced Air Temp		R.H.
	°F	°C	Bph	W/m²	%	°F	°C	°F	°C	%
0100	95	35	0	0	6	19	-7	95	35	6
0200	94	34	0	0	7	21	-6	94	34	7
0300	93	34	0	0	7	20	-7	94	34	7
0400	92	33	0	0	8	22	-6	92	33	7
0500	91	33	0	0	8	22	-6	92	33	7
0600	90	32	18	55	8	22	-6	91	33	7
0700	91	33	85	270	8	22	-6	97	36	5
0800	95	35	160	505	6	19	-7	104	40	4
0900	101	38	231	730	6	23	-5	111	44	4
1000	106	41	291	915	5	24	-4	124	51	3
1100	110	43	330	1040	4	21	-6	133	56	2
1200	112	44	355	1120	4	23	-5	145	63	2
1300	116	47	355	1120	3	18	-8	156	69	1
1400	118	48	330	1040	3	16	-9	158	70	1
1500	119	48	291	915	3	18	-8	160	71	1
1600	120	49	231	730	3	19	-7	158	70	1
1700	119	48	160	505	3	18	-8	153	67	1
1800	118	48	85	270	3	16	-9	145	63	2
1900	114	46	18	55	3	19	-7	131	55	2
2000	108	42	0	0	4	20	-7	118	48	3
2100	105	41	0	0	5	22	-6	105	41	5
2200	102	39	0	0	6	24	-4	103	39	6
2300	100	38	0	0	6	22	-6	99	37	6
2400	98	37	0	0	6	20	-7	95	35	6

Figure TABLE 2-2. Hot Climatic Design Type: Hot-Dry Daily Cycle of Temperature, Solar Radiation, and Humidity. (QSTAG 360 Category A1)

(b) Storage and transit conditions. The daily cycle for storage and transit in table 2-2 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 dewpoint 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 dewpoints 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 dewpoints (high absolute humidity), a cycle such as that in table 2-3 may occur, along with windspeeds 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.

Local Time	Operational Conditions							Storage & Transit Conditions		
	Ambient Air		Solar Radiation		R.H.	Dewpoint		Induced Air Temp		R.H.
	°F	°C	Bph	W/m²	%	°F	°C	°F	°C	%
0100	88	31	0	0	88	84	29	95	35	67
0200	88	31	0	0	88	84	29	94	34	72
0300	88	31	0	0	88	84	29	94	34	75
0400	88	31	0	0	88	84	29	93	34	77
0500	88	31	0	0	88	84	29	92	33	79
0600	90	32	15	45	85	85	29	91	33	80
0700	93	34	100	315	80	86	30	97	36	70
0800	96	36	177	560	76	87	31	104	40	54
0900	98	37	251	790	73	88	31	111	44	42
1000	100	38	302	950	69	88	31	124	51	31
1100	102	39	328	1035	65	88	31	135	57	24
1200	104	40	343	1080	62	88	31	144	62	17
1300	105	41	317	1000	59	88	31	151	66	16
1400	105	41	280	885	59	88	31	156	69	15
1500	105	41	225	710	59	88	31	160	71	14
1600	105	41	147	465	59	88	31	156	69	16
1700	102	39	66	210	65	88	31	151	66	18
1800	99	37	4	15	69	87	31	145	63	21
1900	97	36	0	0	73	87	31	136	58	29
2000	94	34	0	0	79	86	30	122	50	41
2100	91	33	0	0	85	86	30	105	41	53
2200	90	32	0	0	85	85	29	103	39	58
2300	89	32	0	0	88	85	29	99	37	62
2400	88	31	0	0	88	84	29	95	35	63

Figure TABLE 2-3. Hot Climatic Design Type; Hot-Humid Daily Cycle of Temperature, Solar Radiation, and Humidity. (QSTAG 360 Category B3)

2–5. 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 midlatitudes. 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 below, depends on the nature of the equipment involved.

Table 1–1
Materials and High Humidity Deterioration

Type Material	*Type of Site with the Highest Deterioration Rates*
Elastomers	Open
Polymers	Open
Textiles	Forest
Metals	Coastal swamp (mangrove) and forest

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

(a) Operational conditions. Relative humidity above 95 percent in association with a nearly constant temperature at 75°F (24°C) persists for periods of several days (table 2-4).

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

Local Time	Operational Conditions							Storage & Transit Conditions		
	Ambient Air		Solar Radiation		R.H.	Dewpoint		Induced Air Temp		R.H.
	°F	°C	Bph	W/m²	%	°F	°C	°F	°C	%
0100	Nearly constant at 75°F (24°C) throughout the 24 hours.		Negligible			75	24	Nearly constant at 80°F (27°C) throughout the 24 hours.		Same as operational conditions.
0200					100	75	24			
0300					100	75	24			
0400					100	75	24			
0500					100	75	24			
0600					100	75	24			
0700					98	74	23			
0800					97	74	23			
0900					95	74	23			
1000					95	74	23			
1100					95	74	23			
1200					95	74	23			
1300					95	74	23			
1400					95	74	23			
1500					95	74	23			
1600					95	74	23			
1700					95	74	23			
1800					95	74	23			
1900					97	74	23			
2000					98	74	23			
2100					100	75	24			
2200					100	75	24			
2300					100	75	24			
2400					100	75	24			

Figure TABLE 2-4. Hot Climatic Design Type; Constant High Humidity Daily Cycle of Temperature, Solar Radiation, and Humidity, (QSTAG 360 Category B1)

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

(a) Operational conditions. The daily cycle outlined in table 2-5 has a maximum ambient air temperature of 95°F 35°C) for 2 hours. The maximum solar radiation load of 307 Bph 970 W/m²) for not more than 2 hours, is accompanied by windspeeds 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.

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

Figure TABLE 2-5. Basic Climatic Design Type; Variable High Humidity Daily Cycle of Temperature, Solar Radiation, and Humidity. (QSTAG 360 Category B2)

(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: eight 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 windspeed between 10 and 16 fps (3 and 5 mps) during the period with temperature above 105°F (41°C); and a relative humidity of approximately 14 percent concurrent with the high temperatures (table 2-6). For elevations of 3,000 feet to 10,000 feet (914-3048 m), the ground surface temperature and wind remain the same. Ambient air temperatures, however, decrease 5°F per 1,000 feet (9.1°C per 1,000 m) and solar radiation increases at a rate of 4 Bph per 1,000 feet (43 W/m^2 per 1,000 m).

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

Figure TABLE 2-6. Basic Climatic Design Type: Hot Daily Cycle of Temperature, Humidity, and Solar Radiation. (QSTAG 360 Category A2)

(b) Storage and transit conditions. Design criteria are: four continuous hours with an induced air temperature above 140°F (60°C) with relative humidity less than 8 percent; an air temperature extreme of 145°F (63°C) for not more than 2 hours without benefit of solar radiation and with negligible wind (table 2-6).

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 (e.g., 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: five continuous hours with an ambient air temperature of −25°F (−31°C); a minimum ground surface temperature of −35°F (−37°C); windspeed less than 16 fps (5 mps); negligible solar radiation (horizontal surface); and humidity tending toward saturation (table 2-7). 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, windspeeds greater than 16 fps (5 mps) may be associated with temperatures of −25°F (−31°C).

Local Time	Operational Conditions							Storage & Transit Conditions		
	Ambient Air		Solar Radiation		R.H.	Dewpoint		Induced Air Temp		R.H.
	°F	°C	Bph	W/m²	%	°F	°C	°F	°C	%
0100	-24	-31	Negligible during low temperature periods.		Tending toward saturation.			-27	-33	Tending toward saturation.
0200	-25	-32						-28	-33	
0300	-25	-32						-28	-33	
0400	-25	-32						-28	-33	
0500	-25	-32						-28	-33	
0600	-25	-32						-28	-33	
0700	-22	-30						-27	-33	
0800	-18	-28						-27	-33	
0900	-15	-26						-26	-32	
1000	-12	-24						-24	-31	
1100	-8	-22						-22	-30	
1200	-5	-21						-19	-28	
1300	-5	-21						-17	-27	
1400	-6	-21						-15	-26	
1500	-6	-21						-13	-25	
1600	-8	-22						-15	-26	
1700	-11	-24						-18	-28	
1800	-13	-25						-20	-29	
1900	-15	-26						-22	-30	
2000	-17	-27						-24	-31	
2100	-19	-28						-26	-32	
2200	-21	-29						-27	-33	
2300	-22	-30						-27	-33	
2400	-24	-31						-27	-33	

Figure TABLE 2-7. Basic Climatic Design Type; Cold Daily Cycle of Temperature, Humidity, and Solar Radiation. (QSTAG 360 Category C1)

(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 (table 2-7).

2–6. 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 (e.g., Alps, Himalayas, and the Andes).

b. Temperature, humidity, solar radiation.

(1) *Operational conditions.* Design conditions are: Six continuous hours with an ambient air temperature of −50°F

(−46°C); a minimum snow surface temperature of −50°F (−46°C); windspeed less than 16 fps (5 mps); negligible solar radiation (horizontal surface); and relative humidity tending towards saturation (table 2-8).

(2) *Storage and transit conditions.* Same as operational conditions (table 2-8).

2–7. 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.

Local Time	Operational Conditions							Storage & Transit Conditions		
	Ambient Air		Solar Radiation		R.H.	Dewpoint		Induced Air Temp		R.H.
	°F	°C	Bph	W/m²	%	°F	°C	°F	°C	%
0100	-50	-46	Negligible		Tending toward saturation.			-50	-46	Tending toward saturation.
0200	-50	-46						-50	-46	
0300	-50	-46						-50	-46	
0400	-50	-46						-50	-46	
0500	-50	-46						-50	-46	
0600	-50	-46						-50	-46	
0700	-49	-45						-49	-45	
0800	-47	-44						-47	-44	
0900	-45	-43						-45	-43	
1000	-42	-41						-42	-41	
1100	-39	-39						-39	-39	
1200	-35	-37						-35	-37	
1300	-35	-37						-35	-37	
1400	-35	-37						-35	-37	
1500	-35	-37						-35	-37	
1600	-36	-38						-36	-38	
1700	-38	-39						-38	-39	
1800	-39	-39						-39	-39	
1900	-41	-41						-41	-41	
2000	-43	-42						-43	-42	
2100	-45	-43						-45	-43	
2200	-47	-44						-47	-44	
2300	-48	-44						-48	-44	
2400	-49	-45						-49	-45	

Figure TABLE 2-8. Cold Climatic Design Type; Daily Cycle of Temperature, Humidity, and Solar Radiation. (QSTAG 360 Category C2)

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 relative humidity toward saturation (because of low temperature, not high absolute humidity or vapor pressure). Windspeeds 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 (1) above.

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

2–8. 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 (0.80 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 (e.g., missiles, aircraft) that might be subject to erosion from the more extreme rainfall intensities, a design value of 0.07 inches per minute (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 inches per minute (31 mm/min).

(1) A nominal drop-size spectrum for the 0.5 percent extreme is—

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

Figure 2-8. Drop Diameter Range (mm)

(2) The above rainfall intensities may be accompanied by intermittent winds up to 60 fps (18 mps). Higher windspeeds 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 windblown. (See (2) below.) 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 (1930 mm), a rate of about 3 inches per hour (76 mm/hr). 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 inches (0.05 m). Therefore, extremes of blowing snow are given for height intervals up to 33 feet (10 m). Design values should be based on the height of the equipment. The horizontal mass windspeed of 44 fps (13 mps) at a height above fluxes for operational extremes, with a ground or snow surface of 10 feet (3 m), are—

Height (ft)	Height (m)	Mass flux ($lbs/ft^2/sec$)	Mass flux ($kg/m^2/sec$)
33	10	$.45 \times 10^{-3}$	2.2×10^{-3}
25	7.5	$.68 \times 10^{-3}$	3.3×10^{-3}
16	5	$.82 \times 10^{-3}$	4.0×10^{-3}
8.2	2.5	1.40×10^{-3}	6.9×10^{-3}
3.3	1	3.30×10^{-3}	16.0×10^{-3}
2.5	.75	4.50×10^{-3}	22.0×10^{-3}
1.6	.5	6.60×10^{-3}	32.0×10^{-3}
.82	.25	14.00×10^{-3}	66.0×10^{-3}
.33	.1	41.00×10^{-3}	200.0×10^{-3}
.16	.05	109.00×10^{-3}	530.0×10^{-3}

Figure 2-9. Snow Height and Mass Flux

When blown by strong winds, snow crystals are broken and abraded into roughly equal size grains with rounded or subangular corners. More particles occur in the size range of 0.02 min to 0.4 mm, where the size is the effective diameter as—

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

Figure 2-10. Blown Snow Crystal Diameter Formula

—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).

(3) *Snowload.* A third important effect of snow is the structural load imposed by accumulated snow upon buildings, shelters, vehicles, or other relatively large military items. Snowload extremes are not applicable to operations; however, designers of the above equipment may wish to consider the following extremes, which are for snowloads on the ground. Snowloads 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 snowload value is 10 lbs/ft^2 (48.9 kg/m^2), which is equivalent to a depth of 20 inches (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, etc., 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 snowload value is 20 lbs/ft^2 (97.7 kg/m^2), which is equivalent to a snow depth of 40 inches (1016 mm) with a specific gravity of 0.1.

(c) Semipermanently 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 snowload value is 48 lbs/ft^2 (235 kg/m^2), which is equivalent to a snow depth of 96 inches (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 onehalf inch of glaze with specific gravity of 0.9. This includes the colder sections within the basic design type, and all of 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-STD-210B are as follows:

3 inches (76 mm) glaze, specific gravity 0.9.

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

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

(1) 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.

(2) Ice fog consists of suspended ice crystals averaging 5 to 20 micrometers 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 ot a few feet. Ice fog is often locally induced by the operation of motor vehicles, power plants, 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 inches (51 mm) in diameter. The largest hailstone ever recorded measures 5.6 inches (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 oreintation, area, and shape of the elements of the structure.

(1) For operations, the following extremes, as given in MIL-STD-210B, are: a steady windspeed of 73 fps (22 mps) and a gust of 95 fps (29 mps).

(2) The above operational windspeeds are for a height of 10 feet (3 m). Multiplication factors for obtaining speeds at the height of equipment are—

Height (ft)	Height (m)	Operation Steady Winds	Operation Gusts
5	1.5	0.917	0.946
10	3	1.000	1.000
20	6	1.090	1.057
30	9	1.147	1.092
40	12	1.189	1.117
50	15	1.222	1.137
75	23	1.286	1.175
100	30	1.334	1.202
200	61	1.454	1.271
300	91	1.500	1.313
400	122	1.586	1.343
500	152	1.631	1.368
1000	305	1.778	1.445

Figure 2-11. Height—Windspeed Calculations

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, cause undue wear to moving parts, and interfere with electrical contacts. 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 atenuation and degradation of electromagnetic radiation in the atmosphere. Particles vary in diameter from 0.1 to 1,000 micrometers (3.94×10^{-6} inches to 3.94×10^{-2} inches), but most airborne particles are less than 74 micrometers (2.91×10^{-3} inches).

(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 100 km^{-1} for visible wavelengths through the middle infrared (12 micrometers). Such particles range in size up to 500 micrometers (1.97×10^{-2} inches) 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 $\times 10^{-5}$ lb/ft^3 (106×10^{-3} kg/m^3 with windspeeds up to 59 fps (18 mps) at a height of 10 feet (3 in). Particle sizes will range from less than 74 micrometers (2.91×10^{-3} inches) in diameter to 1,000 micrometers (3.94×10^{-2} inches), with the bulk of the particles ranging in size from 74 to 350 micrometers (13.8×10^{-3} inches).

(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 windspeeds of 59 fps (18 mps) at a height of 10 feet (3 in). Under these conditions, the bulk of the particle sizes are likely to be less than 150 micrometers (5.90×10^{-3} inches) except that some large particles (up to 1,000 micrometers) may be in motion within several feet of the ground. In all categories, temperatures are typically above 70°F (21°C) and relative humilities are less than 30 percent. For testing purposes, particle sizes up to 150 micrometers 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 1,000 micrometers should be used, but the bulk of the particles should be between 150 and 500 micrometers. Many items, such as rifles, vehicles, and helicopters, may be exposed to particles up to 1,000 micrometers 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 riot considered in the design and testing of military equipment. Ambient pressure, however, may be important for a few types of equipment, for example, items which 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 mb (31.89 inches).

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

2–9. 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 2-8, 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.

Section III
DISTRIBUTION OF CLIMATIC DESIGN TYPES

2–10. Map of climatic design types.

Figure 2-1 shows land areas where the four climatic design types apply. Discussion of the delimitation of the climatic conditions (para 2-11) is included to permit proper interpretation and use of the map.

2–11. Delimitation of climatic design types.

The primary basis for delimiting the climatic conditions in this regulation is temperature; secondary consideration is given to humidity conditions.

a. Hot climatic design type. The areas where hot conditions apply include most of the lowlatitude deserts of the world. During summer in these areas, temperatures above 110°F (43°C) occur frequently, but except for a few specific localities, temperatures will seldom be above 120°F (49°C). In winter, temperatures are not likely to be extremely low so that the low temperatures of the basic climatic design type apply. If materiel is designed only for the hot type, a special recommendation for low temperature design values should be sought. Limited portions of this area are sometimes subject to very high absolute humilities, although the highest temperatures and highest dewpoints do not occur at the same time.

b. Basic climatic design type. The area this type applies to 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 apply to any one place. Each single design condition (high temperature, low temperature, high humidity) applies to a widespread area. When taken together, the design values should provide for satisfactory equipment throughout the area involved. Tropical areas are included in the basic climatic design type because the temperature of the humid tropics is quite moderate, and the humidity is also experienced in the midlatitudes. The unique feature of the tropics that makes it important to materiel is the persistence of high humidity over long periods of time. This condition not only promotes corrosion but is an excellent environment for insect and microbiological damage.

c. Cold and severe cold design types. The areas designated as cold, and severe cold, primarily northern North America, Greenland, northern Asia, and the Tibetan Highlands of China, were delimited because of the occurrence of low temperatures. In the area of the cold design type, temperature during the coldest month in a normal year may be colder than the basic cold extreme of −25°F (−32°C). In the severe cold areas, temperature during the coldest month in a normal year may be colder than the cold extreme of −50°F (−46°C), but colder than −60°F (−51°C) no more than 20 percent of the hours in the coldest month in the coldest part of the area (northern Siberia where absolute minimum temperatures as low as −90°F (−68°C) have been recorded). Because the extreme low temperatures are not controlled by a daily solar cycle, they persist for a long enough period of time for materiel to reach equilibrium at a temperature near the minimum.

d. Absolute maximum and minimum temperatures. Figures 2-2 and 2-3 are included to show the absolute maximum and minimum temperatures that have been observed. The maps are generalized because of data limitations and the uneven occurrence of extremes.
(Fig. 2-2 and 2-3 were originally fold-ins at the end of the regulation. In this electronic version, they have been reduced here and are presented in context.)

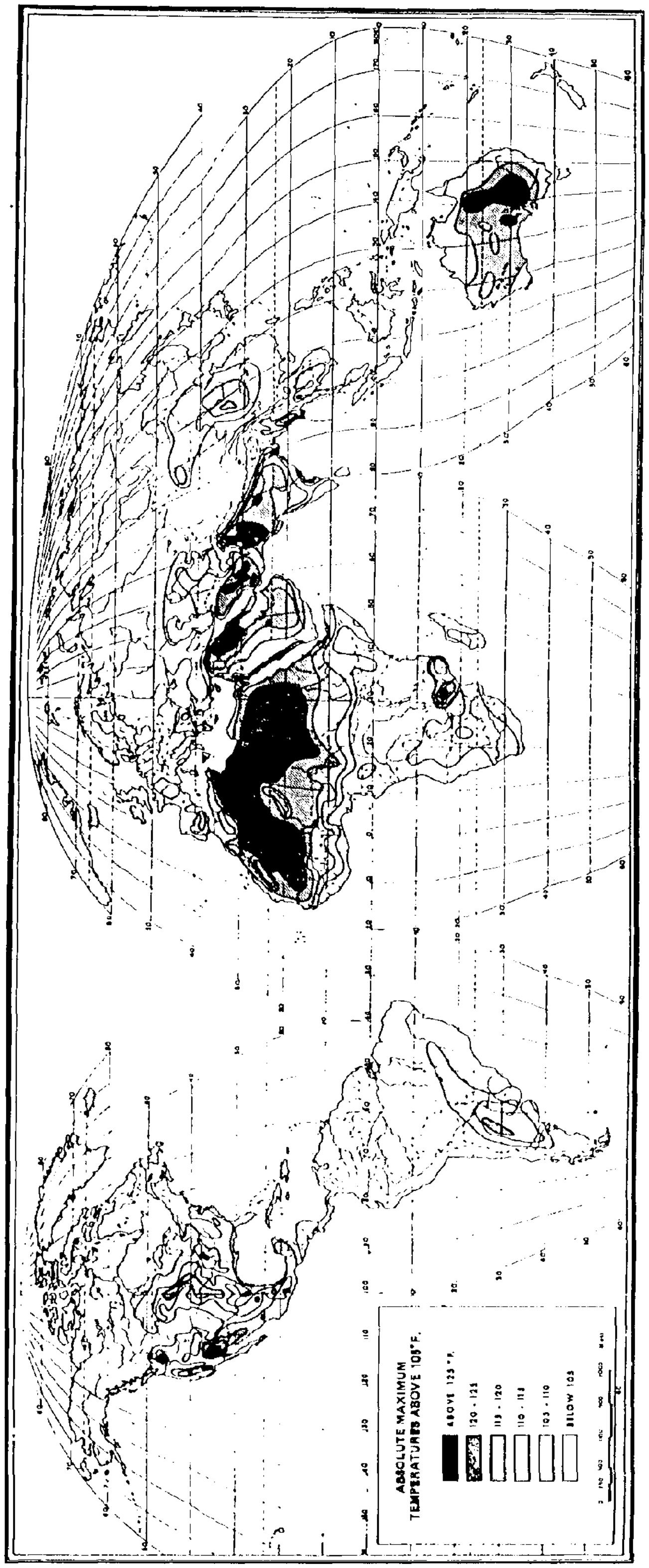

Figure 2-2. Distribution of Absolute Maximum Temperatures

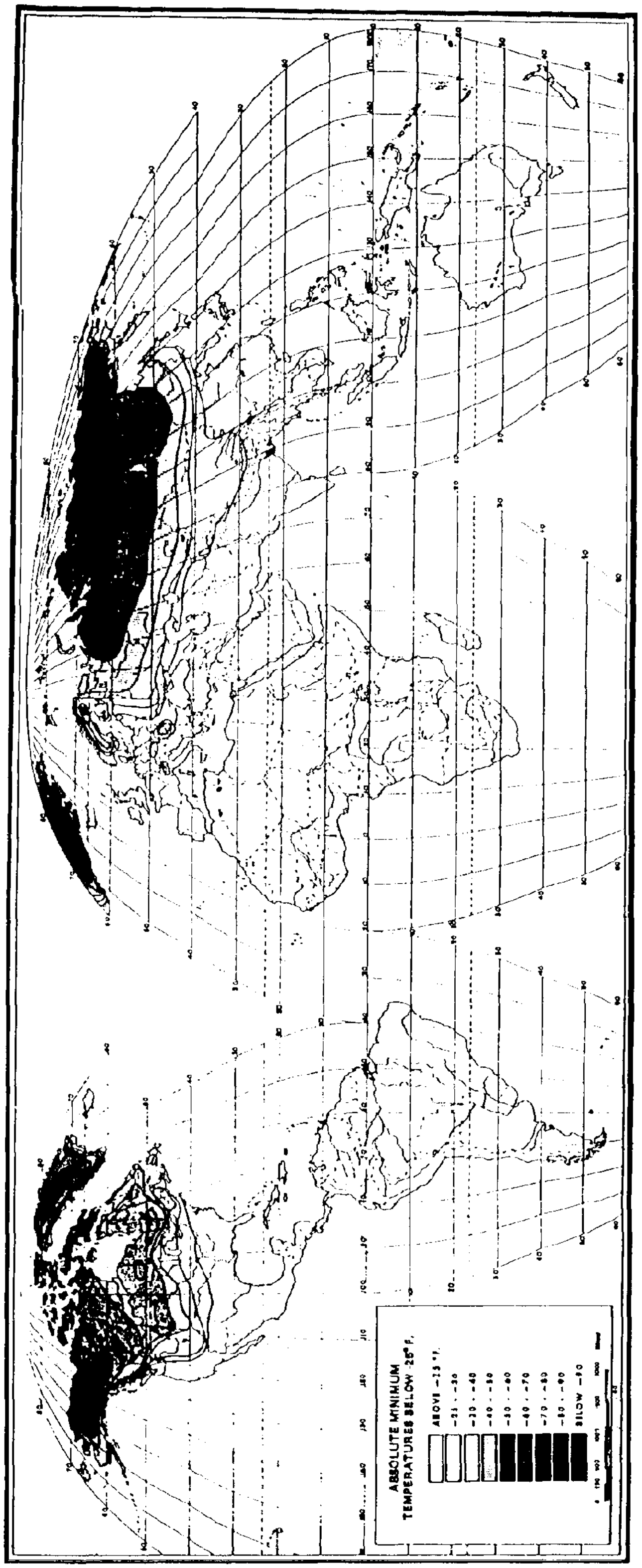

Figure 2-3. Distribution of Absolute Minimum Temperatures

Appendix A
RELATIONSHIP BETWEEN AR 70-38 AND MIL-STD-210B*

*Available from Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120

A–1. Background.

To provide background for the proper use of this regulation, its relationship to MIL-STD-210B is outlined. There are two main differences between the two publications.

a. MIL-STD-210B applies only to materiel developed for worldwide use. AR 70-38 gives design values for most Army materiel, whether intended for worldwide or for more limited use.

b. The treatment of withstanding values.

Both publications reflect a philosophy that accepts a small risk of failure during periods of extreme weather. They also require a complete return to operation after exposure to extreme conditions has ended. MIL-STD-210B, however, considers only the likelihood of natural extremes occurring, whereas AR 70-38 considers the induced conditions many items are exposed to during transit and storage. This difference means that Army materiel must be able to withstand much higher air temperatures than those in MIL-STD-210B, although the high temperatures for operation are the same.

A–2. Risk policy.

In the Ground Environment section, MIL-STD-210B contains single worldwide values for each climatic element to be considered in the design of materiel for operations. For most climatic elements, the design value selected was the value exceeded not more than one percent of the hours in the most extreme month in an average year at the most severe location for that element. (For low temperature the level selected was 20 percent of the hours and for rainfall the level selected was 0.5 percent of the hours.) These values have become known as one percent design values. When they are applied collectively they are often referred to as a one percent risk policy. Although this is a convenient short designation, it can be misleading to those who are not aware of this specific definition of a one percent risk policy. In fact, there is no way to quantify, with any degree of accuracy, the probability that materiel will ever encounter a given extreme of an environmental element. It can be stated with assurance that the designated one percent risk levels as used in MIL-STD-210B are very conservative. For example, on a year-round basis, the risk of encountering the design level of a selected element approaches 1/12 of one percent (there is some likelihood of occurrence in other than the most extreme month). Also, for many of the climatic elements, the design value applies only to the most severe location in the world. Therefore, the risk of materiel encountering this extreme may be very small, particularly if the value at the most severe location is representative of only a small area or the location is in a remote part of the world.

The above considerations led to the adoption of the system now used in AR 70-38. It provides alternate design values for items not intended for worldwide use. Consequently, the world was divided, on the basis of temperature, into four types. The design temperatures in this four-type division are somewhat arbitrary. However, the geographic areas encompassed by the basic design type contain most of the world's population and landmass. In general, the lines delimiting the areas included in a design type have the same basis as MIL-STD-210B; that is, one percent of the hours in the most severe month on average exceeded the design temperature. Note, however, that it is only along the demarcation line that this criterion applies exactly. For example, if more than one percent of the hours in the coldest month at a given location are below −50° (−46°C), the area represented by that location is considered part of the cold climatic design type. Yet, at that location, there may be almost no chance of occurrence of −60°F (−51°C), which is the lower design value for that type. On the other hand, there are stations in the areas included in the severe cold design type that have temperatures below −60°F (−51°C) for as much as 20 percent of the hours in the coldest month. This kind of variation within the regions could be eliminated only by creating a large number of small regions, a procedure that would make this regulation unduly complex.

A–3. Additional guidance.

A general regulation such as this one cannot possibly address in detail the environmental considerations for all materiel. Thus, users are encouraged to seek additional or more specific guidance from the proponent agency.

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