METHOD 507.6

HUMIDITY

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METHOD 507.6, ANNEX A
PHYSICAL PHENOMENA ASSOCIATED WITH HUMIDITY

METHOD 507.6

HUMIDITY

> **NOTE:** Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4.2.2, and Annex C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this Standard.

1. SCOPE.

1.1 Purpose.

The purpose of this Method is to determine the resistance of materiel to the effects of a warm, humid atmosphere.

1.2 Application.

This Method applies to materiel that is likely to be stored or deployed in a warm, humid environment, an environment in which high levels of humidity occur, or to provide an indication of potential problems associated with humidity. Although it is preferable to test materiel at appropriate natural environment sites, it is not always practical because of logistical, cost, or schedule considerations. Warm, humid conditions can occur year-round in tropical areas, seasonally in mid-latitude areas, and in materiel subjected to combinations of changes in pressure, temperature, and relative humidity. Often materiel enclosed in non-operating vehicles in warm, humid areas can experience high internal temperature and humidity conditions. Other high levels of humidity can exist worldwide. Further information on high temperatures and humidity is provided in AR 70-38 (paragraph 6.1, reference a), MIL-HDBK-310 (paragraph 6.1, reference b), or NATO STANAG 4370, AECTP 230 (paragraph 6.1, reference c). See also Part Three of this Standard.

1.3 Limitations.

This Method may not reproduce all of the humidity effects associated with the natural environment such as long-term effects, nor with low humidity situations. This Method does not attempt to duplicate the complex temperature/humidity environment but, rather, it provides a generally stressful situation that is intended to reveal potential problem areas in materiel. This Method includes natural and induced temperature/humidity cycles (for guidance purposes) for identified climatic categories, but these cycles cannot replicate naturally-occurring environments. Testing in the natural environment, whenever practical, may provide more valuable results. Specifically, this Method does not address:

a. Condensation resulting from changes of pressure and temperature for airborne or ground materiel.

b. Condensation resulting from black-body radiation (e.g., night sky effects).

c. Synergistic effects of solar radiation, humidity, or condensation combined with biological and chemical contaminants.

d. Liquid water trapped within materiel or packages and retained for significant periods.

e. Evaluating the internal elements of a hermetically sealed assembly since such materiel is air-tight.

2. TAILORING GUIDANCE.

2.1 Selecting the Humidity Method.

After examining requirements documents and applying the tailoring process in Part One of this Standard to determine if warm temperature/humidity conditions are anticipated in the life cycle of materiel, use the following to confirm the need for this Method and to place it in sequence with other methods.

> **NOTE: Consider the potential synergistic effects of temperature, humidity, and altitude, and the use of Method 520.5 <u>in addition to</u> this Method. However, Method 520 is NOT a substitute for Method 507.**

2.1.1 Effects of Warm, Humid Environments.

Temperature-humidity conditions have physical and chemical effects on materiel; the temperature and humidity variations can also trigger synergistic effects or condensation inside materiel. Consider the following typical problems to help determine if this Method is appropriate for the materiel being tested. This list is not intended to be all-inclusive.

a. Surface effects, such as:

(1) Oxidation and/or galvanic corrosion of metals.

(2) Increased chemical reactions.

(3) Chemical or electrochemical breakdown of organic and inorganic surface coatings.

(4) Interaction of surface moisture with deposits from external sources to produce a corrosive film.

(5) Changes in friction coefficients, resulting in binding or sticking.

b. Changes in material properties, such as:

(1) Swelling of materials due to sorption effects.

(2) Other changes in properties.

(a) Loss of physical strength.

(b) Electrical and thermal insulating characteristics.

(c) De-lamination of composite materials.

(d) Change in elasticity or plasticity.

(e) Degradation of hygroscopic materials.

(f) Degradation of explosives and propellants by absorption.

(g) Degradation of optical element image transmission quality.

(h) Degradation of lubricants.

c. Condensation and free water, such as:

(1) Electrical short circuits.

(2) Fogging of optical surfaces.

(3) Changes in thermal transfer characteristics.

2.1.2 Sequence Among Other Methods.

a. General. Use the anticipated life cycle sequence of events as a general sequence guide (see Part One, paragraph 5.5).

b. Unique to this Method. Humidity testing may produce irreversible effects. If these effects could unrealistically influence the results of subsequent tests on the same item(s), perform humidity testing following those tests. Also, because of the potentially unrepresentative combination of environmental effects, it is generally inappropriate to conduct this test on the same test sample that has previously been subjected to salt fog, sand and dust, or fungus tests. Dynamic environments (vibration and shock) could influence the results of humidity testing. Consider performing these dynamic tests prior to humidity tests.

2.2 Selecting Procedures

This Method consists of two procedures, Procedure I (Induced (Storage and Transit) and Natural Cycles), and Procedure II (Aggravated). Determine the procedure(s) to be used.

> **NOTE**: The materiel's anticipated Life Cycle Environmental Profile (LCEP) may reveal other scenarios that are not specifically addressed in the procedures. Tailor the procedures as necessary to capture the LCEP variations, but do not reduce the basic test requirements reflected in the below procedures. (See paragraph 2.3 below.)

2.2.1 Procedure Selection Considerations.

a. The operational purpose of the materiel.

b. The natural exposure circumstances.

c. Test data required to determine if the operational purpose of the materiel has been met.

d. Test duration.

2.2.2 Difference Between Procedures. (See paragraph 1.3c for related information on limitations.)

a. Procedure I – Induced (Storage and Transit) and Natural Cycles. Once a cycle is selected, perform the storage and transit portion first, followed by the corresponding natural environment portion of the cycle. Procedure I includes:

(1) three unique cycles that represent conditions that may occur during storage or transit, as well as

(2) three unique natural environment cycles that are performed on test items that are open to the environment.

> **NOTE: Although combined under one major column in Table 507.6-I, storage configurations (and any packaging) may differ from configurations for the transit mode (see paragraph 2.3.3). Ensure the configuration used for testing is appropriate for the intended portion of the LCEP. Items in storage or transit could also experience relatively constant conditions if situated near heat-producing equipment, or are sufficiently insulated from external cycling conditions. For the purpose of this test, a "sealed" item is one that could have a relatively high internal level of humidity and lacks continuous or frequent ventilation. It does not include hermetically sealed items.**

The internal humidity may be caused by these or other mechanisms:

(a) Entrapped, highly humid air.

(b) Presence of free water.

(c) Penetration of moisture through test item seals (breathing).

(d) Release of water or water vapor from hygroscopic material within the test item.

b. Procedure II – Aggravated. Procedure II exposes the test item to more extreme temperature and humidity levels than those found in nature (without contributing degrading elements), but for shorter durations. Its advantage is that it produces results quickly, i.e., it may, generally, exhibit temperature-humidity effects sooner than in the natural or induced procedures. Its disadvantage is that the effects may not accurately represent those that will be encountered in actual service. Be careful when interpreting results. This procedure is used to identify potential problem areas, and the test levels are fixed.

2.3 Determine Test Levels, Conditions, and Durations.

Related test conditions depend on the climate, duration, and test item configuration during shipping, storage, and deployment. The variables common to both procedures are the temperature-humidity cycles, duration, and configuration. These variables are discussed below. Requirements documents may impose or imply additional test conditions. Otherwise, use the worst-case conditions to form the basis for selecting the test and test conditions to use.

2.3.1 Test Temperature - Humidity.

The specific test temperature - humidity values are selected, preferably, from the requirements documents. If this information is not available, base determination of the test temperature-humidity values for Procedure I on the world geographical areas in which the test item will be used, plus any additional considerations. Table 507.6-I was developed from AR 70-38 (paragraph 6.1, reference a), MIL-HDBK-310 (paragraph 6.1, reference b), NATO STANAG 4370 (paragraph 6.1, reference d), AECTP 200 (paragraph 6.1, reference e), and NATO STANAG 4370, AECTP 230 (paragraph 6.1, reference c, (part three)) and includes the temperature and relative humidity conditions for three geographical categories where high relative humidity conditions may be of concern, and three related categories of induced conditions. The temperature and humidity data are those used in the source documents mentioned above. The cycles were derived from available data; other geographic areas could be more severe. For Procedure I, the temperature and humidity levels in Table 507.6-I are representative of specific climatic areas; the natural cycles are not adjustable. Figures 507.6-1 through 507.6-6 are visual representations of the cycles in Table 507.6-I.

Although they occur briefly or seasonally in the mid-latitudes, basic high humidity conditions are found most often in tropical areas. 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. Exposed materiel is likely to be constantly wet or damp for many days at a time. A description of each category follows.

a. Constant high humidity (Cycle B1). Constant high humidity is found most often in tropical areas, although it occurs briefly or seasonally in the mid-latitudes. The constant-high-humidity cycle represents conditions in heavily forested areas where nearly constant temperature and humidity may prevail during rainy and wet seasons with little (if any) solar radiation exposure. Tropical exposure in a tactical configuration or mode is likely to occur under a jungle canopy. Exposed materiel is likely to be constantly wet or damp for many days at a time. World areas where these conditions occur are the Congo and Amazon Basins, the jungles of Central America, Southeast Asia (including the East Indies), the north and east coasts of Australia, the east coast of Madagascar, and the Caribbean Islands. The conditions can exist for 25 to 30 days each month in the most humid areas of the tropics. The most significant variation of this cycle is its frequency of occurrence. In many equatorial areas, it occurs monthly, year round, although many equatorial areas experience a distinctive dry season. The frequency decreases as the distance from the equator increases. The mid-latitudes can experience these conditions several days a month for two to three months a year. See Part Three for further information on the description of the environments.

b. Cyclic high humidity (Cycle B2). Cyclic high humidity conditions are found in the open in tropical areas where solar radiation is a factor. If the item in its operational configuration is subject to direct solar radiation exposure, it is permissible to conduct the natural cycle with simulated solar radiation. See Part Three, Table VII, for the associated B2 diurnal solar radiation parameters. In these areas, exposed items are subject to alternate wetting and drying, but the frequency and duration of occurrence are essentially the same as in the constant high humidity areas. Cycle B2 conditions occur in the same geographical areas as the Cycle B1 conditions, but the B1 conditions typically are encountered under a jungle canopy, so the B1 description above also applies to the B2 area.

c. Hot-humid (Cycle B3). Severe (high) dewpoint conditions occur 10 to 15 times a year along a very narrow coastal strip, probably less than 5 miles wide, bordering bodies of water with high surface temperatures, specifically the Persian Gulf and the Red Sea. If the item in its operational configuration is subject to direct solar radiation exposure, it is permissible to conduct the natural cycle with simulated solar radiation. See Part Three, Table V for the associated B3 diurnal solar radiation parameters. Most of the year, these same areas experience hot dry (A1) conditions. This cycle is unique to materiel to be deployed specifically in the Persian Gulf or Red Sea regions, and is not to be used as a substitute for worldwide exposure requirements where B1 or B2 would apply.

In addition to these three categories of natural high-humidity conditions, there are three cycles for induced (storage and transit) conditions:

d. Induced constant high humidity (Cycle B1). Relative humidity above 95 percent in association with nearly constant 27 °C (80 °F) temperature occurs for periods of a day or more.

e. Induced variable - high humidity (Cycle B2). This condition exists when materiel in the variable-high-humidity category receives heat from solar radiation with little or no cooling air. See storage and transit conditions associated with the hot-humid daily cycle of the hot climatic design type below in Table 507.6-I.

f. Induced hot-humid (Cycle B3). This condition exists when materiel in the hot-humid category receives heat from solar radiation with little or no cooling air. The daily cycle for storage and transit in Table 507.6-I shows 5 continuous hours with air temperatures at or above 66 °C (150 °F), and an extreme air temperature of 71 °C (160 °F) for not more than 1 hour.

Table 507.6-I. High humidity diurnal categories.

Time	Natural[1]									Induced (Storage and Transit)								
	High Humidity																	
	Constant Temp. (Cycle B1)			Cyclic High RH (Cycle B2)			Hot Humid (Cycle B3)			Constant Temp. (Cycle B1)			Cyclic High RH (Cycle B2)			Hot Humid (Cycle B3)		
	Temp		RH	Temp		RH	Temp		RH	Temp		RH	Temp		RH	Temp		RH
	ºC	ºF	%	ºC	ºF	%	ºC	ºF	%	ºC	ºF	%	ºC	ºF	%	ºC	ºF	%
0100	Nearly constant at 24°C (75°F) throughout the 24 hours		100[2]	27	80	100	31	88	88	Nearly constant at 27°C (80°F) throughout the 24 hours		100	33	91	69	35	95	67
0200			100	26	79	100	31	88	88			100	32	90	70	34	94	72
0300			100	26	79	100	31	88	88			100	32	90	71	34	94	75
0400			100	26	79	100	31	88	88			100	31	88	72	34	93	77
0500			100	26	78	100	31	88	88			100	30	86	74	33	92	79
0600			100	29	78	100	32	90	85			100	31	88	75	33	91	80
0700			98	27	81	94	34	93	80			98	34	93	64	36	97	70
0800			97	29	84	88	36	96	76			97	38	101	54	40	104	54
0900			95	31	87	82	37	98	73			95	42	107	43	44	111	42
1000			95	32	89	79	38	100	69			95	45	113	36	51	124	31
1100			95	33	92	77	39	102	65			95	51	124	29	57	135	24
1200			95	34	94	75	40	104	62			95	57	134	22	62	144	17
1300			95	34	94	74	41	105	59			95	61	142	21	66	151	16
1400			95	35	95	74	41	105	59			95	63	145	20	69	156	15
1500			95	35	95	74	41	105	59			95	63	145	19	71	160	14
1600			95	34	93	76	41	105	59			95	62	144	20	69	156	16
1700			95	33	92	79	39	102	65			95	60	140	21	66	151	18
1800			95	32	90	82	37	99	69			95	57	134	22	63	145	21
1900			97	31	88	86	36	97	73			97	50	122	32	58	136	29
2000			98	29	85	91	34	94	79			98	44	111	43	50	122	41
2100			100	28	83	95	33	91	85			100	38	101	54	41	105	53
2200			100	28	82	96	32	90	85			100	35	95	59	39	103	58
2300			100	27	81	100	32	89	88			100	34	93	63	37	99	62
2400			100	27	80	100	31	88	88			100	33	91	68	35	95	63

[1] Temperature and humidity values are for ambient air.

[2] For chamber control purpose, 100 percent RH implies as close to 100 percent RH as possible, but not less than 95 percent.

2.3.2 Test Duration.

The number of temperature - humidity cycles (total test time) is critical in achieving the purpose of the test. The durations provided in Table 507.6-II are minimum durations and, in most cases, are far less than necessary to provide an annual comparison. Apply the number of test cycles on a one-for-one basis, i.e., 45 cycles equates to 45 days in the natural environment, and is not related to any acceleration factor. For Procedure I, see Table 507.6-II and use the storage and transit durations for the appropriate cycle (B1, B2, or B3), followed by the corresponding natural cycle duration. For Procedure II guidance, see paragraph 2.3.2c below.

> **NOTE**: The climate station selected for these categories was Majuro, Marshall Islands (7º05’ N, 171º23’E). The station is located at the Majuro Airport Weather Services building. This site is a first-order U.S. weather reporting station. Majuro was selected over 12 available candidate stations from around the world initially because it possessed the required temperature and precipitation characteristics for the B1 category (resulting in high temperature – humidity conditions), and it met the criteria for data availability and quality.
>
> On the average, Majuro receives over 3,300 mm (130 inches) of rainfall annually. Over 250 days experience rainfall >= 0.01 inch, and over 310 days experience rainfall >= trace. Ten years of continuous data were used for the analysis (POR: 1973-1982).
>
> Groupings of consecutive days of rainfall (and resulting humidity) were then extracted. The longest continuous streak of consecutive days >= trace was 51. A cumulative frequency curve was then created. The recommended duration value of 45 days represents the 99^{th} percentile value (actual value = 98.64%).

> **NOTE:** During or after this test, document any degradation that could contribute to failure of the test item during more extensive exposure periods (i.e., indications of potential long term problems), or during exposure to other deployment environments such as shock and vibration. Further, extend testing for a sufficient period of time to evaluate the long-term effect of its realistic deployment duration (deterioration rate becomes asymptotic).

a. Procedure Ia - Induced (Storage and Transit) Cycles

(1) Hazardous test items. Hazardous test items will generally require longer tests than nonhazardous items to establish confidence in test results. Since induced conditions are much more severe than natural conditions, potential problems associated with high temperature/high relative humidity will be revealed sooner, and the results can be analyzed with a higher degree of confidence. Consequently, expose hazardous test items to extended periods (double the normal periods) of conditioning, depending upon the geographical category to which the materiel will be exposed (see Table 507.6-II, induced cycles B1 through B3).

(2) Non-hazardous test items. Induced conditions are much more severe than natural conditions, and potential problems associated with high temperature/high humidity will thus be revealed sooner, and the results can be analyzed, in most cases, with a higher degree of confidence. Expose non-hazardous test items to test durations as specified in Table 507.6-II, induced cycles B1 through B3, depending upon the geographical category to which the material will be exposed.

b. Procedure Ib - Natural Cycles

(1) Hazardous test items. Hazardous test items are those in which any unknown physical deterioration sustained during testing could ultimately result in damage to materiel or injury or death to personnel when the test item is used. Hazardous test items will generally require longer test durations than nonhazardous test items to establish confidence in the test results. Twice the normal test duration is recommended (see Table 507.6-II, cycles B1 through B3).

(2) Nonhazardous test items. Nonhazardous test items should be exposed from 15 to 45 cycles of conditioning, depending upon the geographical area to which the materiel will be exposed (see Table 507.6-II, cycles B1 through B3).

Table 507.6-II. Test cycles (days).

MATERIEL CATEGORY	NATURAL[1]			INDUCED (STORAGE and TRANSIT)		
	Cycle B1	Cycle B2	Cycle B3	Cycle B1	Cycle B2	Cycle B3
Hazardous Items Normal Test Duration	90	90	30	180	180	30
Non-Hazardous Items Normal Test Duration	45	45	15	90	90	15

[1] Perform operational checks at least once every five days; more frequent checks may provide early detection of potential problems.

c. Procedure II – Aggravated Cycle. For Procedure II, in addition to a 24-hour conditioning cycle (paragraph 4.4.2.2), the minimum number of 24-hour cycles for the test is ten. Although the combined 60 °C (140 °F) and 95 percent RH does not occur in nature, this combination of temperature and relative humidity, has historically proven adequate to reveal potential effects in most materiel. Extend the test as specified in the test plan to provide a higher degree of confidence in the materiel to withstand warm, humid conditions. For the test items incorporating seals to protect moisture-sensitive materials, e.g., pyrotechnics, longer test durations may be required.

2.3.3 Test Item Configuration. During conduct of the temperature-humidity procedures of this Method, configure the test item as specified below, or as specifically outlined in the requirements documents. Test item configuration must be selected to reproduce, as closely as technically possible, the configuration that the test item would assume when worst-case situations are encountered during its life cycle.

a. In its assigned shipping/storage container, or as installed in the end item.

b. Out of its shipping/storage container but not set up in its deployment mode.

c. In its operational mode (realistically or with restraints, such as with openings that are normally covered).

2.3.4. Additional Guidelines. Review the requirements documents. Apply any additional guidelines necessary.

2.4 Operational Checkout.

2.4.1 Procedure I (Induced Cycles B1, B2, or B3, Followed By Natural Cycles B1, B2, or B3)

a. Procedure Ia: Induced (storage and transit) cycles B1, B2, and B3 represent storage and transit environments. As such, perform operational checkouts before and after each test.

b. Procedure Ib: Natural cycles B1 - B3 represent the operational environment, and, theoretically, the materiel could be functioning non-stop in the natural environment. In this case, operate the test item continuously throughout the test procedure. If shorter operational periods are identified in the requirements document(s), operate the test item at least once every five cycles for a duration necessary to verify proper operation. This operational checkout will help determine effects of the natural cycles on test item(s) as soon as possible.

2.4.2 Procedure II - Aggravated.

Procedure II does not represent naturally-occurring conditions; therefore it may produce an acceleration of potential temperature-humidity effects. If the test item is intended to be operated in a warm, humid environment, perform at least one operational checkout every five cycles during the periods shown on Figure 507.6-7.

2.5 Test Variations.

The most important ways the tests can vary are in the number of temperature-humidity cycles, relative humidity, and temperature levels and durations, test item performance monitoring (where appropriate), and test item ventilation.

2.6 Philosophy of Testing.

Procedures Ia and Ib are intended to reveal representative effects that typically occur when materiel is exposed to elevated temperature-humidity conditions in storage and transit, followed by actual service where moderate to high instances of such an environment exist. (See paragraph 2.1.1 above for categories and examples of these effects.)

Test item failures do not necessarily indicate failures in the natural environment. Test results must be evaluated accordingly. The most productive sequence of testing is to expose the test item to the storage and transit environment, then follow it by exposure to the naturally occurring cycles anticipated for the operational environment.

2.6.1 Procedure I - Induced (Storage and Transit) Cycles.

Three induced cycles in Table 507.6-I and Figures 507.6-1 though 507.6-3 present what is referred to as "Storage and Transit Conditions." The most extreme of the three cycles (cycle B3) has five continuous hours with air temperatures at or above 66 °C (150 °F), and an extreme air temperature of 71 °C (160 °F) for not more than 1 hour. Testing for these conditions should be done, if practical, according to the daily cycle.

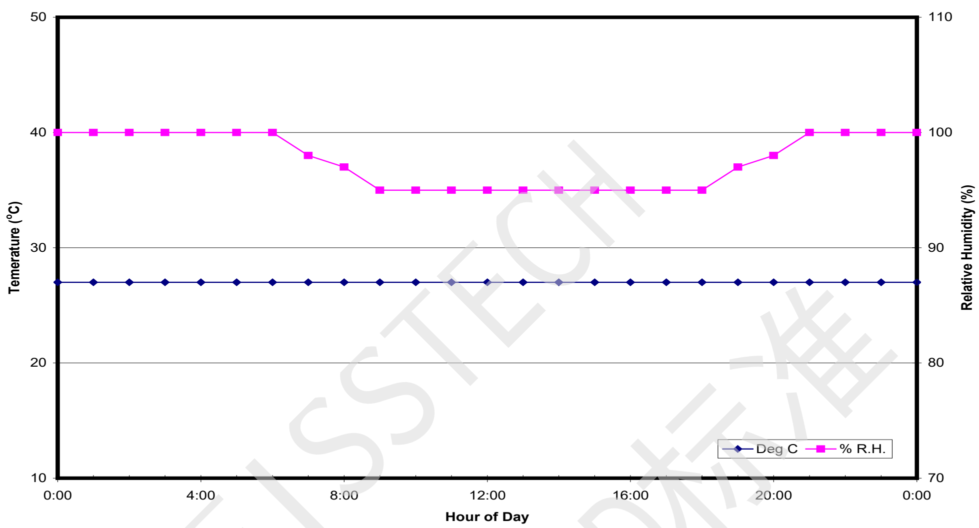

Figure 507.6-1. Induced Cycle B1 - Storage and transit.

Table 507.6-III. Constant temperature and humidity - Induced cycle B1.

Time	Temp. °C	Temp. °F	RH Percent	Time	Temp. °C	Temp. °F	RH Percent
0100	Nearly constant at 27°C (80°F) throughout the 24 hours.		100	1300	Nearly constant at 27°C (80°F) throughout the 24 hours.		95
0200			100	1400			95
0300			100	1500			95
0400			100	1600			95
0500			100	1700			95
0600			100	1800			95
0700			98	1900			97
0800			97	2000			98
0900			95	2100			100
1000			95	2200			100
1100			95	2300			100
1200			95	2400			100

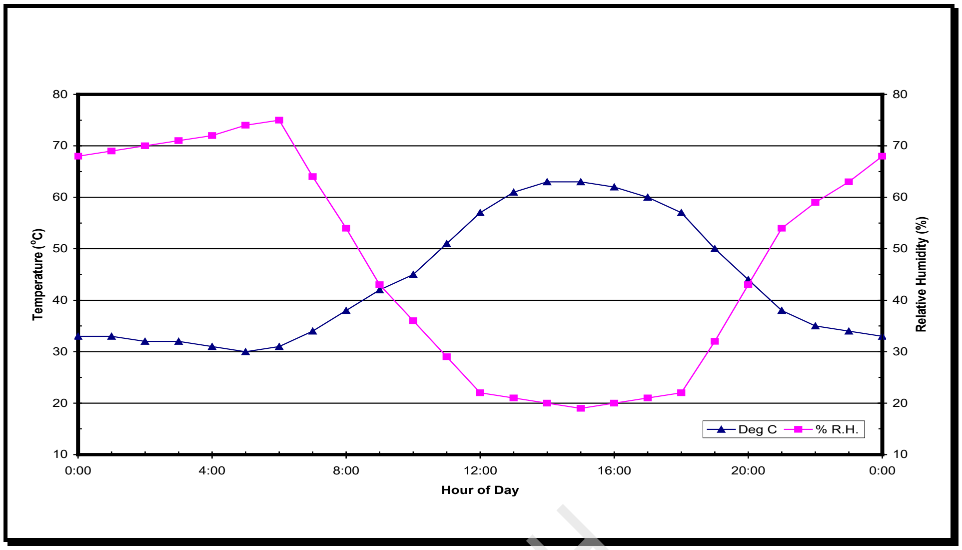

Figure 507.6-2. Induced Cycle B2 - Storage and transit.

Table 507.6-IV. Cyclic high relative humidity - Induced cycle B2.

Time	Temp.		RH	Time	Temp.		RH
	ºC	ºF	Percent		ºC	ºF	Percent
0100	33	91	69	1300	61	142	21
0200	32	90	70	1400	63	145	20
0300	32	90	71	1500	63	145	19
0400	31	88	72	1600	62	144	20
0500	30	86	74	1700	60	140	21
0600	31	88	75	1800	57	134	22
0700	34	93	64	1900	50	122	32
0800	38	101	54	2000	44	111	43
0900	42	107	43	2100	38	101	54
1000	45	113	36	2200	35	95	59
1100	51	124	29	2300	34	93	63
1200	57	134	22	2400	33	91	68

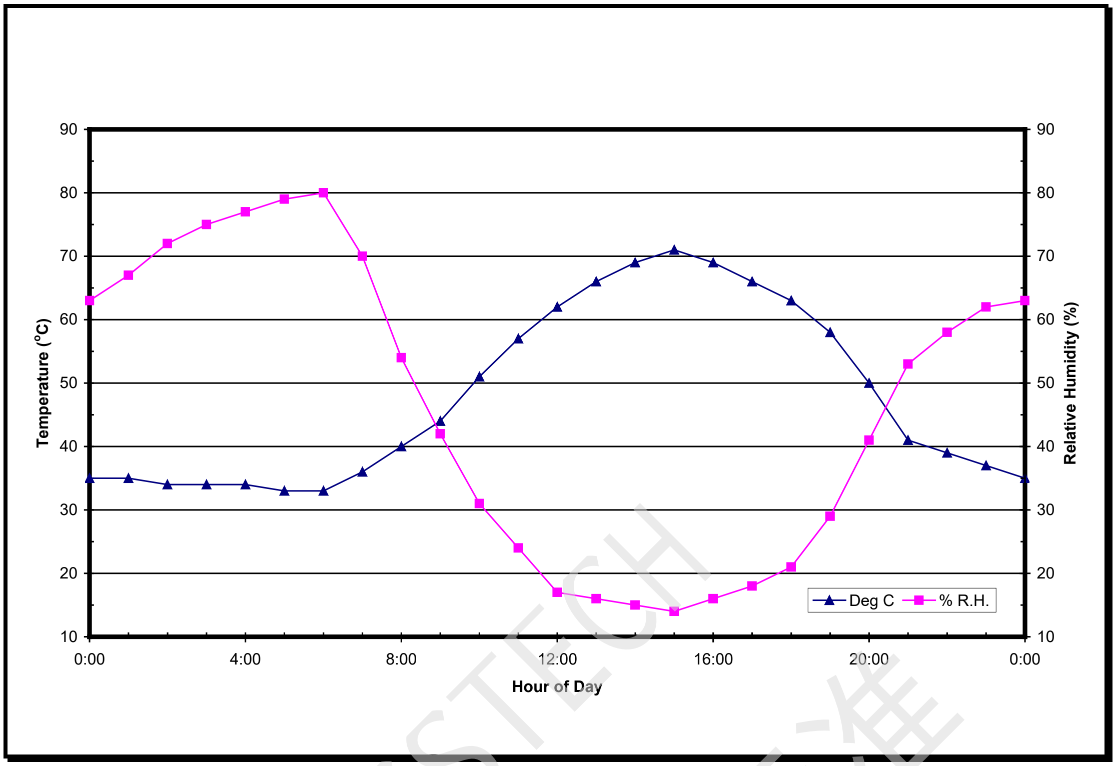

Figure 507.6-3. Induced Cycle B3 - Storage and transit.

Table 507.6-V. Hot Humid - Induced Cycle B3.

Time	Temp. °C	Temp. °F	RH Percent	Time	Temp. °C	Temp. °F	RH Percent
0100	35	95	67	1300	66	151	16
0200	34	94	72	1400	69	156	15
0300	34	94	75	1500	71	160	14
0400	34	93	77	1600	69	156	16
0500	33	92	79	1700	66	151	18
0600	33	91	80	1800	63	145	21
0700	36	97	70	1900	58	136	29
0800	40	104	54	2000	50	122	41
0900	44	111	42	2100	41	105	53
1000	51	124	31	2200	39	103	58
1100	57	135	24	2300	37	99	62
1200	62	144	17	2400	35	95	63

2.6.2 Procedure I - Natural Cycles.

Three natural cycles in Table 507.6-I and Figures 507.6-4 through 507.6-6 reflect data in specific climatic regions as identified in AR 70-38 (paragraph 6.1, reference a) and NATO STANAG 4370, AECTP 230 (paragraph 6.1, reference c). The complex temperature/humidity/solar radiation environment with its associated antagonistic elements such as microbial growth, acidic atmosphere, and other biological elements produce synergistic effects that cannot be practically duplicated in the laboratory. Coupled with these test data interpretation problems are the extensive durations of real-world environments that, in most cases, are too lengthy to realistically apply in the laboratory. Before undertaking such laboratory testing, consider testing in the natural environment. Otherwise, exercise caution in applying such cycles and in interpreting test results.

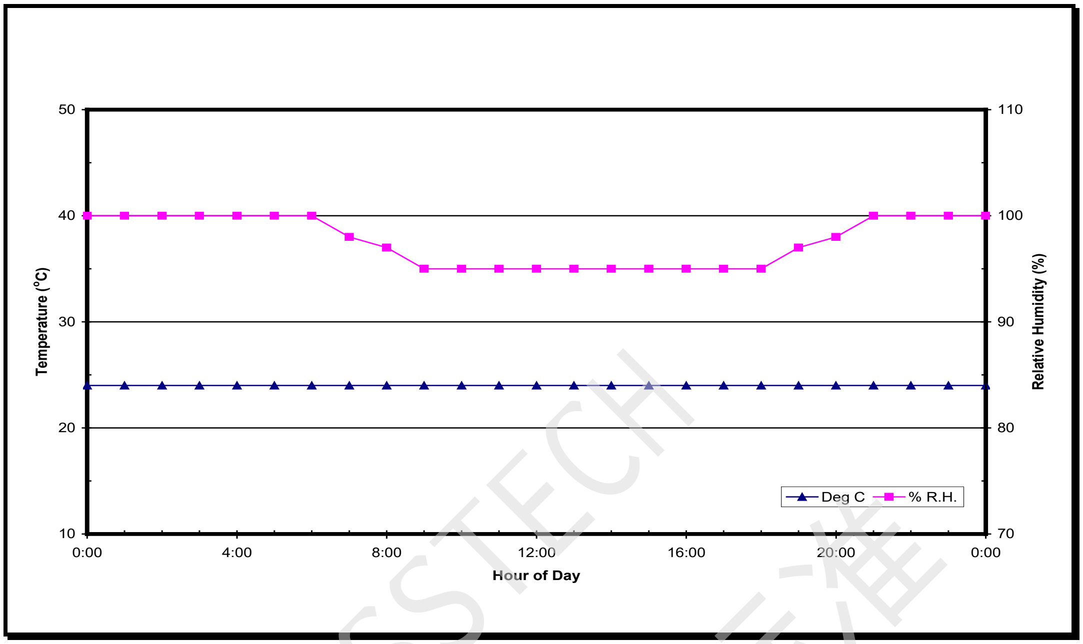

Figure 507.6-4. Natural Cycle B1 – Constant high humidity.

Table 507.6-VI. Constant temperature and humidity - Natural Cycle B1.

Time	Temp. ºC / ºF	RH Percent	Time	Temp. ºC / ºF	RH Percent
0100	Nearly constant at 24ºC (75ºF) throughout the 24 hours.	100	1300	Nearly constant at 24ºC (75ºF) throughout the 24 hours.	95
0200		100	1400		95
0300		100	1500		95
0400		100	1600		95
0500		100	1700		95
0600		100	1800		95
0700		98	1900		97
0800		97	2000		98
0900		95	2100		100
1000		95	2200		100
1100		95	2300		100
1200		95	2400		100

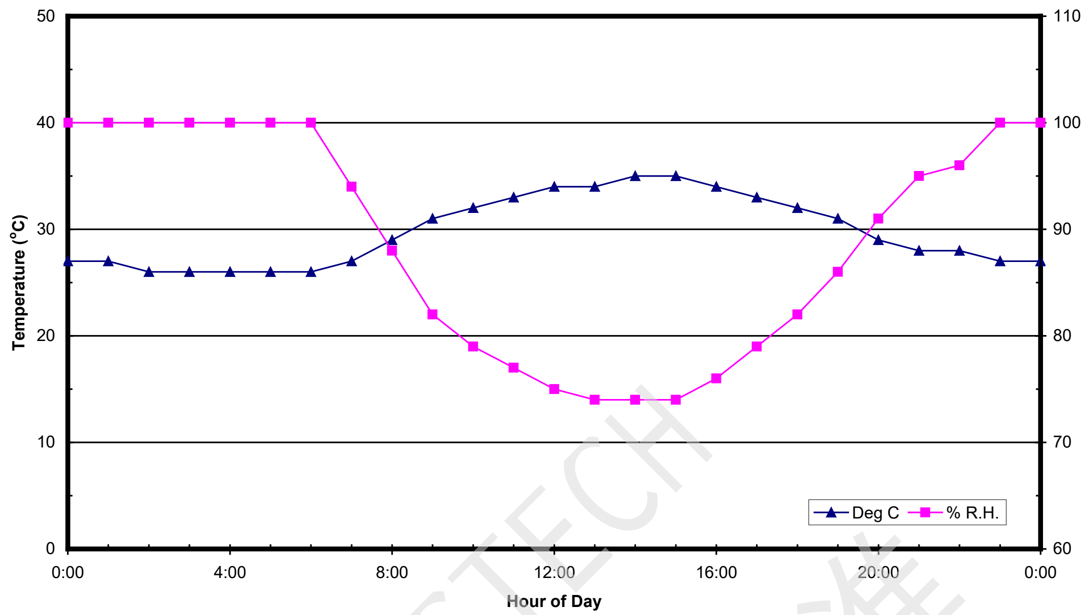

Figure 507.6-5. Natural Cycle B2 – Cyclic high humidity.

Table 507.6-VII. Cyclic high relative humidity – Natural Cycle B2.

Time	Temp. ºC	Temp. ºF	RH Percent	Time	Temp. ºC	Temp. ºF	RH Percent
0100	27	80	100	1300	34	94	74
0200	26	79	100	1400	35	95	74
0300	26	79	100	1500	35	95	74
0400	26	79	100	1600	34	94	76
0500	26	78	100	1700	33	92	79
0600	26	78	100	1800	32	90	82
0700	27	81	94	1900	31	88	86
0800	29	84	88	2000	29	85	91
0900	31	87	82	2100	28	83	95
1000	32	89	79	2200	28	82	96
1100	33	92	77	2300	27	81	100
1200	34	94	75	2400	27	80	100

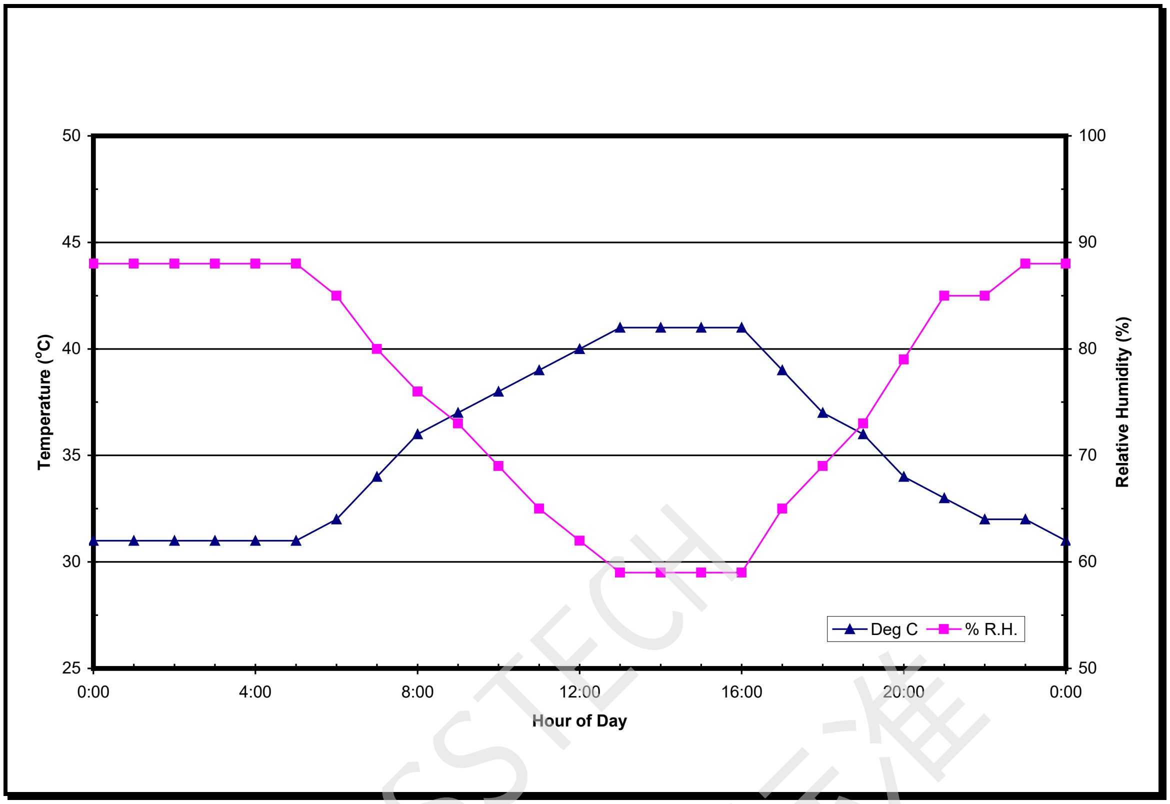

Figure 507.6-6. Natural Cycle B3 - Hot humid.

Table 507.6-VIII. Hot Humid - Natural Cycle B3.

Time	Temp.		RH	Time	Temp.		RH
	ºC	ºF	Percent		ºC	ºF	Percent
0100	31	88	88	1300	41	105	59
0200	31	88	88	1400	41	105	59
0300	31	88	88	1500	41	105	59
0400	31	88	88	1600	41	105	59
0500	31	88	88	1700	39	102	65
0600	32	90	85	1800	37	99	69
0700	34	93	80	1900	36	97	73
0800	36	96	76	2000	34	94	79
0900	37	98	73	2100	33	91	85
1000	38	100	69	2200	32	90	85
1100	39	102	65	2300	32	89	88
1200	40	104	62	2400	31	88	88

2.6.3 Procedure II - Aggravated Cycle (Figure 507.6-7).

The purpose of the aggravated test procedure is to produce representative effects that typically occur when materiel is exposed to elevated temperature-humidity conditions. (See paragraph 2.1.1 above for categories and examples of these effects.) Accordingly, this procedure does not reproduce naturally occurring or service-induced temperature-humidity scenarios. It may induce problems that are indicative of long-term effects. Test item failures do not necessarily indicate failures in the real environment.

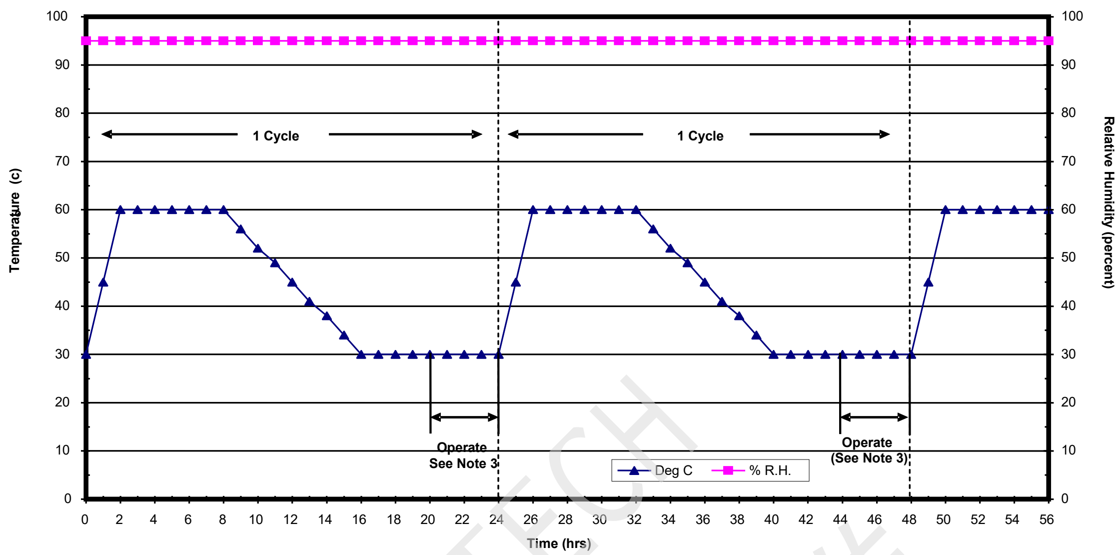

Figure 507.6-7. Aggravated temperature-humidity cycle.

NOTES:

1. Maintain the relative humidity at 95 ±4 percent at all times except that during the descending temperature periods the relative humidity may drop to as low as 85 percent.
2. A cycle is 24 hours.
3. Perform operational checks near the end of the fifth and tenth cycles.

Table 507.6-IX. Aggravated cycle.

Time	Temp. °C	°F	RH Percent
0000	30	86	Constant at 95 percent
0200	60	140	
0800	60	140	
1600	30	86	
2400	30	86	
0200	60	140	
0800	60	140	
1600	30	86	
2400	30	86	

3. INFORMATION REQUIRED.

3.1 Pretest.

The following information is required to conduct humidity tests adequately.

a. General. Information listed in Part One, paragraphs 5.7 and 5.9, and Annex A, Task 405 of this Standard.

b. Specific to this Method.

(1) Any sealed areas of the test item to be opened during testing or vice versa.

(2) If an operational test procedure is required following the Induced (Storage and Transit) test.

(3) Periods of materiel operation or designated times for visual examinations (see paragraph 2.4.1).

(4) Operating test procedures, if appropriate.

c. Tailoring. Necessary variations in the basic test procedures to accommodate environments identified in the LCEP.

3.2 During Test.

Collect the following information during conduct of the test:

a. General. Information listed in Part One, paragraph 5.10, and in Annex A, Tasks 405 and 406 of this Standard.

b. Specific to this Method.

(1) Record of chamber temperature and humidity versus time conditions.

(2) Test item performance data and time/duration of checks.

3.3 Post-Test.

The following post test data shall be included in the test report.

a. General. Information listed in Part One, paragraph 5.13, and in Annex A, Task 406 of this Standard.

b. Specific to this Method.

(1) Previous test methods to which the test item has been subjected.

(2) Results of each operational check (before, during, and after test) and visual examination (and photographs, if applicable).

(3) Length of time required for each operational check.

(4) Exposure durations and/or number of test cycles.

(5) Test item configuration and special test setup provisions.

(6) Any deviation from published cycles / procedures.

(7) Any deviations from the original test plan.

4. TEST PROCESS.

4.1 Test Facility.

Ensure the apparatus used in performing the humidity test includes the following:

4.1.1 General Description.

The required apparatus consists of a chamber or cabinet, and auxiliary instrumentation capable of maintaining and monitoring (see Part One, paragraph 5.18) the required conditions of temperature and relative humidity throughout an envelope of air surrounding the test item. (See Part One, paragraph 5.)

4.1.2 Facility Design.

Unless otherwise specified, use a test chamber or cabinet with a test volume and the accessories contained therein constructed and arranged in such a manner as to prevent condensate from dripping on the test item. Vent the test volume to the atmosphere to prevent the buildup of total pressure and prevent contamination from entering.

4.1.3 Test Sensors and Measurements.

Determine the relative humidity by employing either solid state sensors whose calibration is not affected by water condensation, or by an equivalent method such as fast-reacting wet-bulb/dry-bulb sensors or dew point indicators. Sensors that are sensitive to condensation, such as the lithium chloride type, are not recommended for tests with high relative humidity levels. A data collection system, including an appropriate recording device(s), separate from the chamber controllers is necessary to measure test volume conditions. If charts are used, use charts readable to within ±0.6 °C (±1 °F). If the wet-wick control method is approved for use, clean the wet bulb and tank and install a new wick before each test and at least every 30 days. Ensure the wick is as thin as realistically possible to facilitate evaporation (approximately 1/16 in. thick) consistent with maintaining a wet surface around the sensor. Use water in wet-wick systems that is of the same quality as that used to produce the humidity (see Part One, paragraph 5.16). When physically possible, visually examine the water bottle, wick, sensor, and other components making up relative humidity measuring systems at least once every 24 hours during the test to ensure they are functioning as desired.

4.1.4 Air Velocity.

Use an air velocity flowing across the wet bulb sensor of not less than 4.6 meters/second (900 feet/minute, or as otherwise specified in sensor response data), and ensure the wet wick is on the suction side of the fan to eliminate the effect of fan heat. Maintain the flow of air anywhere within the envelope of air surrounding the test item between 0.5 and 1.7 meters/second (98 to 335 feet/minute).

4.1.5 Humidity Generation.

Use steam or water injection to create the relative humidity within the envelope of air surrounding the test item. Use water as described in Part One, paragraph 5.16. Verify its quality at periodic intervals (not to exceed 15 days) to ensure its acceptability. If water injection is used to humidify the envelope of air, temperature-condition it before its injection to prevent upset of the test conditions, and do not inject it directly into the test section. From the test volume, drain and discard any condensate developed within the chamber during the test so as to not reuse the water.

4.1.6 Contamination Prevention.

Do not bring any material other than water into physical contact with the test item(s) that could cause the test item(s) to deteriorate or otherwise affect the test results. Do not introduce any rust or corrosive contaminants or any material other than water into the chamber test volume. Achieve dehumidification, humidification, heating and cooling of the air envelope surrounding the test item by methods that do not change the chemical composition of the air, water, or water vapor within that volume of air.

4.2 Controls.

a. Measurement and recording device(s). Ensure the test chamber includes an appropriate measurement and recording device(s), separate from the chamber controllers.

b. Test parameters. Unless otherwise specified, make continuous analog temperature and relative humidity measurements during the test. Conduct digital measurements at intervals of 15 minutes or less.

c. Capabilities. Use only instrumentation with the selected test chamber that meets the accuracies, tolerances, etc., of Part One, paragraph 5.3.

4.3 Test Interruption.

Test interruptions can result from two or more situations, one being from failure or malfunction of test chambers or associated laboratory test equipment. The second type of test interruption results from failure or malfunction of the test item itself during operational checks.

4.3.1 Interruption Due to Chamber Malfunction.

a. General. See Part One, paragraph 5.11, of this Standard.

b. Specific to this Method.

   (1) Undertest interruption. If an unscheduled interruption occurs that causes the test conditions to fall below allowable limits, the test must be reinitiated at the end of the last successfully completed cycle.

   (2) Overtest interruptions. If the test item(s) is exposed to test conditions that exceed allowable limits, conduct an appropriate physical examination of the test item and perform an operational check (when practical) before testing is resumed. This is especially true where a safety condition could exist, such as with munitions. If a safety condition is discovered, the preferable course of action is to terminate the test and reinitiate testing with a new test item. If this is not done and test item failure occurs during the remainder of the test, the test results may be considered invalid. If no problem has been encountered during the operational checkout or the visual inspection, reestablish pre-interruption

conditions and continue from the point where the test tolerances were exceeded. See paragraph 4.3.2 for test item operational failure guidance.

4.3.2 Interruption Due to Test Item Operation Failure.

Failure of the test item(s) to function as required during operational checks presents a situation with several possible options.

a. The preferable option is to replace the test item with a "new" one and restart from Step 1.

b. A second option is to replace / repair the failed or non-functioning component or assembly with one that functions as intended, and restart the entire test from Step 1.

> **NOTE**: When evaluating failure interruptions, consider prior testing on the same test item and consequences of such.

4.4 Test Execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the test item in a warm, humid environment.

4.4.1 Preparation for Test.

4.4.1.1 Test Setup.

a. General. See Part One, paragraph 5.8.

b. Unique to this Method. Verify that environmental monitoring and measurement sensors are of an appropriate type and properly located to obtain the required test data.

4.4.1.2 Preliminary Steps.

Before starting the test, determine the test details (e.g., procedure variations, test item configuration, cycles, durations, parameter levels for storage/operation, etc.) from the test plan.

4.4.1.3 Pretest Checkout.

All items require a pretest checkout at standard ambient conditions to provide baseline data. Conduct the checkout as follows:

Step 1. Install appropriate instrumentation, e.g., thermocouples, in or on the test item.

Step 2. Install the test item into the test chamber and prepare the test item in its storage and/or transit configuration in accordance with Part One, paragraph 5.8.1.

Step 3. Conduct a thorough visual examination of the test item to look for conditions that could compromise subsequent test results.

Step 4. Document any significant results.

Step 5. Conduct an operational checkout (if appropriate) in accordance with the test plan, and record results.

Step 6. If the test item operates satisfactorily, proceed to the appropriate test procedure. If not, resolve the problems and repeat Step 5 above.

4.4.2 Test Procedures.

4.4.2.1 Procedure I - Storage and Transit Cycles (Cycles B2 or B3), and Natural (Cycles B1, B2, or B3).

Step 1. With the test item in the chamber, ensure it is in its storage and/or transit configuration, adjust the chamber temperature to 23 ± 2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain for no less than 24 hours.

Step 2. Adjust the chamber temperature and relative humidity to those shown in the appropriate induced (storage and transit) category of Table 507.6-I for time 2400.

Step 3. Unless other guidance is provided by the test plan, cycle the chamber air temperature and RH with time as shown in the appropriate storage and transit cycle of Table 507.6-I (or in the appropriate approximated curve from Figures 507.6-1, 507.6-2, or 507.6-3) through the 24-hour cycle, and for the number of cycles indicated in Table 507.6-II for the appropriate climatic category.

Step 4. Adjust the chamber temperature to 23 ± 2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain until the test item has reached temperature stabilization (generally not more than 24-hours).

Step 5. If only a storage and/or transit test is required, go to Step 15.

Step 6. Conduct a complete visual checkout of the test item and document the results.

Step 7. Put the test item in its normal operating configuration.

Step 8. Conduct a complete operational checkout of the test item and document the results. If the test item fails to operate as intended, follow the guidance in paragraph 4.3.2 for test item failure. Otherwise, go to Step 9.

Step 9. Compare these data with the pretest data.

Step 10. Adjust the test item configuration to that required for naturally occurring temperature humidity cycles (B1, B2, or B3).

Step 11. Adjust the chamber conditions to those given in Table 507.6-I for the time 2400 of the specified cycle.

Step 12. Perform 24-hour cycles for the number of cycles indicated in Table 507.6-II for the appropriate climatic category with the time-temperature-humidity values specified in Table 507.6-I, or the appropriate approximated curve of Figures 507.6-4 through 507.6-6.

Step 13. If the materiel (test item) could be functioning non-stop in the natural environment, operate the test item continuously throughout the test procedure. If shorter operational periods are identified in the requirements document(s), operate the test item at least once every five cycles, and during the last cycle, for the duration necessary to verify proper operation. If the test item fails to operate as intended, follow the guidance in paragraph 4.3.2 for test item failure.

Step 14. Adjust the chamber temperature to 23 ± 2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain until the test item has reached temperature stabilization (generally not more than 24-hours).

Step 15. Conduct a complete visual examination of the test item and document the results.

Step 16. Conduct an operational checkout of the test item in accordance with the approved test plan, and document the results. See paragraph 5 for analysis of results.

Step 17. Compare these data with the pretest data.

4.4.2.2 Procedure II - Aggravated.

This test consists of a 24-hour conditioning period (to ensure all items at any intended climatic test location will start with the same conditions), followed by a series of 24-hour temperature and humidity cycles for a minimum of 10 cycles, or a greater number as otherwise specified in the test plan, unless premature facility or test item problems arise.

Step 1. With the test item installed in the test chamber in its required configuration, adjust the temperature to 23 ± 2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain for no less than 24 hours.

Step 2. Adjust the chamber temperature to 30 °C (86 °F) and the RH to 95 percent.

Step 3. Expose the test item(s) to at least ten 24-hour cycles ranging from 30-60 ºC (86-140 °F) (Figure 507.6-7) or as otherwise determined in paragraph 2.2.1. Unless otherwise specified in the test plan, conduct a test item operational check (for the minimum time required to verify performance) near the end of the fifth and tenth cycles during the periods shown in Figure 507.6-7, and document the results. If the test item fails to operate as intended, follow the guidance in paragraph 4.3.2 for test item failure. Otherwise, continue with Step 4.

> **NOTE:** If the operational check requires the chamber to be open or the test item to be removed from the chamber, and the check cannot be completed within 30 minutes, in order to prevent unrealistic drying, recondition the test item at 30°C ±2 °C (86°F ± 4 °F) and 95 percent RH for one hour, and then continue the checkout. Extend the test time for that cycle by one hour. Continue this sequence until the checkout has been completed.
>
> If the operational check is conducted in the chamber, and extends beyond the 4-hour period noted in Figure 507.6-7, do not proceed to the next cycle until the checkout is completed. Once the check has been completed resume the test.

Step 4. At the completion of 10 or more successful cycles, adjust the temperature and humidity to 23 ±2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain until the test item has reached temperature stabilization (generally not more than 24-hours).

Step 5. Perform a thorough visual examination of the test item, and document any conditions resulting from test exposure.

Step 6. Conduct a complete operational checkout of the test item and document the results. See paragraph 5 for analysis of results.

Step 7. Compare these data with the pretest data.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraphs 5.14 and 5.17, the following information is provided to assist in the evaluation of the test results.

a. Allowable or acceptable degradation in operating characteristics.

b. Possible contributions from special operating procedures or special test provisions needed to perform testing.

c. Whether it is appropriate to separate temperature effects from humidity effects.

d. Any deviations from the test plan.

6. REFERENCE/RELATED DOCUMENTS.

6.1 Referenced Documents.

a. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions; 1 August 1979.

b. MIL-HDBK-310, Global Climatic Data for Developing Military Products; 23 June 1997.

c. NATO STANAG 4370, Allied Environmental Conditions and Test Publication (AECTP) 230; Climatic Conditions.

d. NATO STANAG 4370, Environmental Testing; 19 April 2005.

e. Allied Environmental Conditions and Test Publication (AECTP) 200, Environmental Conditions (under STANAG 4370), January 2006

6.2 Related Documents.

a. Synopsis of Background Material for MIL-STD-210B, Climatic Extremes for Military Equipment. Bedford, MA: Air Force Cambridge Research Laboratories, 24 January 1974. DTIC number AD-780-508.

b. Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Tests (under STANAG 4370), Method 306; January 2006.

c. Egbert, Herbert W. "The History and Rationale of MIL-STD-810 (Edition 2)," January 2010; Institute of Environmental Sciences and Technology, Arlington Place One, 2340 S. Arlington Heights Road, Suite 100, Arlington Heights, IL 60005-4516.

(Copies of Department of Defense Specifications, Standards, and Handbooks, and International Standardization Agreements are available online at https://assist.dla.mil.

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METHOD 507.6, ANNEX A

PHYSICAL PHENOMENA ASSOCIATED WITH HUMIDITY

1. ABSORPTION.

The accumulation of water molecules within material. The quantity of water absorbed depends, in part, on the water content of the ambient air. The process of absorption occurs continuously until equilibrium is reached. The penetration speed of the molecules in the water increases with temperature.

2. ADSORPTION.

The adherence of water vapor molecules to a surface whose temperature is higher than the dew point. The quantity of moisture that can adhere to the surface depends on the type of material, its surface condition, and the vapor pressure. An estimation of the effects due solely to adsorption is not an easy matter because the effects of absorption, that occurs at the same time, are generally more pronounced.

3. BREATHING.

Air exchange between a hollow space and its surroundings caused by temperature variations. This commonly induces condensation inside the hollow space.

4. CONDENSATION.

The precipitation of water vapor on a surface whose temperature is lower than the dew point of the ambient air. As a consequence, the water is transformed from the vapor state to the liquid state.

The dew point depends on the quantity of water vapor in the air. The dew point, the absolute humidity, and the vapor pressure are directly interdependent. Condensation occurs on a test item when the temperature at the surface of the item placed in the test chamber is lower than the dew point of the air in the chamber. As a result, the item may need to be preheated to prevent condensation.

Generally speaking, condensation can only be detected with certainty by visual inspection. This, however, is not always possible, particularly with small objects having a rough surface. If the test item has a low thermal constant, condensation can only occur if the air temperature increases abruptly, or if the relative humidity is close to 100 percent. Slight condensation may be observed on the inside surface of box structures resulting from a decrease in the ambient temperature.

5. DIFFUSION.

The movement of water molecules through material caused by a difference in partial pressures. An example of diffusion often encountered in electronics is the penetration of water vapor through organic coatings such as those on capacitors or semiconductors, or through the sealing compound in the box.

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