3932

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Materiel Test Procedure 5-2-584
White Sands Missile Range

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

MICROBIAL RESISTANCE TESTS

1. OBJECTIVE

The principal objectives of this materiel test procedure (MTP) are to present general discussions concerning the degradation effects of fungus, streptomycetes, and bacteria, and to provide test methods for determining the microbial resistance or susceptibility of equipment.

2. BACKGROUND

Microorganisms are encountered in every environment. The most commonly found are fungi, bacteria, and streptomycetes. The problems that are introduced by the presence of these microorganisms involve:

a. Their physical presence or occupying of space
b. What they use for food or source of energy
c. What metabolic wastes or enzymes they excrete

The physical presence of microorganisms has been known to produce living bridges across electrical circuits. Foods for microorganisms include a vast array of substances. In some cases, a large number of organisms can use the same food, such as cellulose, leather, canvas, and others which contain readily available nutrients. In other situations, only certain kinds of organisms can use a substrate as food, such as silicon rubber, fuels, paints, polyvinyl chloride, propellants, and others where specific enzyme systems are necessary to digest the substrate to a usable form. Certain types of microorganism derive energy from chemical reactions. This energy is obtained through the oxidation/reduction reactions to hydrogen. This activity usually results in corrosion products. Finally, the materials excreted by microorganisms are diverse, but the most common include organic acids and enzymes. These materials can lead to production of corrosion products.

3. REQUIRED EQUIPMENT

a. Test Chamber as described in Appendix A
b. Test Tubes
c. Flask
d. Autoclave
e. 6 and 9 inch Petri Dishes
f. Pipette
g. Noncorrosive Wire Hangers
h. Microscope
i. Whatman No. 2 Filter Paper
j. Cultures
k. Atomizer
l. Applicable Chemicals for mediums

m. Tensile Testing Equipment
n. Soil Trays or Boxes
o. Polyethylene Chamber and Frame
p. Immersion Heaters
q. Inspection Lights having 2X and 4X Magnification Lenses
r. Cotton Swabs
s. Conditioning Shroud

4. REFERENCES

A. MIL-C-9452, Chamber, Fungus Resistance Testing.
B. MIL-E-5272C, General Specification, Environmental Testing, Aeronautical and Associated Equipment.
C. MIL-F-8261A, General Specification, Fungus Resistance Tests, Aeronautical and Associated Equipment.
D. MIL-STD-810B, Environmental Test Methods.
E. Greathouse, G. A. and Wessel, C. J., Deterioration of Materials, Causes and Preventive Techniques, Reinhold Publishing Corp., New York, New York, 1964.
F. Hawker, L. E., Linton, A. H., Folkes, B. F., and Carlile, M. J., An Introduction to the Biology of Microorganisms, Edward Arnold Publishers, Ltd., London, England, 1960.
G. Foster, J. W., Chemical Activities of Fungi, Academic Press, Inc., New York, New York, 1952.
H. Gilman, J. C., A Manual of Soil Fungi, Iowa State University Press, Ames, Iowa, 1959.
I. Gregory, P. H., The Microbiology of the Atmosphere, Leonard Hill Limited, London, England, 1961.
J. MTP 4-2-818, Testing the Fungus Resistance.

5. SCOPE

5.1 SUMMARY

The microbial tests, described in paragraphs of 6.2 of this MTP, are summarized as follows:

NOTE: The tests summarized in a. and b. are based upon MIL-STD-810B, "Environmental Test Methods".

a. Laboratory Fungus Resistance Test of Large Materials - This procedure describes a fungus resistance test to be conducted on large assemblies or large pieces of material which cannot be reduced to sample size. The test is conducted to determine the resistance of the test specimen to the harmful effects of fungus.

NOTE: The tests summarized in b. and c. are based on the tests that are conducted at WSMR, using military specifications only as guidelines.

b. Field Quality Assurance Test - A procedure for conducting a fungus

resistance test in the field on a missile system with a "live" warhead.

c. Laboratory Microbial Resistance Test - A procedure for determining the resistance of material to the attack of fungi, bacteria, and Streptomycetes. This test is a 90-day test in which material is exposed to bacteria, fungi, and Streptomycetes simultaneously.

5.2 LIMITATIONS

The variety of equipment to which this MTP is applicable precludes detailed coverage of any specific item. The testing considerations and methods outlined are intentionally general to provide coverage for various equipment and may be adapted, as necessary, to accommodate specific equipment and specific environmental conditions. Further, the variety of fungus, Streptomycetes, and bacterial types precludes coverage of the entire field. Only those species of fungus as set forth in applicable military specifications and those microorganisms that have been more frequently observed, during quality assurance and service life testing, are discussed. (Studies on the comparison of microorganisms found on missiles under natural conditions and those specified in military specifications are found in Appendix B.) This MTP concerns itself with the testing of large assemblies and pieces of material, see MTP 4-2-818 for fungus resistance tests of sample size material and small components and assemblies.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Personnel involved in testing must be familiar with characteristics and intended usage of the specimen to be tested.

b. Personnel should ensure that the applicable instructions and/or detailed specifications are available.

c. A test chamber of the type described in Appendix A should be available.

6.2 TEST CONDUCT

6.2.1 Laboratory Fungus Resistance Test of Large Materials

6.2.1.1 Preparation for Test

a. Prepare a mineral-salts solution as follows:

1) Mix the following ingredients:

a)	Potassium dihydrogen orthophosphate (KH_2PO_4)	0.7g
b)	Potassium monohydrogen orthophosphate (K_2HPO_4)	0.7g
c)	Magnesium sulfate ($MgSO_4 \cdot 7H_2O$)	0.7g
d)	Ammonium nitrate (NH_4NO_3)	1.0g
e)	Sodium chloride (NaCl)	0.005g
f)	Ferrous sulfate ($FeSO_4 \cdot 7H_2O$)	0.002g
g)	Zinc sulfate ($ZnSO_4 \cdot 7H_2O$)	0.002g

h) Manganous sulfate ($MnSO_4 \cdot 7H_2O$) 0.001g
i) Distilled water 1000ml

2) Sterilize the mineral salts solution by autoclaving at 121°C (250°F) for 20 minutes.
3) Adjust the pH of the solution by the addition of 0.01 normal solution of NaOH so that after sterilization the pH is between 6.0 and 6.5.

b. Prepare a mixed spore suspension using the following fungi:

Fungi	ATCC (see Note 1)	NLABS (see Note 2)
Aspergillus niger	9642	386
Aspergillus flavus	9643	380
Aspergillus versicolor	11730	432
Penicillium funiculosum	9644	391
Chaetomium globosum	6205	459

NOTE 1. American Type Culture Collection, 12301 Parklawn, Rockville, Maryland 20852.
2. Pioneering Research Division, U. S. Army Natick Laboratories, Natick, Massachusetts 01760.
3. Maintain cultures of these fungi separately on an appropriate medium such as potato dextrose agar. However, the culture of Chaetomium globosum shall be cultured on strips of filter paper on the surface of mineral-salts agar. (Mineral salts agar is identical to mineral salts solution, but contains in addition 15.0 0g of agar per liter). The stock cultures may be kept for not more than four months at 6° ± 4° C (43°F). Use subcultures incubated at 29°C (84°F) for 7 to 20 days in preparing the spore suspension.

1) Prepare a spore suspension of each of the five fungi by pouring into one subculture of each fungus a sterile 10 ml portion of water or of a sterile solution containing 0.05g per liter of nontoxic wetting agent such as sodium dioctyl sulfosuccinate. Use a sterile platinum or nichrome inoculating wire to scrape gently the surface growth from the culture of the test organism. Pour the spore charge into a sterile 125 ml glass-stoppered Erlenmeyer flask containing 45 ml of sterile water and 10 to 15 solid glass beads, 5 mm in diameter. Shake the flask vigorously to liberate the spores from the fruiting bodies and to break the spore clumps.
2) Filter the shaken suspension through a thin layer of sterile glass wool in a glass funnel into a sterile flask in order to remove mycelial fragments.
3) Centrifuge the filtered spore suspension asceptically, and discard the supernatant liquid.

4) Resuspend the residue in 50 ml of sterile water and centrifuge.
5) Wash the spores obtained from each of the fungi in this manner three times.
6) Dilute the final washed residue with sterile mineral salts solution in such a manner that the resultant spore suspension shall contain 1,000,000 ± 200,000 spores per ml.
7) Repeat this operation for each organism used in the test and blend equal volumes of the resultant spore suspension to obtain the final mixed spore suspension.
8) The spore suspension may be prepared fresh each day or may be held at 6° ± 4°C for not more than four days.
9) Proper use of controls will be established for the test, e.g., filter paper.

c. Operate the equipment to be tested under standard ambient conditions and make a record of all data necessary to determine compliance with required performance.

6.2.1.2 Test Conduct

a. Inoculate test and control items, as follows:

1) Mount the test and control items on suitable fixtures or suspended from hangers.

NOTE: Plugs, covers, and inspection plates used in service should remain in place. When mechanical or electrical connections are not used, the connections that are normally protected in service shall be covered.

2) Precondition the chamber and its contents at 29°C (84°F) and 95 percent relative humidity (R.H1) for at least four hours.
3) Inoculate the test and control items with the mixed fungus spore suspension by spraying it on the test and control items in the form of a fine mist from a previously sterilized atomizer until they are thoroughly wet with the spray. Incubation is to be started immediately following the inoculation.

b. Incubate test and control items and perform the following:

1) Maintain the test chamber at 29°C and 95 percent R.H. (minimum) during the life of the test. Keep the test chamber closed during the incubation period except during inspection or for addition of other test items.
2) After 14 days, inspect the control items. They should show an abundant growth of fungus. If they do not, the entire test shall be repeated.
3) If control growth is satisfactory, continue the test for another 14 days (28 days from inoculation).

c. Remove the test item from the chamber at the end of the test period

and inspect and operate it as required. Record the following:

1) Groundings
2) Short circuits
3) Deterioration of organic materials
4) Corrosion
5) Data needed to evaluate operability of the test item

6.2.2 Field Quality Assurance Test (for explosive elements)

a. Transport a test item which has a "live" warhead to a remote test site and place it in an enclosed chamber.

NOTE: The test chamber is constructed of polyethylene attached to a suitable frame, and large enough to completely enclose the item to be tested. Water troughs containing immersion heaters placed adjacent to the test item are used to provide proper humidity at 95% ± 5%.

b. Place the entire polyethylene chamber in a conditioning shroud to maintain the temperature at 86 ± 3.6°F.

c. Condition the test specimen for 24 hours at 86 ± 3.6°F.

d. Make an opening in the polyethylene chamber large enough for a man to enter.

e. Prepare a spore suspension in the manner of paragraph 6.2.1.1, steps a and b using the listed fungi.

f. Spray the composite spore suspension on the test item and reseal the conditioning shroud.

g. Visual inspections should be made periodically to determine fungal development.

NOTE: Examinations should be conducted visually through the semi-transparent polyethylene wall of the test chamber. More critical examinations may be conducted by making a small hole in the polyethylene and examining the missile with inspection lights having 2X and 4X magnification lenses.

h. Open the test chamber at the end of the 28-day test period and give the test item a detailed external examination.

i. Remove materials for laboratory investigation in one of two ways:

1) Samples consisting of portions of the test item, such as paint, insulation, etc., may be removed asceptically.
2) Moist sterile swabs may be used to remove the micro-organisms from any given area of the test item surface.

j. Give all test item parts a post test fungus check by disassembling them and carefully checking them internally. Samples shall be taken of all fungus found.

k. Make pour plate studies from the cotton swabs to obtain

quantitative and qualitative data.

6.2.3 Laboratory Microbial Resistance Test

a. Examine the material to be tested and record its physical condition. (Photographs may be used to establish a visual record of these observations).

b. Place the test item in a test conduct chamber of the type described in Appendix A.

c. Maintain the test chamber at 86 ± 2.5°F and 95 ± 5 percent humidity.

d. Place moist soil beds consisting of a sandy soil and a soil rich in organic matter in the chamber adjacent to the test item.

e. Culture the following fungi and Streptomyces spp on sterile straws and bacteria on nutrient Agar slants:

1) Bacteria:

a) Bacillus megaterium
b) Bacillus subtilis
c) Bacillus cereus

2) Fungi:

a) Myrothecium verrucaria
b) Fusarium bulbigenum
c) Pullularia pullulans
d) Spicaria violacea
e) Aspergillus niger

3) Streptomycetes:

a) Streptomyces albus
b) Streptomyces globisporous
c) Streptomyces acidophilus

NOTE: The fungi and Streptomycetes used should be 7- to 14-days old. Cultures and the bacteria should be 2- to 3-day old cultures.

f. Incubate the microorganisms at room temperature until the spores and cells are to be harvested (7 to 14 days).

g. Add 10 ml of sterile mineral salt solution to each tube containing a bacterial culture and 100 ml of sterile mineral salt solution to each flask containing fungi or Streptomyces spp.

h. Shake the cultures vigorously to suspend the cells or spores in the solution.

i. Filter the Streptomyces spp and fungi spore suspensions through sterile glass wool to remove any Mycelial fragments and other debris that may be present in the liquid medium.

j. Mix all the suspensions together to get a composite suspension.

k. Spray all external surfaces of the test item using an atomizer.

1. Incubate the test item for a total of 90 days with detailed visual inspections and performance rating checks at 30, 60, and 90-day intervals.

m. At the end of the test period, the test item should be removed from the chamber and examined visually and microscopically and an operational capability test run on it. Record the following:

1) The performance rating of the equipment
2) Microorganisms found growing on or from the test item
3) Microbial corrosion or degradation observed of the test item

n. Conduct a final performance rating check and examination seven days after completion of the test to note any additional changes that may have occurred.

6.3 TEST DATA

6.3.1 Laboratory Fungus Resistance Test of Large Material

6.3.1.1 Preparation for Test

Record the following:

a. Item being tested.
b. Data necessary to determine compliance with required performance of the test item.

6.3.1.2 Test Conduct

Record the following:

a. Condition of viability control specimen at the end of the incubation period.
b. All data necessary to determine compliance with required performance of the test item.
c. Check for the following anomalies:

1) Groundings
2) Short circuits
3) Deterioration
4) Corrosion

6.3.3 Field Quality Assurance Test

a. Record the amount of area covered by fungus and where the area was.
b. Record all the types of organisms found on the test item.

6.3.3 Laboratory Microbial Resistance Test

a. Record the test item's physical condition before the test.

b. Record all data necessary to determine compliance with required performance of the test item before the test.

c. Record the type and location of all microorgans found on the test item.

d. Record the test item's physical condition after the test has been completed.

e. Record all data necessary to determine compliance with required performance of the test item after the test.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Laboratory Fungus Resistance Test of Large Materials

Compare the operation of the test item before and after the test is conducted and depict the effects of the fungus.

6.4.2 Field Quality Assurance Test

State the effectiveness of the resistance to fungus of the test specimen.

6.4.3 Laboratory Microbial Resistance Test

Compare the performance of the test item before and after the test. Explain the effect of the microorgans on the test item.

APPENDIX A

TEST CHAMBER

Test personnel should use specified test facilities and equipment that are available insofar as these have been proven effective through previous use. The test chamber used in conducting the fungus resistance tests on relatively small specimens should be of adequate size to accommodate the specimen and permit proper positioning of the specimen. The chamber should be a self-contained unit that is capable of establishing and maintaining the environmental conditions discussed in paragraph 6.2.1. The chamber interior should be insulated, completely fungus proof, and the bottom of the chamber should contain provisions for draining. The doors should be sealed tightly without a center mullion which would limit the capacity of the chamber. The shelves of the chamber should be removable and capable of supporting 75 pounds per square foot. A humidifier, heat source, and other equipment necessary to meet the requirements of the fungus resistance test should be provided.

The environmental conditions within the chamber are maintained by electrical heaters which are immersed in distilled water and located on the bottom of the chamber. The heaters should be capable of raising the chamber temperature from 65 to 86 degrees Fahrenheit (°F) in 10 minutes and must be automatically controlled. A temperature indicator must be provided and some chambers may have provisions for continuously recording the temperature and humidity. The chamber should operate on 110-volt, 60-cycle alternating current (a-c) which is supplied through a single plug extension. The velocity of air through the chamber should not exceed 25 feet per minute.

Figure 1 is for reference only and in no way limits or restricts the use of chambers of different designs, providing the requirements of military specification MIL-C-9452, "Chamber, Fungus Resistance Testing" are satisfied. The chamber should, however, generally conform to Figure A-1 and provide, by some approved means, all of the features shown.

For testing large specimens, such as a complete missile system, a polyethylene test chamber may be constructed, to the proper size, for accommodating the test specimen. Such a test chamber is discussed in paragraph 6.2.2.

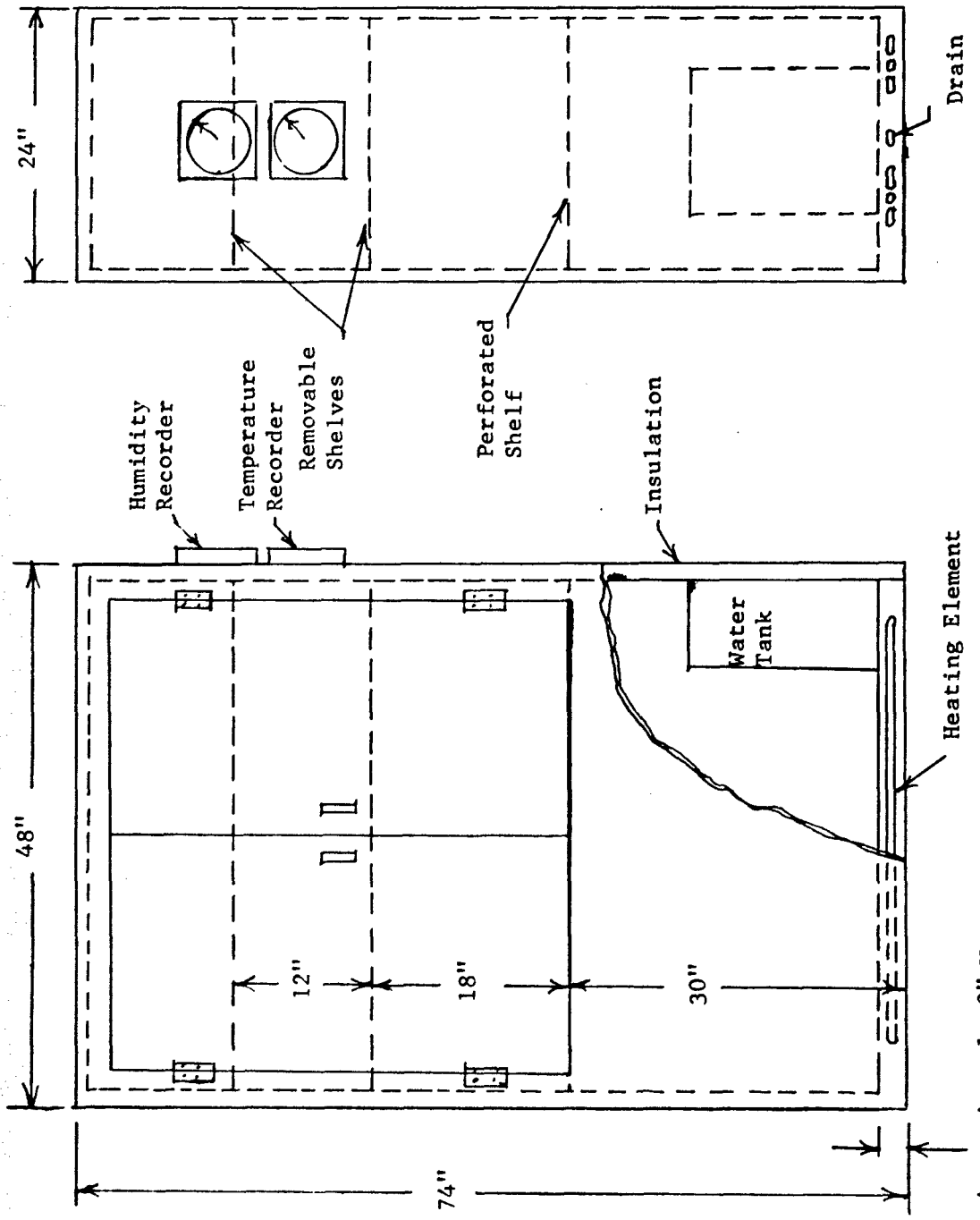

Figure A-1. Typical Fungus Resistance Test Chamber

APPENDIX B

MICROBIAL TEST STUDIES

LABORATORY QUALITY ASSURANCE TEST STUDIES

The primary purpose of these studies is to compare the microorganisms found on missile systems under natural conditions with those that are specified by military specifications for use in quality assurance tests.

The number and types of microorganisms found on missiles undergoing a service life test were compared with those which occurred on missile systems subjected to the quality assurance test. During the quality assurance test, bacteria, although never sprayed on the missile systems as test inocula, were found in every examination. Fungi were not observed in all areas where they had been inoculated on the missile systems undergoing the quality assurance tests. In general, where high numbers of fungi were found on the missiles in the quality assurance test, few and in many instances, no fungi were observed on the missiles undergoing the service life test. Few similarities existed when the results of the numbers and types of microorganisms found in the quality assurance test were compared with those found in the service life test. Therefore, the quality assurance test would yield little or no significant information on the biodeterioration that would occur in the field under natural environmental conditions. In the comparison, the test organisms as specified in military specification MIL-E-5272C, were observed in abundance on the missiles only when used as test inocula. The MIL-E-5272C test organisms were observed three times from a total of 73 biological degraded service life components examined. One of these organisms occurred on the paper log book accompanying the missile rather than on the missile itself. The designated MIL-E-5272C and MIL-STD-810 test organisms; therefore, are of little importance in the biodeterioration of modern missile systems. Other organisms, such as bacteria species, Cladosporium herbarum, Fusarium spp., and Pullularia pullulans were observed in the quality assurance test and all service life tests even though the missiles were not inoculated with them. The occurrence of bacteria in 72 out of a possible 73 examinations implicates the importance of this group of organisms in the microbial testing of missiles.

The results of these studies indicate that consideration should be given to continually comparing the microorganisms found on missile systems in service life tests with those in use in quality assurance tests. Consideration should be given to the use of bacteria and Streptomycetes as well as fungi in the testing of missile systems. Study results indicate that the test specimens presently designated for the quality assurance test are ineffectual, insignificant, and out-of-date in the present missile testing program. The lack of similarity between the service life test and quality assurance test results emphasizes this fact. The missile systems now in use are constructed of complex materials, both natural and synthetic. It is suggested that one would suspect that the types of organisms attacking a missile system will change as the materials in the construction of the system are changed. Consideration should be given to the use of the types of organisms previously mentioned, and

in addition, other organisms, such as Alternaria humicola, Nigrospora sphaerica, and certain Streptomyces spp. might be found to be equally important. The microorganisms that are continually found associated with the missiles in the field are most likely those responsible for biodeterioration. The use of these organisms in the quality assurance test offers a more realistic approach and greater possibility of obtaining the desired results. This would also update and strengthen the present fungus resistance test.

LABORATORY SERVICE LIFE TEST STUDIES

Numerous service life test studies have been conducted to isolate and identify microorganisms found on missile systems subjected to natural environmental conditions. Microorganisms were isolated from missiles which were received from, or examined, in various parts of the world. Identifications of these microorganisms have thus far revealed the presence of 79 species and six groups (spp.) which lack species designations. The purposes of these studies were primarily:

a. To determine the microbial resistance or susceptibility of missile systems subjected to various natural environmental conditions.
b. To isolate and identify the microorganisms degrading test materials.
c. To establish a microbial bank (collection) of cultures which will be used for further studies in biodeterioration of missile systems.

The isolation and identification of microorganisms on eleven missiles subjected to natural environmental conditions resulted in the frequency of occurrence as shown in Table B-I.

The organisms Pullularia pullulans and Fusarium spp. were found on all of the missile systems examined. On these systems, where bacteria were recorded, bacteria A and other bacteria were observed 100 percent of the time. Intermediate were Myrothecium verrucaria and bacteria D which were observed 64 percent and 68 percent of the time, respectively. Bacteria B and C were found 50 percent of the time, while Spicaria violacea, Nigrospora sphaerica, and Penicillium spp. were observed in 45 percent of the examinations. Many other organisms were observed, but their distribution frequency was less prominent than those discussed.

Of the ten microorganisms, as specified by MIL-E-5272C, only one organism, Myrothecium verrucaria, was found to any extent on the missile systems under natural conditions. Three organisms, Aspergillus terreus, A. flavus, and Chaetomium globosum were each found on one of eleven missiles examined. Forty other species were found as frequently as these test organisms, while 35 other species and six groups (spp.) were found more abundantly on missiles under natural conditions. Four of the organisms, as specified in MIL-E-5272C, were not isolated or identified from any of the eleven missiles. These were Aspergillus niger, Memnoniella echinata, Penicillium citrinium, and P. ochrochloron.

Table B-I. Microorganisms Isolated and Identified from Missiles Subjected to Field Conditions Throughout the World (Sheet 1 of 3)

Organisms	Missiles Examined											
Employed in Military Specification MIL-E-5272C	1	2	3	4	5	6	7	8	9	10	11	Total
Aspergillus niger	0	0	0	0	0	0	0	0	0	0	0	0
Aspergillus terreus	0	0	0	+	0	0	0	0	0	0	0	1
Asperigillus flavus	0	0	0	0	0	0	0	0	0	+	0	1
Chaetomium globosum	0	0	0	0	0	0	0	0	0	0	+	1
Memnoniella echinata	0	0	0	0	0	0	0	0	0	0	0	0
Myrothecium verrucaria	+	+	+	+	+	+	0	0	+	0	0	7
Penicillium citrinum	0	0	0	0	0	0	0	0	0	0	0	0
Penicillium ochrochloron	0	0	0	0	0	0	0	0	0	0	0	0
Other Organisms												
Acremonium sp.	0	0	0	+	0	0	0	0	0	0	0	1
Acrothecium sp.	0	0	0	0	0	0	0	+	0	0	0	1
Alternaria fasciculata	0	0	0	0	0	0	+	0	0	0	0	1
Alternaria grisea	+	0	0	0	0	0	0	0	0	0	0	1
Alternaria humicola	0	+	+	0	0	0	0	+	0	0	+	4
Alternaria spp.	0	0	0	0	+	0	+	0	0	0	0	2
Arthrobotrys sp.	0	0	0	0	0	0	0	0	0	+	0	1
Aspergillus flavipes	0	+	+	0	0	0	0	0	0	0	0	2
Aspergillus fumigatus	0	0	0	0	0	0	0	0	+	0	+	2
Aspergillus nidulans	0	0	0	0	0	0	0	+	0	0	0	1
Aspergillus quadrilineatus	0	0	0	0	0	0	+	0	0	0	0	1
Aspergillus sydowi	0	0	+	0	0	0	0	0	0	0	0	1
Aspergillus tamarii	0	0	0	0	0	0	+	0	0	0	+	2
Aspergillus ustus	0	+	+	0	0	0	+	0	0	0	0	3
Aspergillus versicolor	0	0	+	0	0	0	0	0	0	0	0	1
Aspergillus spp.	0	0	0	+	0	0	0	0	+	+	+	4
Botryodiplodia sp.	0	0	0	0	0	+	0	0	0	0	0	1
Cephalosporium sp.	0	0	0	0	0	+	0	0	0	0	0	1
Chaetomella horrida	0	0	+	0	0	0	0	0	0	0	0	1
Chaetomella sp.	0	0	0	0	0	0	0	+	0	0	0	1

Table B-I. Microorganisms Isolated and Identified from Missiles Subjected to Field Conditions Throughout the World (Sheet 2 of 3) cont'd.

Organisms	Missiles Examined											
	1	2	3	4	5	6	7	8	9	10	11	Total
Chaetomium olivaceum	0	0	0	0	0	0	0	0	0	+	0	1
Chaetomium sp.	0	0	0	0	0	+	0	+	0	0	+	3
Cladosporium epiphyllum	0	0	0	0	0	0	0	0	+	0	+	2
Cladosporium herbarum	0	0	0	0	0	0	0	0	+	+	+	3
Cladosporium sp.	0	0	0	+	0	+	0	0	0	0	0	2
Curvularia geniculata	0	0	0	0	0	0	0	0	+	0	0	1
Curvularia lunata	0	0	0	0	0	0	0	0	0	+	0	1
Curvularia pallescens	0	0	0	0	0	0	0	+	0	0	0	1
Curvularia spp.	0	0	0	+	+	+	+	0	0	0	0	4
Dendrophoma sp.	0	0	0	0	0	+	0	0	0	0	0	1
Epicoccum nigrum	0	0	+	0	0	0	+	+	0	0	+	4
Epicoccum purpurascens	0	0	0	0	0	0	0	0	+	0	+	2
Fimetaria fimicola	0	0	0	0	0	0	+	0	0	0	0	1
Fusarium scirpi	0	0	0	+	0	0	0	0	0	0	0	1
Fusarium solani	0	0	0	+	0	0	0	0	0	0	0	1
Fusarium spp.	+	+	+	+	+	+	+	+	+	+	+	11
Helminthosporium anomalum	0	0	0	0	0	0	0	0	0	0	+	1
Helminthosporium sativum	0	0	0	0	0	0	0	0	+	0	0	1
Helminthosporium sp.	0	0	0	0	0	+	+	0	0	0	0	2
Hormiscium sp.	0	0	0	0	0	+	0	0	0	0	0	1
Hormodendrum cladosporioides	+	0	0	0	0	0	0	+	0	+	0	3
Hormodendrum hordei	0	0	+	0	0	0	0	0	0	0	+	2
Hormodendrum olivaceum	0	0	0	0	0	0	0	+	0	0	0	1
Hormodendrum resinae	0	0	+	0	0	0	0	0	0	0	0	1
Hormodendrum sp.	0	0	0	0	0	0	+	0	0	0	0	1
Hyalopus sp.	0	0	0	0	0	0	0	0	0	0	+	1
Monilia geophila	0	0	0	0	0	0	+	0	0	0	0	1
Mucor sp.	0	0	0	0	0	+	0	0	0	0	0	1
Nigrospora sphaerica	0	+	0	+	0	0	0	0	+	+	+	5
Nigrospora sp.	0	0	0	0	0	+	+	+	0	0	0	3

Table B-I. Microorganisms Isolated and Identified from Missiles Subjected to Field Conditions Throughout the World (Sheet 3 of 3) cont'd.

Organisms	Missiles Examined											
	1	2	3	4	5	6	7	8	9	10	11	Total
Penicillium javanicum	0	0	0	0	0	0	≠	0	0	0	0	1
Penicillium steckii	0	0	0	0	0	0	0	≠	0	0	0	1
Penicillium spp.	0	0	0	≠	≠	≠	0	0	≠	≠	0	5
Pestolotia sp.	0	0	0	0	0	≠	≠	0	0	0	0	2
Phoma glomerata	0	0	0	0	0	0	0	0	0	0	≠	1
Phoma hibernica	0	0	0	0	0	0	0	≠	0	0	0	1
Phoma sp.	0	0	≠	≠	0	0	0	≠	0	≠	0	4
Pullularia pullulans	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠	11
Pyrenochaeta decipiens	0	0	0	0	≠	0	0	0	≠	≠	0	3
Pyrenochaeta sp.	0	0	0	≠	0	≠	0	0	≠	0	0	3
Rhinotrichum sp.	0	0	0	0	0	0	0	≠	0	0	0	1
Rhizoctonia sp.	0	0	0	0	0	0	0	≠	0	0	0	1
Scherotium sp.	0	0	0	0	0	0	0	0	0	0	≠	1
Septonema sp.	0	0	0	0	0	0	≠	≠	0	0	0	2
Sphaeronema spinella	0	0	0	0	0	0	0	0	≠	≠	0	2
Sphaeropsis sp.	0	0	0	0	0	0	0	0	0	≠	0	1
Spicaria violacea	≠	≠	≠	0	0	≠	0	0	≠	0	0	5
Spicaria sp.	0	0	0	0	0	0	0	0	0	0	≠	1
Stachybotrys alternans	0	0	0	≠	0	≠	0	0	0	0	0	2
Stemphylium verruculosum	≠	0	0	0	0	0	0	≠	0	≠	0	3
Stemphylium sp.	0	0	0	≠	0	≠	0	≠	0	0	0	3
Streptomyces sp.	0	0	≠	0	0	≠	0	0	0	0	0	2
Syncephalastrum racemosum	0	0	0	0	0	≠	0	0	0	0	0	1
Trichoderma lignorum	≠	0	0	0	≠	≠	≠	0	0	0	0	4
Thielavia sp.	0	0	0	0	0	0	0	≠	0	0	0	1
Verticillium sp.	0	0	0	≠	≠	0	0	0	0	0	0	2
Bacteria A	≠	≠	≠	not examined					≠	≠	≠	6
Bacteria B	≠	0	≠	not examined					0	≠	0	3
Bacteria C	≠	0	0	not examined					0	≠	≠	3
Bacteria D	≠	≠	≠	not examined					≠	0	0	4
Other Bacteria	≠	≠	≠	not examined					≠	≠	≠	6