

2 November 1966

Matériel Test Procedure 4-2-818*
Aberdeen Proving Ground

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

TESTING FOR FUNGUS RESISTANCE

1. OBJECTIVE

The objective of this procedure is to present test methods and techniques that are pertinent in the evaluation of the fungus resistance properties of materials used in Army equipment.

2. BACKGROUND

Fungi considerably damaged Army matériel stored and used in the tropics during World War II and are reported to be responsible for greatly shortening the useful life of equipment in Southeast Asia.

Military items such as fire control systems, radar, communication equipment, optical and photographic equipment and supplies material, automotive components, ammunition and other supplies can be damaged, weakened or made ineffective if not protected from fungi. In addition, secondary damage may accrue through decomposition of protective coatings or seals, thus admitting moisture leading to corrosion or deterioration of electronic components or instruments that were supposed to be hermetically sealed. A further possibility is the short circuiting of electrical equipment by layers of fungi, as has been observed in the case of automotive generators, distributors, magnetos, and similar items.

Appendix A describes the nature of fungi, the conditions under which they survive best, some of the materials which are susceptible to fungal attack, and methods of protecting material from fungi.

3. REQUIRED EQUIPMENT

- a. Test chamber as described in Appendix B
- b. Test tubes
- c. Flasks
- d. Autoclave
- e. 6 and 9 inch petri dishes - Commonly used are 100 mm and 150 mm diameter dishes
- f. Pipettes
- g. Cultures as required in the applicable test
- h. Applicable chemicals for culture media as required
- i. Atomizer
- j. Additional equipment as required in the applicable test procedures

4. REFERENCES

- A. MIL-C-9452(USAF), Chamber, Fungus Resistance Testing, 8 June 1954

*Supersedes Interim Pamphlet 70-81

20020805025

AD 718231

- B. MIL-8261A(USAF), Fungus Resistance Tests, Aeronautical and Associated Materials, 20 December 1955
- C. MIL-F-13927A(ORD), Fungus-Resistance Test; Automotive Components, with Amendment 1, 1 March 1962
- D. MIL-STD-810B, Environmental Test Methods, 15 June 1967
- E. Federal Standard 101A, Preservation, Packaging and Packing Materials, Test Procedures
- F. Federal Standard 141A, Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling and Testing
- G. Federal Standard 406, Plastics; Methods of Testing
- H. Federal Specification CCC-T-191B, Textile Test Methods
- I. Federal Specification KK-L-311A, Leather, Methods of Sampling and Testing
- J. American Society for Testing Materials - Standards (ASTM Standards)
- K. Selected books, articles and reports listed in Appendix D
- L. Proposed Procedure for Screening of Microbial Inhibitions in Hydrocarbon/Water Systems - Society for Industrial Microbiology Publication No. 2, July 1966
- M. MTP 5-2-584, Microbial Resistance Tests

5. SCOPE

5.1 SUMMARY

This MTP describes the various laboratory test procedures to be used for the determination of the fungus resistance, and effects of fungi on various types of material.

5.2 LIMITATIONS

This MTP is limited to those materials that may be cut or reduced to sample size and small components. Large components and assemblies are tested as described in MTP 5-2-584 and field tests in the tropics are conducted as described in the tropic environmental tests.

6. PROCEDURES

6.1 PREPARATION FOR TEST

- a. Personnel involved in testing must be familiar with the characteristics of the specimen to be tested.
- b. Personnel should ensure that the detailed material specifications of the test item are available.
- c. A test chamber of the type described in Appendix B should be available.

6.2 TEST CONDUCT

The following test item materials shall be tested to determine their resistance to, and the effects of, fungi on their material characteristics.

6.2.1 Paint, Varnish, Lacquer, and Related Products

These test item materials shall be subject to the following procedures, as applicable.

- a. As described in Fed. Std. 141A (reference 4F) Method 6271.1
- b. As described in the ASTM Standards Manual (reference 4J) Method D-1924, Determining Resistance of Plastics to Fungi.

6.2.2 Paper, Packaging, Cellulose, Casein, Flexible Barrier Materials and Leather

These test item materials shall be subject to the following procedures, as applicable.

- a. As described in Fed. Spec. KK-L-311A (reference 4I) Method 5011
- b. As described in Fed. Std. 101A (reference 4E) Method 233
- c. As described in the ASTM Standards Manual (reference 4J):
 - 1) Method D-1924
 - 2) Method D-1286

6.2.3 Electrical Insulating Materials

These test item materials shall be subject to the procedures described in Method 1924 of the ASTM Standards Manual (reference 4J).

6.2.4 Plastics

These test item materials shall be subject to the following procedures, as applicable.

- a. As described in Fed. Std. 406 (reference 4G) Method 6091
- b. As described in the ASTM Standards Manual (reference 4J) Method D-1924

6.2.5 Textile Materials (Including Yarn, Thread, Cordage and Cloth)

These test item materials shall be subject to the procedures as described in Fed. Spec. CCC-T-191B (reference 4H), as applicable.

- a. For yarn, thread and cordage:
 - 1) Method 4750: Direct inoculation, pure culture, sterile specimen method
 - 2) Method 4751: Direct inoculation, pure culture, non-sterile specimen method
 - 3) Method 4752: Enriched soil suspension method
 - 4) Method 4756: Mycelial mat, degradation method
 - 5) Method 4758: Mycelial mat, disfiguration method

b. For thread and cordage, the following:

- 1) Method 4760: Mixed culture method
- 2) Method 4780: Soil burial method

c. For webbing:

- 1) Method 4752: Enriched soil suspension method
- 2) Method 4780: Soil Burial method

c. For cloth:

- 1) Method 5750: Direct inoculation, pure culture, sterile specimen method
- 2) Method 5751.1: Direct inoculation, pure culture, non-sterile specimen method
- 3) Method 5752: Enriched soil suspension method
- 4) Method 5756: Mycelial mat, degradation method (bottle)
- 5) Method 5757: Mycelial mat, degradation method (petri-dish)
- 6) Method 5758: Mycelial mat, disfiguration method
- 7) Method 5760.1: Mixed culture method
- 8) Method 5762: Soil burial method

6.2.6 Petroleum Products (Lubricants, Liquid Fuels, and Related Products)

These test item materials shall be subject to the Proposed Procedures for Screening of Microbial Inhibitors in Hydrocarbon/Water Systems (reference 4L).

6.2.7 Automotive Components

Those test items which are not subject to the applicable tests of paragraphs 6.2.1 through 6.2.6 shall be subject to the applicable procedures of MIL-F-13927A (reference 4C).

6.3 TEST DATA

6.3.1 Paint, Varnish, Lacquer and Related Products

Record the following, as applicable:

- a. Data collected as described in ASTM Standard D-1924
- b. Data collected as described in Method 6271.1 of Fed. Std. 141A

6.3.2 Paper, Packaging, Cellulose, Casein, Flexible Barrier Materials, and Leather

- a. Data collected as described in Method 5011 of Fed. Spec. KK-L-311A
- b. Data collected as described in Method 233 of Fed. Std. 101A
- c. Data collected as described in ASTM standard D-1286
- d. Data collected as described in ASTM standard D-1924

6.3.3 Electrical Insulating Materials

Data shall be collected and recorded as described in ASTM standard D-1924.

6.3.4 Plastics

Record the following, as applicable:

- a. Data collected as described in Method 6091 of Fed. Std. 406
- b. Data collected as described in ASTM standard D-1924

6.3.5 Textile Materials (Including Yarn, Thread, Cordage and Cloth)

Data collected and recorded as described in the applicable Fed. Spec. CCC-T-191B method (see paragraph 6.2.5).

6.3.6 Petroleum Products (Lubricants, Liquid Fuels, and Related Products)

Data shall be collected and recorded as described in Proposed Procedures for Screening Microbial Inhibitors in Hydrocarbon/Water Systems

6.3.7 Automotive Components

Data shall be collected and recorded as described in the applicable procedures of MIL-F-13927A.

6.4 DATA REDUCTION AND PRESENTATION

Data shall be presented in graph, chart, or narrative form to indicate the fungus resistance of the test materials or the effects of fungi on the properties of the test materials. See Appendix C for precautions to be observed when evaluating test results.

APPENDIX A

FUNGI

A. Nature of Fungi

Fungi are a versatile group of micro-organisms capable of attacking a wide variety of materials, the place of fungi in nature being to decompose dead organic material. Fungi are living organisms, usually rather simple in structure lacking the green pigment, chlorophyll, that enables higher plants and certain lower organisms to manufacture their own food. Because of this lack, fungi are dependent on already formed organic matter for the source of their nutrition. Besides a carbon source, the other requirements are oxygen and small amounts of some inorganic elements - nitrogen, phosphorus, magnesium, and potassium as water soluble compounds. The mineral requirements of fungi are usually available on the surfaces of industrial materials from handling or from dust, dirt, or debris in the atmosphere. The prime factor in the problem of fungal deterioration is humidity. Deterioration may occur whenever relative humidity exceeds 75 percent, even with temperatures as low as 40°F, although the optimum temperature is about 86° for most of the deteriorative fungi. Rapid deterioration of susceptible materials will take place under a combination of high humidity and temperatures of 70° to 95°F, both of which environmental characteristics are common in the tropics.

B. Material Affected by Fungi

Industrial materials that may be deteriorated by fungi include, but are not limited to, the following:

- a. Textiles
- b. Wood and paper
- c. Rope and cordage
- d. Leather
- e. Cork
- f. Gaskets (vegetable fiber, felt, cork)
- g. Insulating material for electrical cables or hookup wire
- h. Adhesives
- i. Plastics and plasticizers
- j. Vinyl coverings
- k. Paints and varnishes
- l. Synthetic resins
- m. Sealing compounds
- n. Lens coatings and cements
- o. Glass (through etching)
- p. Explosives and propellants
- q. Fuels and lubricants
- r. Rubber

C. Protective Measures

Methods used to avoid damage by fungi either, incorporated during manufacture or, as applied during service include:

1. Frequent cleaning and maintenance of surfaces and components that are susceptible.
2. Keeping materiel dry through use of desiccants and heating.
3. Direct application of fungicides (e.g., Pentachlorophenol incorporated into wood; Paranitrophenol in leather, and copper compounds in cotton textiles).
4. Use of fungicides as additives in paints and varnishes used to protect or mark equipment and supplies.
5. Utilization of coatings known to be fungus resistant.
6. Hermetic sealing with a dry atmosphere in the container.
7. Maintaining a positive pressure with dry air or other dry gas.
8. Inclusion of fungicides in sealing compounds, adhesives, insulating materials.
9. Addition to well sealed equipment of a coating or capsule that contains a volatile fungicidal agent.
10. Specification of appropriate fungus-resistant materials for use in manufacture of critical components (e.g., nylon for powder bags).

NOTE: Use of fungicides both for direct application and as additives sometimes results in toxic or corrosive side effects, and should be undertaken with due design engineer caution and regard for expert guidance available at agencies such as the Pitman-Dunn Research Laboratory of Frankford Arsenal.

D. Test Facilities

Laboratory testing of small items such as fuzes may be referred to the Pitman-Dunn Research Laboratory, Frankford Arsenal, provided the item contains little, if any, explosive material and is therefore acceptable from the safety standpoint, and provided their research workload will permit this accommodation. Inquiry in this regard may be addressed to the Pitman-Dunn Research Laboratory. As to field tests, the facilities of the U. S. Army Tropic Test Center, Fort Clayton, are available. The Pitman-Dunn Research Laboratory can also be of assistance in field testing, since its research on materials includes field exposures in the Canal Zone evaluated by scientific personnel sent there at least twice a year. These personnel (usually including experts on mycology, corrosion, and lubrication) will assist in the examination of any items field tested in the Canal Zone if the examination can be accomplished during the time of their visit.

E. Design Considerations for Fungus Resistance Testing

Consideration of fungus resistance may arise first in the statement of Qualitative Materiel Requirements (QMR) which may indicate that an item must be usable in the tropics. The statement of Technical Characteristics (TC) should reflect this information by requiring maximum practicable protection from deterioration caused by fungi. The designer should then review each material and component for fungus susceptibility, and incorporate appropriate

features into the design specifications for supply and manufacture of prototype components and assemblies. One thing the designer may specify is that critical materials and components must pass the MIL-F-13927A, MIL-STD-801B, or other prescribed fungus-resistance tests. It is the job of the project engineer to monitor and evaluate the engineer design process to determine the extent to which it appears to be guarding against fungi. If prototype manufacturing and supply specifications are sufficiently definite as to fungus resistance, and if contractors and suppliers furnish certificates of compliance, commodity commands may regard engineer design tests for fungi as unnecessary; the extent of the need for engineering tests for fungi may then depend on the project engineer's evaluation of the entire situation. Design stage evidence as to fungus resistance must be carefully considered by project engineers, who may obtain advice in this matter from the Pitman-Dunn Research Laboratory. Laboratory tests for fungus resistance should be included in engineering test plans for those components whose performance is critically dependent on this characteristic unless adequate data are available from actual fungus-resistance tests conducted during the engineer design phase. For any item which may have susceptibility, a fungus-resistance test provision should always appear in plans for the tropical test phase of the engineering test.

APPENDIX B

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 required in section 6.2. 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 B-1 is for reference only and in no way limits or restricts the use of chambers of different designs, providing the requirements of military specifications MIL-C-9452, "Chamber, Fungus Resistance Testing" are satisfied. The chamber should, however, generally conform to Figure B-1 and provide, by some approved means, all of the features shown.

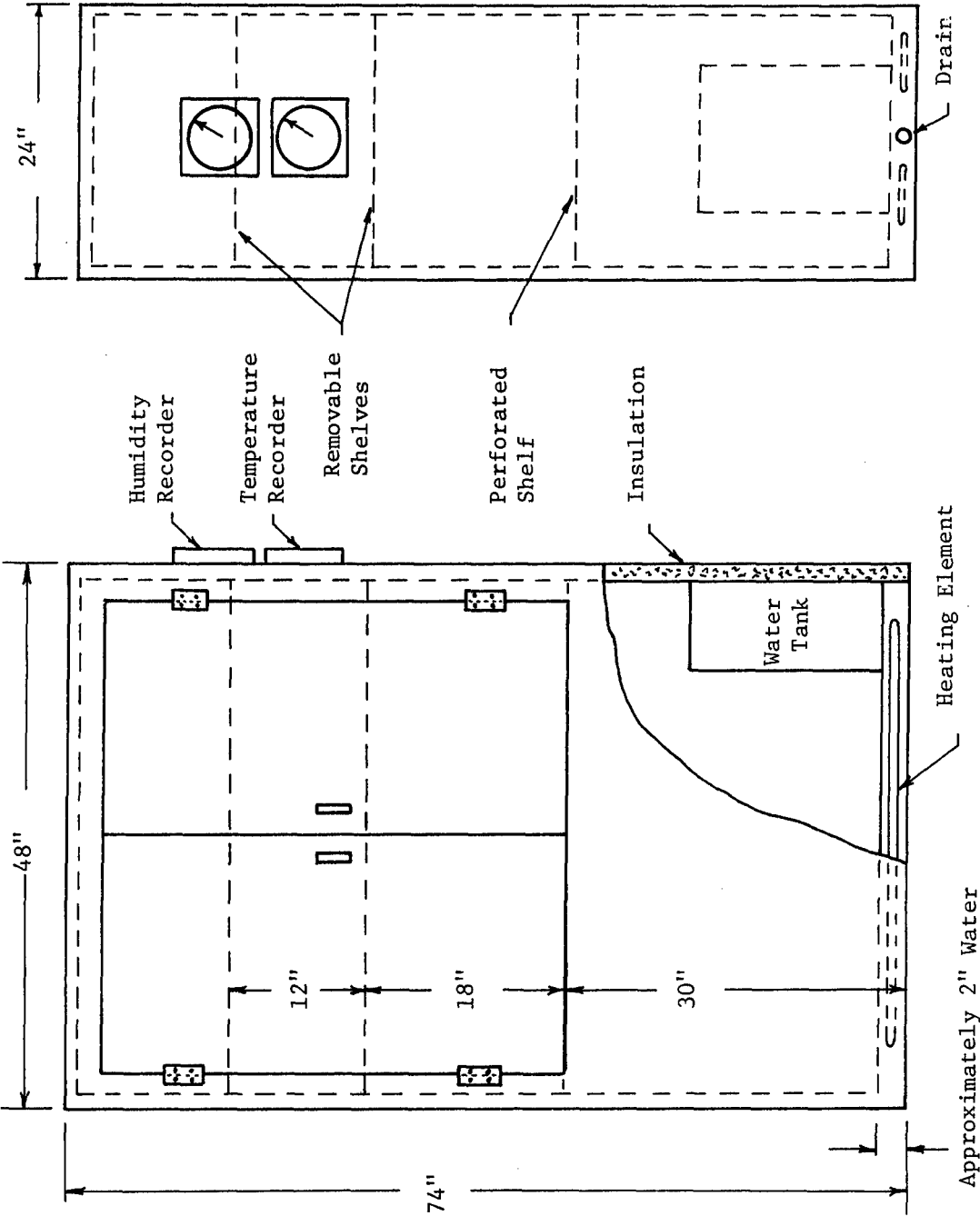


Figure B-1 Typical Fungus Resistance Test Chamber

APPENDIX C

EVALUATION PRECAUTIONS

Expert inspection and interpretation of test results are essential to avoid possible misinterpretation. Two points of caution, suggested by the Pitman-Dunn Research Laboratory, are as follows:

a. Many cottony "growths" that appear on items, particularly during exposure to high humidity, are not fungus. Corrosion products, crystallization, or blooming ingredients, may simulate fungus growth when viewed by the naked eye. Further examination with a microscope or a simple chemical test may be necessary to confirm that the appearance of a growth is biological in character.

b. Deteriorations by fungi may occur without the appearance of the characteristic growth of fungus mycelium on the surface of the item. This is particularly true in a natural exposure where the appearance of the organism may differ considerably from that usually seen in laboratory procedures. Most of the laboratory test methods used for specification purposes, including the test organisms, are selected because relatively copious fungus growth occurs on the surfaces of items, making it easier to observe and evaluate. Not all of the fungi found in nature that will grow on industrial materials manifest themselves so clearly as the cause of deterioration as the ones chosen for specification testing. Also, the medium used in test methods is balanced in order to give ideal growth for identification and testing purposes. Under field conditions, nutrients are often deficient, leading to atypical growth. Further, fungus growth may be mostly below the surface of a material, or the deterioration may be primarily enzymatic in nature with only a small amount of actual mycelium formation. Cotton cloth exposed in the wet tropics in the shade rapidly deteriorates because of fungal attack. Except for some pigment-producing fungi that stain, the cloth does not have a surface layer of mold growth. The organism is within the cotton fibers and decomposes the cellulose molecules that make up the cotton fiber.

APPENDIX D

SELECTED REFERENCES

A. BOOKS AND ARTICLES

1. Wolf, F. A. and Wolf, F. T. The Fungi, Vols. 1 & 2, John Wiley and Sons, 1947.
2. Greathouse, Glenn A. and Wessel, Carl J., Deterioration of Materials, Causes and Preventive Techniques, Reinhold Publishing Company, 1954.
3. Ramsbottom, J., Fungi and Modern Affairs, Smithsonian Institution Annual Report, 1945, pp. 313-326.
4. Horigan, Francis D. and Sage, Cary R., The Technology of Fungi, Mold and Mildew, Quartermaster Research and Development Laboratories, Philadelphia, Pa., January 1950.
5. Shanor, Leland, Handbook of Some Fungi Associated with Tropical Deterioration; Office, Scientific Research and Development Report No. 6267, October 1945.
6. Proskauer, R., Fungus and Moisture Protection, Electronics, May 1954, pp. 119-123.
7. Ainsworth, G. C., and Sussman, A. S., The Fungi, Vol. I, The Fungal Cell, Academic Press, New York, N. Y. (1965)
8. Ainsworth, G. C. and Sussman, A. S., The Fungi, Vol. II, The Fungal Organism, Academic Press, New York, N. Y. (1966)
9. Alexopoulos, C. J., Introductory Mycology, John Wiley & Sons, Inc., New York, N.Y. (1966).

B. REPORTS

1. Fungicides

- a. Horsfall, James G., Fungicides and Their Action, Chronica Brittanica Company, Waltham, Mass., 1945.
- b. Fungicides for Preventing Tropical Deterioration, National Defense Research Council Tropical Deterioration Research Committee Report No. 8, January 1945.
- c. Comparative Evaluation of Commerical Fungicides, National Defense Research Council Tropical Deterioration Administrative Committee Misc, Report No. 12, January 1945.
- d. Ross, S. H. and Teitell, L., Fungicides for Micro-Crystalline Waxes, Frankford Arsenal Report No. 1128, April 1953.
- e. Ross, D. H., Antibiotics as Preservatives for Industrial Materials, Applied Microbiology, 6,268 (1958).
- f. Ross, S. H. and Teitell, L., U. S. Patent 3,638,819, Antibiotics as Preservatives for Industrial Materials, (1962)

2. Barrier Materials

- a. Leonard, John M. and Pitman, A. L. Tropical Performance of

Fungicide Coatings, Naval Research Laboratory Report No. 3781, January 1951.

- b. Burke, Evelyn S., Fungus Proof Barrier Materials, Rock Island Arsenal Report No. 57-496, February 1957.
- c. Burke, Evelyn S., Fungus Proofing of Barrier Materials, Rock Island, Arsenal Report No. 56-1664, July 1956.
- d. Ross, S. H., Rosewasser, E. S., and Teitell, L., Effects of Fungi on Barriers, Modern Packaging, 29, 180, (1956).
- e. Ross, S. H., and Teitell, L., Factors in the Development of Fungus Proof Barrier Materials, I. Treatments for Kraft Paper. Developments in Industrial Microbiology, 7,21, (1966).
- f. Teitell, L., and Ross, S. H., Factors in the Development of Fungus-Proof Barrier Materials, II. Plastic and Asphalt Laminates. Developments in Industrial Microbiology, 7,22, (1966).
- g. Conn, E. and Teitell, L., Ceraseals as Moisture and Fungus Proofing Material, Frankford Arsenal Report No. 712, March 1946.
- h. Counts, J. B., Cold Application Strippable Compound, Engineering Laboratories Report No. 34, Development and Proof Services, Aberdeen Proving Ground, March 1956.
- i. Johnson, R. E. and Lemar, R. L., Development of a Fungus or Mold Resistant Wax Dipcoating Compound, Rock Island Arsenal Report No. 54-2293, June 1954.
- j. Leonard, J. M. and others, Comparative Fungicidal Attenuations in Oil-Modified Coatings, Naval Research Laboratory Report No. 4674, December 1955.
- k. Fungistatic Varnish - Comparative Study, Naval Bureau of Ordnance, Proposed Varnish and USA Spec. 3-210 Varnish; Laboratory Services Division Report No. 40, Development and Proof Services, Aberdeen Proving Ground, January 1948.

3. Sealing Compounds

Teitell, L., Fungicides for Sealing Compounds, Frankford Arsenal Report No. 886, 1949.

4. Electrical Apparatus

- a. Lee, Charles B., Experimental Evaluation of Fungus Attack on Electrical Cables, Detroit Arsenal Materials Laboratory Report No. 2989A (Pt. I), July 1954.
- b. Teitell, Albert C., Fungus Growths and Electrical Apparatus, General Electric Review, August 1945, pp. 19-20.
- c. Leonard, John M. and Patorullet, Constance E., Protection of Selenium Rectifiers Against Damage by Mercurial Fungicides, Naval Research Laboratory Report No. 4376, 1954.

- d. Teitell, L., Berk, S. and Kravitz, A., Effects of Fungi on the DC Surface Conductance of Electrical Insulating Materials, Applied Microbiology, 3, 75-81 (1955).
- e. Rychtira, M. and Bartakova, B., Tropic Proofing Electrical Equipment, Leon and Hill, Ltd., London (1963).
- f. Berk, Sigmund, Evaluation of Test Methods for Fungus Resistance of Non-Rigid Synthetic Electrical Insulating Materials, Frankford Arsenal Report No. 921, October 1949.
- g. Teitell, L. and Berk, S., Effects of Fungi on Tensile Strength, Electrical Insulating Tapes, Frankford Arsenal Report No. 966, June 1950.

5. Gaskets

- a. Berk, Sigmund, Fungus Proofing of Gasket Materials, Frankford Arsenal Report No. 695, January 1946.
- b. Berk, Sigmund, Fungicidal Treatment for Cork Gaskets, Frankford Arsenal Report No. 757, December 1946.

6. Optical

- a. Teitell, L., and Berk, S., Prevention of Mold Growth in Optical Instruments, Frankford Arsenal Report No. 968, April 1950.
- b. Berk, S., and Teitell, L., Radioactive Materials in Prevention of Mold Growth on Optical Instruments. Industrial and Engineering Chemistry, 46, 778-784, (1954).

7. Plastics

- a. Berk, Sigmund, Fungus Tests on Polyvinyl Chloride Films Plasticized With Three Plasticizers, Frankford Arsenal Report No. 889, January 1949.
- b. Berk, S. and Leiser, F., Fungus Resistance Tests on Molded Melamine Formaldehyde Plastics, Frankford Arsenal Report No. 725, June 1946.
- c. Day, L. E., Resistance of Polystyrene Plastics to Soil Burial, Picatinny Arsenal Technical Memo 1661, October 1965.
- d. Ross, S. H. and Dougherty, F. J., Jr., Fungus Resistance of Vinyl Polymer Insulating Cable Coverings, Frankford Arsenal Report No. M68-12-1, November 1967.
- e. Ross, S. H., Biocides for a Strippable Vinyl Plastic Barrier Material, Frankford Arsenal Report No. R-1396, July 1957.
- f. Berk, S., Ebert, H., and Teitell, L., Utilization of Plasticizers and Related Organic Compounds by Fungi, Industrial and Engineering Chemistry, 49, 1115-1124, (1957).

8. Leather

- a. Teitell, L., Fungicidal Treatment for Leather, Frankford Arsenal Report No. 848, February 1948.
- b. Ross, S. H. and Berk, S., Fungicidal Treatment for Leather, Frankford Arsenal Report No. 1335, July 1956.
- c. Cordon, T. C., et. al., Protection of Army Ordnance Leather Equipment from Molds, J. Am. Leather Chemists Assoc., 44, 472-503 (1949)
- d. Dahl, S. and Kaplan, A. M., Fungicidal Effectiveness of Compounds Applied to Leather, J. Am. Leather Chemists Assoc., 52, 536-549 (1957)

9. Textiles

- a. Shanor, Leland, Fungus-Proofing of Textiles and Cordage for Use in Tropical Service; Office, Scientific Research and Development Report No. 4513, January 1945.
- b. Teitell, L., Textile Preservatives for Field Treatment, Frankford Arsenal Report No. 787, May 1947.

10. Wood

- a. Analytical Methods of Fungicides Used in U. S. Army Specification 3-186, Sealer, Wood, Preservative, Laboratory Services Division Report No. 39, Development and Proof Services, Aberdeen Proving Ground, December 1947.
- b. Verrall, A. F., Preservative Moisture-Repellant Treatments for Wooden Packing Boxes, Forest Products Journal, 9, 3-25 (1959)

11. Greases

Ross, S. H., Fungus Resistance of Dust Retentive Greases, Frankford Arsenal Memorandum Report No. 605, April 1955.

12. Explosives

- a. Axelrod, S. A., Effects of Fungicidal Treatment of Lumber Upon the Stability of Explosives, Picatinny Arsenal Report No. 1828, June 1951.
- b. Dougherty, F. J. and Ross, S. H., Fungus Resistance of Consumable and Combustible Cartridge Cases, Frankford Arsenal Report No. M65-11-1, March 1965.

13. Metals

Reed, M. and others, The Corrosion of Metals by Volatile Fungicides, Frankford Arsenal Report No. 1194, April 1954.

14. Lubricants

Gisser, H., The Behavior of Instrumental Lubricants in Tropical Exposure, Frankford Arsenal Report No. R-866, September 1948.

15. Paints

Ross, S. H., and Dougherty, F. J., Jr., Fungus Resistance of Three Coatings for Use as Finished on Weapons Systems, Frankford Arsenal Report #M67-32-1, June 1967.

16. Miscellaneous Effects

- a. McKee, Herbert C., Study of Deleterious Actions Due to Combined Effects of Humidity and Atmospheric Pollutants, Southwest Research Institute (for OCO), January 1960.
- b. Kravitz, A., Fungitoxic Activities of Volatile Compounds, Frankford Arsenal Report No. 1379, March 1957.
- c. Evangelides, H. A., Vapor Phase Corrosion Inhibitors, Frankford Arsenal Report No. 786, May 1947.
- d. Teitell, L. and Frager, F., Corrosive Effects of AXS-1247 and AXS-1296 Fungicides, Frankford Arsenal Report No. 610, April 1945.
- e. Rosenberg, Harold and Mostiller, J. C., Evaluation of Organic Fluorine Compounds for Use in Military Aircraft, Wright Air Development Center Report No. TR-54-580, 1955.
- f. Teitell, L., Fungistatic Activity of Some Nitrotenzoic Acids and Their Esters, Frankford Arsenal Report No. 933, September 1949.