OBSERVATIONS ON THE TESTING OF FUNGICIDES IN NEOPRENE, VINYL, AND VARNISH COVERED ELECTRICAL WIRES AND CABLE

by
W. S. TAYLOR

R. T. VANDERBILT CO., INC.

Presented at 1st Symposium on Technical Progress
in Communication Wires and Cables

Asbury Park, New Jersey
8 - 10 December 1952

OBSERVATIONS ON THE TESTING OF FUNGICIDES IN NEOPRENE, VINYL, AND VARNISH COVERED ELECTRICAL WIRE AND CABLE

By
W. S. Taylor
R. T. Vanderbilt Co., Inc.

Many of the failures of electrical wire and cable can be traced to moisture inside the protective jacket. When the wire was made this moisture was not present. One entry of the moisture is through small holes eaten through the covering or jacket by micro-organisms. These failures are probably greater in number and importance when the wire and cable is used for military purposes because of the rigorous outdoor exposures to which they are subjected. Although in military operations communication failure is often a matter of life and death, protection of civilian installations is becoming increasingly important.

Neoprene, vinyl, saturants and varnish normally used in insulating at coating compounds contain materials that are subject to attack by micro-organisms. These materials are added to impart certain desired physical and chemical properties to the covering compounds. Plasticizers and processing aids, such as paraffin, stearic acid and oils used in Neoprene composition are attacked by micro-organisms. The materials most widely attacked in vinyl films are plasticizers like diisobutyl adipate, ricinoleates and derivatives, butoxy ethyl stearate and most of the vegetable oil" plasticizers. Most of the saturants commonly used contain paraffin or oil type materials which are also subject to attack by micro-organisms, while in varnish films, the oils and resins are the susceptible portion of the film. Until cheaper, better, more resistant materials can be substituted for these constituents which support fungus and bacterial growth, the problem of micro-organism attack will be present.

There exist certain chemical compounds which can be added to the formula containing these nutrient materials, that will prevent the micro-organisms from growth in or on the protective coverings of wire and cable assemblies. These compounds are commonly known as fungicides. There are innumerable fungicides, but very few are capable of preventing growth of micro-organisms without altering the physical and chemical properties of the nutrient containing materials and thereby making the protective covering less effective. We will briefly enumerate some of the micro-organisms that are capable of attacking these materials, types of tests used in evaluating fungicide incorporated in these coverings, and results obtained in our laboratory using various tests and fungicides.

There are two major types of micro-organism growth encountered in this wire and cable covering field: surface and internal growth. Surface growth usually has a major effect on appearance and surface resistivity and a slight effect on physical properties, while internal growth generally alters the properties to the extent that the desired electrical qualities of the covering are lost.

Some of the organisms that cause this damage are very difficult to cultivate on artificial nutrient media, so that most resistant of those more easily cultivated are used as test organisms. The Aspergilli niger, flavus, oryzae and versicolor, the Penicillia luteum and citrinium, Trichoderma T-1, Myrothecium verrucaria, Chaetomium globosum and Pseudomonas aeruginosa are some of the common organisms capable of attacking these covering materials and one or more are used in each of the various standard tests.

Our laboratory has evaluated a large number of fungicides in each of these wire and cable coverings in the last several years. In considering a fungicide as a candidate for use in these materials, it should be checked for desired physical and chemical properties before attempting to use it in one of the formulation. Candidate fungicides should be soluble or compatible, not interfere with electrical properties and be non-toxic to humans. Normally Mercury bearing fungicides can not be used in these covering compositions, as mercury has a tendency to interfere with the electrical properties. Selenium rectifiers are an example of equipment especially sensitive to mercury. Any fungicides that would form electrolytes when mixed with the susceptible materials would also be discarded for the same reason.

A resume of tests and results obtained, from work done by our laboratory follows:

After basic evaluation of laboratory batches of Neoprene, it was found that approximately 1.0 - 2.0% of a synergistic mixture of the Zinc salt of dimethyl-dithiocarbamic acid and the zinc salt of 2-mercaptobenzothiazole (commercially known as VANCIDE 51Z) based on the weight of the Neoprene content, was sufficient to fungusproof the Neoprene. The actual amount of VANCIDE 51Z needed to make the Neoprene fungus proof is based on the amount of susceptible or edible portion of the formula, but 1.0 - 2.0% is normally enough to do the job. Table I shows the formula used for these laboratory studies.

TABLE I

Neoprene Laboratory Formula

Neoprene GN	100
Accelerator	1.5
Stabilizer - Antioxidant	3
Black	65
Magnesium Oxide	4
Zinc Oxide	7.5
Stearic Acid	3
Paraffin	8
Light Mineral Oil	8
VANCIDE 51	1.5

Several batches were then made up by various industrial producers of Neoprene jacket and the results obtained upon testing the submitted samples verified the laboratory findings. In two applications, 0.5 - 0.75% of this synergistic mixture of the zinc salts of dimethyldithiocarbamic acid and 2-mercaptobenzothiazole based on the weight of the Neoprene was sufficient to impart fungus-proofing without an effect on the electrical properties of the Neoprene wire covering. Due to the lack of commercial fungicides used at present in Neoprene, no other fungicides were tested. U. S. Army Specification No. 60-977-2 was the standard test used in this work.

Table II illustrates a Neoprene telephone wire job.

TABLE II

Test - U. S. A. Specification 60-977-2 as stipulated in AXS-1819

Samples	Evidence of growth after 14 days incubation
Neoprene with no fungicide	++
Neoprene with 0.5% VANCIDE 51Z	0
Neoprene with 0.75% VANCIDE 51Z	0

Key: 0 = no fungus growth + = slight fungus growth ++ = moderate fungus growth +++ = profuse fungus growth

In preliminary studies of fungicides as candidates for application in polyvinylchloride resin compositions to prevent growth of microorganisms on vinyl films and tubing, the normal procedure in our laboratory is to evaluate the candidate in susceptible plasticizers alone. If the fungicide is found to protect the plasticizer, it is added to a laboratory batch of

vinyl resin and made into a film. This film is then subjected to various established tests. Some of the common failures of fungicides when used in vinyl films are 1) tenderizing of the film when exposed to sunlight 2) "blooming" of fungicide 3) lowering of electrical properties by present of "electrolytes" 4) toxicity to humans.

N-trichloromethylthiotetrahydrophthalimide, hereafter called VANCIDE 89, met the prerequisites for a candidate fungicide. Table III lists a series of common plasticizers in which VANCIDE 90 was screened

TABLE III

VANCIDE 89 in Vinyl Plasticizers

Plasticizer	14 days Percent VANCIDE needed to prevent growth	28 days Percent VANCIDE needed to prevent growth
2,2 (2-ethylhexamide diethyldi-2-ethyl hexoate	not susceptible	not susceptible
Trimethylene glycol di-2-ethylbutyrate	1	1
Ethylene glycol monoethyl ether acetylricinoleate	1	2
Cresyl diphenyl phosphate	1	1
Butoxyethyl stearate	1	2
Diisobutyl adipate	5	5

Test - Pieces of filter paper dipped in plasticizer and exposed on agar plate. Procedure as in USAF 12047a and MIL-V-173a.

After numerous laboratory batches incorporating VANCIDE 89 were prepared and evaluated, satisfying the preceding points, it was found that a concentration of 1 to 2 parts per 100 parts of vinyl resin would prevent growth of test micro-organisms. Again the exact amount of VANCIDE 89 needed was directly proportional to the susceptible materials present in the vinyl compound. Several commercial batches of vinyl film and tubing have been made with various plasticizers and formulae. All of these have been tested in our laboratory and Government labs and will pass MIL-I-7444(USAF), the pertinent specification.

Preliminary evaluation of varnishes commonly used in covering of wire and cable coverings showed that VANCIDE 89 was sufficiently soluble and fungus-proofed the varnish when added in reasonable quantities. The commercial control, and Government approved fungicide, was salicylanilide. Basic screening in the laboratory indicated that approximately 0.5% VANCIDE 89 was equal in activity to 1.0% salicylanilide in a number of different varnishes. Upon testing three commercial varnishes it was learned that 0.5% VANCIDE 89 was equal to 1.0 - 3.0% salicylanilide. Table IV compares VANCIDE 89 with salicylanilide in these varnishes.

TABLE IV

Comparison of Fungicides in Commercial Varnish Sample

Test - As outlined in USN 52-T-15, JAN-C-76 and MIL-V-173a

Fungicide	Evidence of growth on samples		
	7 day	14 day	21 day
No fungicide	///	///	///
0.25% VANCIDE 89	/	//	//
0.5% VANCIDE 89	0	0	0
0.75% VANCIDE 89	0	0	0
1.0% VANCIDE 89	0	0	0
0.25% Salicylanilide	///	///	///
0.5% Salicylanilide	///	///	///
0.75% Salicylanilide	///	///	///
1.0% Salicylanilide	0	0	/
2.0% Salicylanilide	0	0	/
2.5% Salicylanilide	0	0	0

Key: amount of growth on the sample
0 = no growth
/ = slight fungus growth
// = moderate fungus growth
/// = profuse fungus growth

One commercially coated electrical wire was submitted for testing, with the salicylanilide treated varnish sample failing and the VANCIDE 89 treated varnish coated wire sample passing the test. Military Specifications used in this type of evaluation included 52-T-15, JAN-C-76 and MIL-V-173a.

In Canada, The Electronics Standards Sub-Committee, Department of National Defence has announced VANCIDE 89 is approved as a fungicide for butyrate lacquer for hook-up wire to Specifications JAN-C-76 and JCMAAF-W-4.

SUMMARY

Service failures of electrical wire and cable assemblies are oftentimes found to be caused by micro-organism attack on the protective coverings. Laboratory study has shown the coverings contain certain materials that support the growth of these micro-organisms. Two recently developed fungicides, VANCIDE 51Z and VANCIDE 89, when used in the required proportions gave the necessary protection from this attack without altering the desirable properties of the Neoprene, vinyl and varnish coverings.