

WADC TECHNICAL REPORT 53-38
PART 11

PACKAGING REQUIREMENTS FOR BEARINGS

**Part 11. Performance of Procoated Black Iron Can Packages Containing
Volatile Corrosion Inhibitor and Antifriction Bearings (Series T)**

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Wright Air Development Center
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FOREWORD

This report was prepared by the U. S. Forest Products Laboratory under USAF Contract No. AF 18(600)-103. The contract was initiated under Research and Development Order No. 618-11(C-B), "Packaging Requirements for Bearings", and it was administered by the Packaging Branch, Materials Laboratory, Directorate of Research, Wright Air Development Center, with Mr. Albert Olevitch acting as project engineer.

ABSTRACT

This study was initiated to investigate the performance of volatile corrosion inhibitors as protection for two types of antifriction bearings in procoated black iron cans.

Interior protection was provided by dicyclohexylammonium nitrite-impregnated paper or crystals. Procoated black iron cans were used to contain antifriction bearings with steel or brass retainers.

The packages were exposed at a 3-week cyclic exposure with temperature extremes of -65° to 160°F . One group of bearings with brass retainers were examined after this exposure. Following the 3-week cyclic exposure period, both brass and steel antifriction bearing packages were stored for 60 days at 160°F . and 92 percent relative humidity.

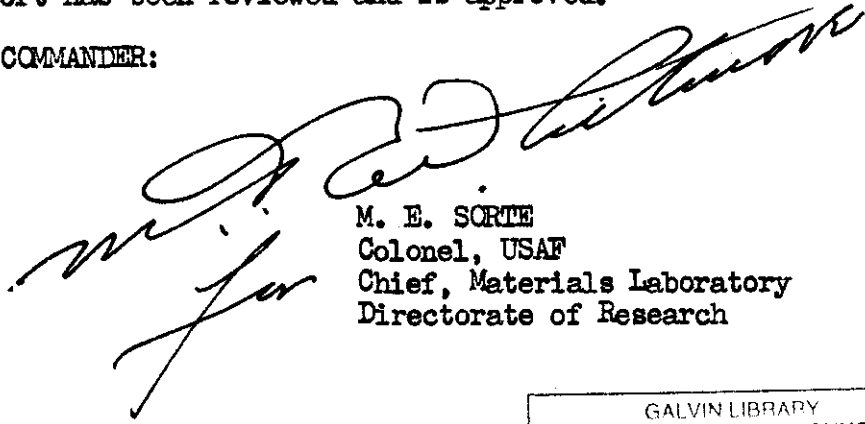
Although the dicyclohexylammonium nitrite was successful in minimizing corrosion on ferrous parts, the tendency of crystals to undergo sublimation resulted in a dense formation of crystals on all surfaces of the bearing. The presence of these crystals on functional surfaces acted to freeze the rolling parts.

The use of MIL-C-10506 procoating material as a protective coating on the black iron cans was unsatisfactory in this test.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:


M. E. SORTE
Colonel, USAF
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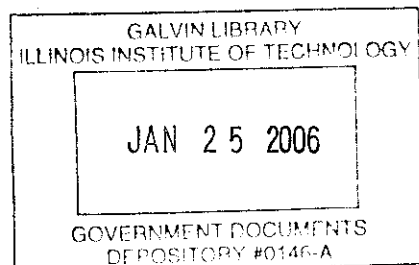


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INTRODUCTION

The U. S. Forest Products Laboratory in cooperation with the Packaging Branch, Materials Laboratory, Directorate of Research, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, has undertaken a project to determine packaging requirements for antifriction bearings. This report covers one phase of the general study and was undertaken to determine the suitability of using one type of volatile corrosion inhibitor as a means of preservation for antifriction bearings in black iron cans. Black iron cans were selected because it was thought that the inhibitor would have less reaction on these than on tin-plated cans.

MATERIALS

Bearings

Bearings for this test were of two types; steel antifriction bearings having brass retainer rings, and an all-steel bearing.

The steel bearings were approximately 2-1/4 inches in outside diameter and 3/8 inch in width. The bearings with brass retainers were 2 inches in diameter and 9/16 inch in width. The bearings were supplied by Mallory Air Force Depot, Memphis, Tenn.

Corrosion Inhibitors

Two inhibitor systems were used in this experiment:

1. Inhibitor a, volatile corrosion inhibiting crystals of dicyclohexylammonium nitrite.
2. Inhibitor b, a 30 pound kraft paper conforming to Specification MIL-P-3420 containing 2 grams per square foot of chemicals which react to produce essentially dicyclohexylammonium nitrite.

Intimate Wrap

Three materials were used as intimate wraps in this investigation:

1. Barrier No. 37, a polyethylene film, 2 mils thick.
2. Barrier No. 39, a creped laminate of polyethylene extruded on kraft paper.
3. Barrier No. 42, a polyester film (polyethylene glycol ester of terephthalic acid), not surface treated.

Oil

The only oil used in this test was compound N, an uninhibited lubricating oil conforming to Specification USAF 3519.

Procoating

The procoating used in this experiment was paint A, an olive-drab paint conforming to Specification MIL-C-10506, type II.

Cans

The cans for this test were shallow-drawn black iron; 0.012 inch thick, 1-3/4 inches deep, and approximately 2-3/4 inches at the outside diameter. The cans were sealed with a hand sealer.

PREPARATION OF TEST SPECIMENS

Prior to receiving the standard cleaning procedure, the outer ring was polished in a special jig with a slurry of levigated alumina and fingerprint neutralizer on soft cotton flannel cloth. The bearings were then rinsed in petroleum ether and examined with a low-power (7X) binocular microscope to be sure that no corrosion remained on the surface. Only stain- and corrosion-free bearings were used in this experiment.

The actual cleaning operation given bearings prior to preserving and sealing in cans was as follows:

1. Rinse in agitated Stoddard solvent (Specification P-S-661a).
2. Immerse for 2 minutes in fingerprint remover (Specification USAF 14156A).
3. Rinse in 3 successive baths of petroleum ether (bp 35° to 60°C.).
4. Drain and dry for 20 to 30 minutes in a ventilated infrared oven. Cans used in this test were given the same cleaning procedure and kept in the infrared drying oven until needed. Clean rubber gloves were used to protect bearings from contamination.

A total of 72 bearings were used in this test. Each bearing was packaged individually according to the following plan:

Packaging Plan for Bearings with Brass Retainers

Specimen No.	Preservation within can		Exposure for
	Intimate wrap or oil:	Inhibitor	3 weeks plus storage for:
			<u>Days</u>
1-3	None	0.2-gram crystals (inhibitor <u>a</u>)	0
4-6	.....do.....	.....do.....	60
7-9	Polyethylene kraft (barrier No. 39)	.....do.....	0
10-12	.....do.....	.....do.....	60
13-15	None (control)	None (control)	0
16-18	.....do.....	.....do.....	60
19-21	None	14-sq.in. inhibited paper (inhibitor <u>b</u>)	0
22-24	.....do.....	.....do.....	60
25-27	Polyester film (barrier No. 42)	0.2-gram crystals (inhibitor <u>a</u>)	0
28-30	.....do.....	.....do.....	60
31-33	Polyethylene film (barrier No. 37)	.....do.....	0
34-36	.....do.....	.....do.....	60
37-39	Oil (compound N)	None	0
40-42	.....do.....	.....do.....	60
43-45	.....do.....	0.2-gram crystals (inhibitor <u>a</u>)	0
46-48	.....do.....	.....do.....	60

Packaging Plan for All-steel Bearings

Specimen No.	Preservation within cans		Exposure for
	Intimate wrap or oil:	Inhibitor	3 weeks plus storage for:
			<u>Days</u>
49-51	None	0.2-gram crystals (inhibitor <u>a</u>)	60
52-54	Polyethylene kraft (barrier No. 39)	.....do.....	60
55-57	None (control)	None	60
58-60	None	14-sq.in. inhibited paper (inhibitor <u>b</u>)	60
61-63	Polyester film (barrier No. 42)	0.2-gram crystals (inhibitor <u>a</u>)	60
64-66	Polyethylene film (barrier No. 37)	.....do.....	60
67-69	Oil (compound N)	None	60
70-72	.....do.....	0.2-gram crystals (inhibitor <u>a</u>)	60

Packaging Procedure

Bearings and cans were taken from the oven as needed and given the appropriate preservation called for on the above plan. The bearings requiring uninhibited oil (compound N) were dipped in the oil and allowed to drain momentarily before being placed in cans for sealing. In preparation of test specimens involving corrosion inhibiting crystals (inhibitor a) and intimate wrap materials, the crystals were placed within the intimate

wrap. As in the cleaning operation, rubber gloves were worn when the bearings were handled.

All cans were sealed immediately after packing and subjected to a temperature of 125°F. for 5 minutes.

Final treatment of cans consisted of spraying the outside of sealed cans with procoating material. The dry film thickness was approximately 1.5 mils.

TEST PROCEDURE

All of the test packages were placed in open wood racks and subjected to the following exposure:

1. Six hours, 8 a.m. to 2 p.m., at room temperatures of 70° to 80°F.
2. Two hours, 2 p.m. to 4 p.m., in a chamber at -65°F.
3. Sixteen hours, 4 p.m. to 8 a.m., in a humidity cabinet maintained at 160°F. and 92 percent relative humidity. This cycle was repeated for 3 weeks. Over the weekend the specimens were stored at 160°F. and 92 percent relative humidity.

Following the 3-week exposure period, some of the cans containing bearings with brass retainers were opened and the remainder, together with the steel bearings, were stored for 60 days at 160°F. and 92 percent relative humidity.

Examination

At the end of the 3-week cycle and the 60-day storage periods, the respective groups of test packages were examined as follows:

1. The outside of each can was examined for corrosion.
2. Each can was given a quick leak test by submerging precooled cans in warm water. Cans that leaked emitted air bubbles.
3. The cans were opened, and an examination was made to determine the extent of corrosion of the inner can surfaces.
4. The intimate wrap was examined for possible discoloration or deterioration.
5. Each bearing was carefully examined. The polished outer rings were examined with a low-power (7X) binocular microscope. The extent of corrosion occurring on the outer ring was estimated and rated according to the following corrosion rating schedule:

Corrosion Rating Schedule

Numerical rating	:	Corrosion (percent of area affected)
0	:	None
1	:	0 - 3
2	:	3 - 10
3	:	10 - 30
4	:	30 - 50
5	:	50 - 100

DISCUSSION OF RESULTS

Can Exterior

After the 3-week exposure cycle, the visible corrosion of the can exterior was limited to slight rusting along the seals of all cans.

After 60 days of storage, all cans were moderately to severely corroded along the seals and also on the top and bottom surfaces (fig. 1).

Quick Leak Test

After the 3-week cyclic exposure, all cans were tested by the quick leak test and found to be free from leaks. After 60 days of storage, however, 12 out of 48 cans were found to have leaks.

Can Interiors

After the 3-week exposure cycle, a slight amount of corrosion was visible on the interior of 3 of 24 specimens examined. After 60 days of storage, all 48 specimens exhibited some corrosion or staining on the interior surfaces.

Intimate Wrap

Although the intimate wrap materials enclosed with inhibitor were finely coated with a layer of crystals, none appeared to have suffered any deterioration.

Condition of Bearings

After the 3-week cyclic exposure, all bearings, including control specimens, were free of corrosion. After 60 days of storage, the entire

contents of all cans containing dicyclohexylammonium nitrite (inhibitors a or b) were coated with crystals resulting from sublimation of the inhibitors. The presence of the crystals on bearing raceways made it impossible to rotate the bearing parts. By using Stoddard solvent (Specification P-S-661a) and a great deal of force it was possible to loosen the bearings so that they would spin freely. Bearings thus freed were found to be frozen tight again upon examination a few days later. Almost all bearings were spotted with a deposit that appeared like a smooth, rust colored, semisolid material under the microscope. Since it was easily removed by rubbing with a cloth saturated with Stoddard solvent, and showed no evidence of pitting beneath, it was not considered to be corrosion. Tables 1 and 2 are based on the corrosion rating of bearings after these deposits were removed. All but 3 of the 24 brass retainers were stained and corroded.

SUMMARY OF OBSERVATIONS

1. After the 60-day storage period, all black iron cans procoated with MIL-C-10506 paint were in a badly corroded condition.
2. After the 60-day storage period, the inside surfaces of cans containing inhibitor were corroded but no more than the control packages without inhibitor.
3. Sublimation of the inhibitor, dicyclohexylammonium nitrite, resulted in dense formation of crystals that froze the bearings.

4. The use of inhibitor did not entirely prevent corrosion of the bearings.

5. The intimate wrap of polyester films with either the crystals or impregnated paper gave the best performance.

CONCLUSIONS

Under the test conditions of this study, the following conclusions were made:

1. MIL-C-10506 material sprayed on black iron cans does not give sufficient protection to prevent corrosion of the cans during this exposure.

2. The inherent characteristic of dicyclohexylammonium nitrite, that of being able to undergo sublimation, results in a dense deposit of crystals on the bearings. The presence of crystals on the balls and races acts to freeze the bearings, and they can be freed only after a considerable force is exerted on the bearings or the crystals are removed with a solvent.

RECOMMENDATIONS

Since this investigation was concerned with only one type of several different types volatile corrosion inhibitors it is recommended that an investigation of the other types of volatile corrosion inhibitors be made.

Table 1.--Corrosion ratings of specimens with brass retainers after 60 days of exposure

Preservation within can			Number ¹ in test	Number of specimens per corrosion rating class				
Oil	Inhibitor	Intimate wrap		0	1	2	3	4 : 5
None	a (crystals)	None	2			2		
Do.....	.....do.....	Poly-kraft (barrier No. 39)	3		2	1		
Do.....	None	None	2				1	1
Do.....	b (paper)	.....do.....	3		3			
Do.....	a (crystals)	Polyester film (barrier No. 42)	2		2			
Do.....	.....do.....	Polyethylene (barrier No. 37)	3			2	1	
Oil (compound N)	None	None	3			3		
Do.....	a (crystals)	.....do.....	3				2	1

¹Specimens that failed the quick leak test were omitted. Three specimens were prepared for each variable.

Table 2.--Corrosion ratings of all-steel specimens after 60 days of exposure

Preservation within can				Number ¹ in test	Number of specimens per corrosion rating class					
Oil	Inhibitor	Intimate wrap			0	1	2	3	4	5
None	a (crystals)	None		3		1	2			
Do.....	.....do.....	Poly-kraft (barrier No. 39)		1		1				
Do.....	None	None		2			2			
Do.....	b (paper)	.....do.....		3			3			
Do.....	a (crystals)	Polyester film (barrier No. 42)		3			3			
Do.....	.....do.....	Poly-film		0						
Oil (compound N)	None	None		1			1			
Do.....	a (crystals)	.....do.....		2			1	1		

¹-Specimens that failed the quick leak test were omitted.

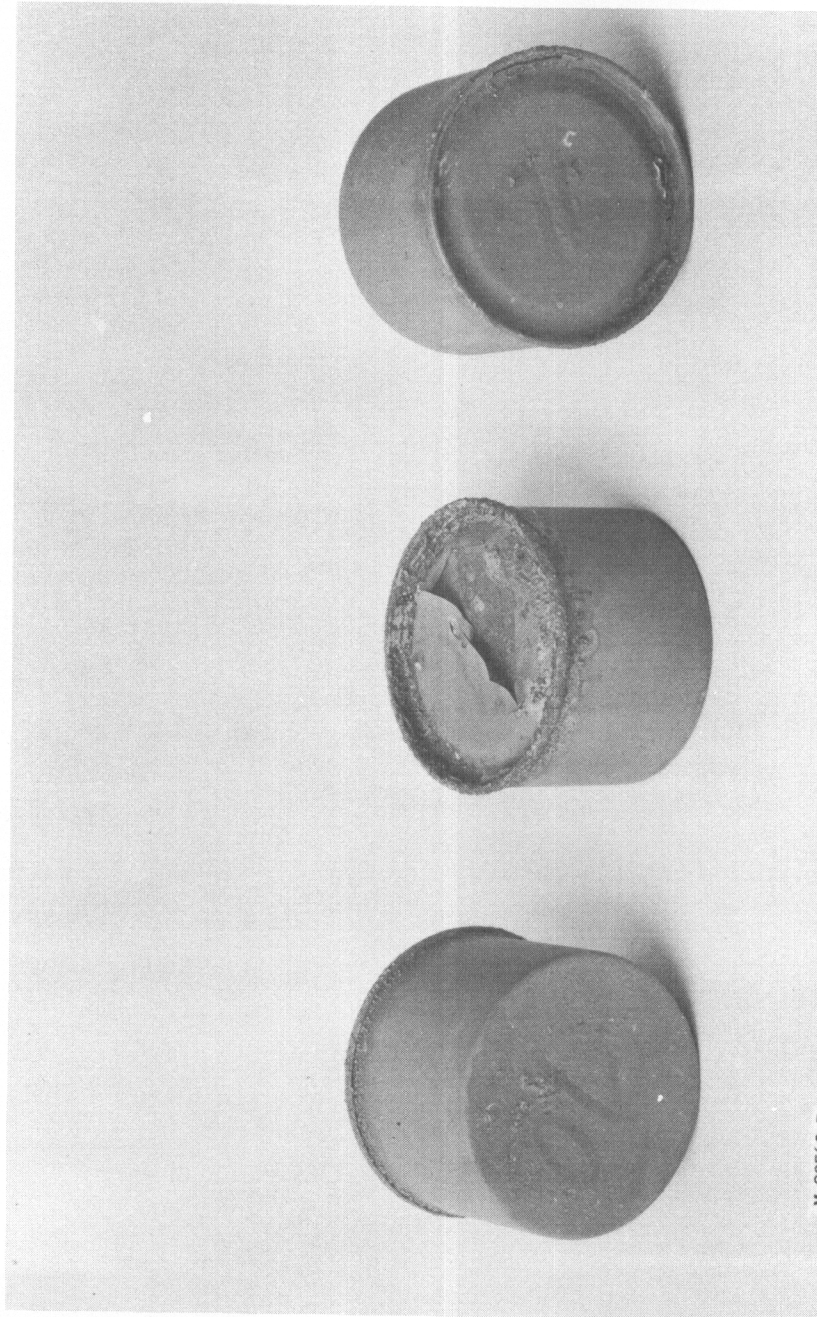


Figure 1. --Black iron cans after the 3-week cyclic exposure and 60 days of storage.