

WADC TECHNICAL REPORT 54-12

**THE EFFECT OF A SYNTHETIC LUBRICANT AND TWO DIBASIC ACID ESTERS
ON CERTAIN USAF FABRICS**

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FOREWORD

This report was prepared by the Textiles Branch and was initiated under Research and Development Order No. 612-13, "Textile Materials for Air Force Clothing". The report was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Lt C. D. Smith acting as project engineer.

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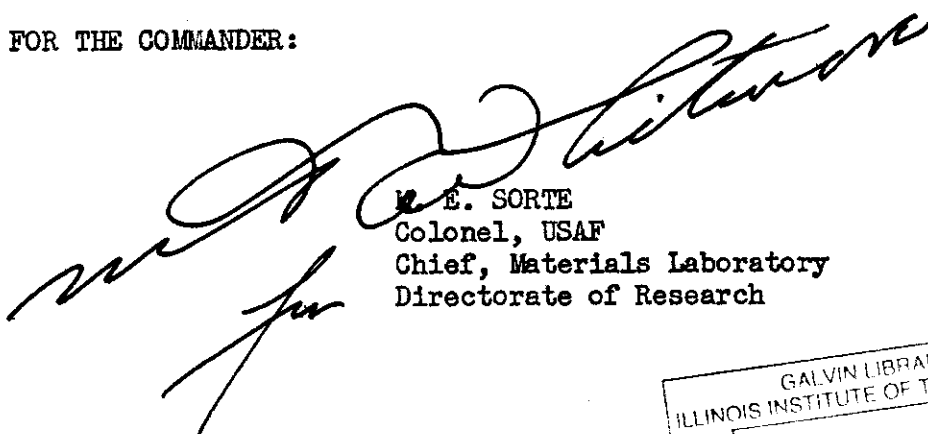
ABSTRACT

This investigation was initiated to determine if fabrics employed by the USAF were subject to degradation or deterioration when exposed to the lubricating oil covered by Specification MIL-L-7808 and the acid esters, di-2-ethyl hexyl adipate and di-2-ethyl hexyl sebacate. Need for an investigation was realized upon receipt of information that fabrics had been damaged when exposed to synthetic lubricants. In order to accomplish the desired program a series of fabrics composed of fibers that are commonly used in USAF fabrics was exposed to the above synthetic lubricants at room temperature and at 160°F. After exposure, laundering and dry cleaning tests were conducted to determine their effect in conjunction with the lubricants. By diaphragm burst tests it was found that no damage was apparent in the fabrics used when exposed to the above synthetic lubricants.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:



W. E. SORTE
Colonel, USAF
Chief, Materials Laboratory
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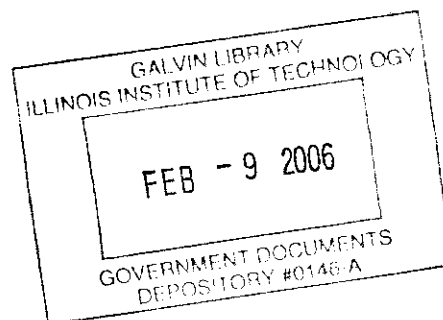


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THE EFFECT OF A SYNTHETIC LUBRICANT AND TWO DIBASIC ACID ESTERS ON CERTAIN USAF FABRICS

I. INTRODUCTION

Information has been received that fabric exposed to Lubricating Oil, Gas Turbine, Aircraft, Specification MIL-L-7808 has deteriorated. The oil is a synthetic lubricant usually composed principally of a sebacic acid ester. Because the Air Force plans increased use of synthetic lubricants of this type, an investigation of the degradation or deterioration of fabrics caused by synthetic lubricants was initiated. The investigation was planned to include Air Force functional fabrics which contained fibers of any nature that could be exposed during normal use to the lubricants under investigation.

It was considered desirable to conduct tests that would provide information on damage caused by MIL-L-7808 and would also give an indication of damage which might be caused by other synthetic lubricants in use by the Air Force. It was thought that by using di-2-ethyl hexyl adipate and di-2-ethyl hexyl sebacate (these are basic constituents of many Air Force synthetic lubricants) in addition to the oil covered by Specification MIL-L-7808 the desired information could be obtained. By using the above materials the results obtained in tests using the lubricant itself could be compared with results obtained when using its basic constituent (oil covered by MIL-L-7808 is principally di-2-ethyl hexyl sebacate) and, theoretically, the damage caused by lubricants composed principally of the same material could be estimated. Depending on the results obtained in comparing these two materials, conclusions could possibly be drawn from tests employing the di-2-ethyl hexyl adipate in relation to the synthetic lubricants of which it is a principal constituent. Basically, this was why the specific lubricants were chosen for this study.

II. SELECTION OF FABRICS

It was evident that tests on all the different Air Force fabrics would be too lengthy and confusing to be readily useful. It was considered more practical and just as conclusive to test a series of fabrics that would give an indication of the damage to the different fibers that are used in Air Force fabrics. The following fabrics were selected for testing:

1. 100% cotton - 4 oz. 2x2 basket weave
2. 100% wool - Shade 193 - MIL-C-4485
3. 100% nylon - MIL-C-7020
4. 100% rayon - For experimental cargo parachutes
5. 100% Dacron - For experimental parachutes - Fabric made in accordance with MIL-C-7020.
6. 100% Orlon - Experimental fabric for wing covers.
7. Nylon-viscose - MIL-C-4072 - Has nylon warp and viscose rayon filling and is used in Air Force raincoats.

By determining damage to the above fabrics it was thought that it would be possible to predict damage to fabrics composed of blends of the fibers that were represented in the fabrics tested. For example, if the fabric composed of fiber "X" showed damage and the fabric composed of fiber "Y" showed no damage, then a fabric composed of a blend of fibers "X" and "Y" should show damage depending on the amount of fiber "X" used in the blends. Other variable factors such as temperature, type of oil, and length of exposure could also affect degradation.

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III. TREATMENTS OF FABRICS

It was necessary to decide what treatment was to be given the test fabrics and what test method was to be used for evaluation. It was evident that the fabrics should be exposed at room temperature and at elevated temperatures and it was considered advisable to determine the effect of dry cleaning and laundering along with exposure because it was probable that Air Force items would be subjected to these treatments. A complete schedule of treatments was outlined for each fabric as follows:

A. Treatments of fabrics with lubricants at room temperature.

1. Original fabric - no treatment given.
2. Fabric soaked in di-2-ethyl hexyl adipate at room temperature for 72 hours.
3. Fabric soaked in di-2-ethyl hexyl sebacate at room temperature for 72 hours.
4. Fabric soaked in MIL-L-7808 lubricant at room temperature for 72 hours.

B. Treatments of fabrics with lubricants at elevated temperature.

1. Fabric subjected to 160°F for 72 hours - no other treatment.
2. Fabric soaked in di-2-ethyl hexyl adipate at 160°F for 72 hours.
3. Fabric soaked in di-2-ethyl hexyl sebacate at 160°F for 72 hours.
4. Fabric soaked in MIL-L-7808 lubricant at 160°F for 72 hours.

C. Treatments of fabrics with lubricants at room temperature and dry cleaning.

1. Fabric dry cleaned - no other treatment.

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2. Fabric soaked in di-2-ethyl hexyl adipate at room temperature for 72 hours then dry cleaned.
3. Fabric soaked in di-2-ethyl hexyl sebacate at room temperature for 72 hours then dry cleaned.
4. Fabric soaked in MIL-L-7808 lubricant at room temperature for 72 hours then dry cleaned.

D. Treatments of fabrics with lubricants at elevated temperature and dry cleaning.

1. Fabric subjected to 160°F for 72 hours then dry cleaned.
2. Fabric soaked in di-2-ethyl hexyl adipate at 160°F for 72 hours then dry cleaned.
3. Fabrics soaked in di-2-ethyl hexyl sebacate at 160°F for 72 hours then dry cleaned.
4. Fabric soaked in MIL-L-7808 lubricant at 160°F for 72 hours then dry cleaned.

E. Treatments of fabrics with lubricants at room temperature and laundering.

1. Fabric laundered - no other treatment.
2. Fabric soaked in di-2-ethyl hexyl adipate at room temperature for 72 hours then laundered.
3. Fabric soaked in di-2-ethyl hexyl sebacate at room temperature for 72 hours then laundered.
4. Fabric soaked in MIL-L-7808 lubricant at room temperature for 72 hours then laundered.

F. Treatments of fabrics with lubricants at elevated temperature and laundering.

1. Fabric subjected to 160°F for 72 hours then laundered.
2. Fabric soaked in di-2-ethyl hexyl adipate at 160°F for 72

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hours then laundered.

3. Fabric soaked in di-2-ethyl hexyl sebacate at 160°F for 72 hours then laundered.
4. Fabric soaked in MIL-L-7808 lubricant at 160°F for 72 hours then laundered.

The fabrics were brought to standard conditions, 70°F and 65% relative humidity, by conditioning for 24 hours, after each treatment, and then evaluation tests were conducted.

Dry cleaning of the fabrics was conducted as described in method 5610, Federal Specification CCC-T-191b. Dry cleaning solvent conformed to the requirements of Federal Specification P-S-661. Each dry cleaning was conducted using five samples of fabric, 4 inches by 4 inches each, and 350 milliliters of solvent per jar. The Launder-Ometer was run for 25 minutes at a temperature of 85°F, after which the samples were extracted in a centrifugal extractor, air dried, and conditioned.

The laundering was also conducted in the Launder-Ometer and was conducted with five samples, 4 inches by 4 inches each, contained in each jar. Laundering was done by using 350 milliliters of 0.5 percent soap solution per jar. The treatment was run for 30 minutes at 100°F, after which the samples were rinsed thoroughly at 100°F, extracted in a centrifugal extractor, air dried, and conditioned.

IV. TEST AND EVALUATION

The test chosen for evaluation of the effect of the various treatments was, "Strength of Cloth; diaphragm bursting method", number 5122, Federal Specification CCC-T-191b. This test was originally designed for testing of paper but since has been adapted to fabrics and is a good means for rapid evaluation, although it does not provide accuracy to the degree that a ravel strip test does.

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Due to the mechanism of bursting fabrics in a diaphragm device, the fabric direction having the lower elongation will normally be the first to fail. Hence, in testing the nylon-viscose rayon fabric the filling (rayon) direction consistently was the first to fail. In effect then, the tests on this cloth primarily determined the resistance of the direct spun viscose rayon to degradation by the various treatments, without respect to effects on the nylon.

Five samples of each fabric were treated in each of the twenty-four treatments previously outlined. Results of tests on these samples have been tabulated in Tables 1, 2, 3, 4, 5, and 6. Each table must be considered separately in evaluation of degradation because each table contains test results of an original or a treated control fabric along with results of tests of fabrics that had been given the same treatments as the control and in addition had been exposed to the lubricants under controlled conditions. For example, in Table 4, the samples that were exposed to 160°F for 72 hours then dry cleaned must be considered control samples because similar samples were soaked in the lubricants under the same conditions and were given the same dry cleaning afterwards.

Upon examination of the test results, variations in bursting strength were found but these variations were small enough that they may be considered either test error or normal differences in fabrics. These results presented conclusive evidence that there was no damage to any of the fabrics as a result of exposure to any of the three lubricants that was drastic enough to cause concern.

As a result of this investigation, it is believed that the degradation of

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fabrics reported to have been caused by synthetic lubricants must have been caused by either different chemicals or different conditions than the ones used in this investigation.

Table I
Strengths of Fabrics Treated with Lubricants at Room Temperature

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Original fabric no treatment given	155	145	175	170	265	245	270
	165	135	170	180	265	235	295
	175	140	170	175	260	235	295
	165	140	160	180	255	230	320
	160	135	170	170	265	230	320
Average	164	139	169	175	262	235	300
Fabric soaked in di-2-ethyl hexyl adipate room temperature, 72 hours	155	140	160	165	255	245	305
	180	135	170	165	260	260	290
	170	145	175	175	255	265	300
	165	140	170	170	255	265	305
	145	140	165	170	255	260	280
Average	163	140	168	169	256	259	296
Fabric soaked in di-2-ethyl hexyl sebacate room temperature, 72 hours	155	140	165	160	260	255	300
	165	145	160	170	255	265	305
	140	135	160	170	250	260	305
	150	140	160	165	255	265	305
	160	140	160	170	260	260	300
Average	154	140	161	167	256	261	303
Fabric soaked in MIL-L-7808 lubricant room temperature, 72 hours	165	135	165	175	255	275	295
	160	140	165	175	255	275	310
	165	140	160	170	255	270	305
	165	135	165	165	260	250	315
	145	135	165	165	255	240	305
Average	160	137	164	170	256	262	306

Note: Results reported are Mullen Burst Points

Table 2
Strengths of Fabrics Treated with Lubricants at Elevated Temperature

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Fabric subjected to 160° F. 72 hours No other treatment	160	140	165	190	255	245	295
	165	140	165	175	255	260	300
	160	135	165	170	255	260	295
	150	135	160	180	255	255	300
Average	175	135	165	175	250	250	295
	162	137	164	178	254	254	297
Fabric soaked in di-2-ethyl hexyl adipate 160° F. - 72 hours	150	135	165	165	260	245	290
	165	140	165	160	260	255	300
	150	140	160	180	255	255	285
	165	140	160	165	250	255	300
Average	165	145	160	165	260	260	300
	159	140	162	167	257	254	295
Fabric soaked in di-2-ethyl hexyl sebacate 160° F. - 72 hours	150	140	165	170	265	260	290
	155	135	160	170	255	260	295
	165	140	160	170	250	240	290
	145	140	160	165	250	255	280
Average	155	140	155	170	255	260	270
	154	139	160	169	255	255	285
Fabric soaked in MIL-L-7808 lubricant 160° F. - 72 hours	170	140	165	165	255	260	290
	160	140	160	180	250	260	300
	170	135	160	175	255	260	310
	165	140	165	170	250	265	300
Average	170	140	160	165	250	260	295
	167	139	162	171	252	261	299

Note: Results reported are Mullen Burst Points

Table 3
Strengths of Fabrics Treated with Lubricants at Room Temperature
and Dry Cleaning

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon- Viscose
Fabric dry cleaned No other treatment	165	140	165	190	255	270	300
	160	135	160	180	260	260	295
	165	135	170	180	260	260	310
	160	140	170	180	255	270	295
	<u>170</u>	<u>140</u>	<u>165</u>	<u>170</u>	<u>255</u>	<u>250</u>	<u>305</u>
Average	165	138	166	180	257	262	301
Fabric soaked in di-2-ethyl hexyl adipate room temperature, 72 hours dry cleaned	150	140	160	170	250	260	300
	165	140	165	175	250	275	310
	160	140	165	165	255	255	305
	160	145	160	170	250	255	310
	<u>160</u>	<u>135</u>	<u>165</u>	<u>165</u>	<u>255</u>	<u>265</u>	<u>310</u>
Average	159	140	163	169	252	262	307
Fabric soaked in di-2-ethyl hexyl sebacate room temperature, 72 hours dry cleaned	170	135	170	175	255	265	300
	150	140	160	165	260	270	290
	155	135	155	160	260	260	305
	155	140	160	155	255	260	310
	<u>165</u>	<u>140</u>	<u>160</u>	<u>170</u>	<u>260</u>	<u>240</u>	<u>300</u>
Average	159	138	161	165	258	259	301
Fabric soaked in MIL-L- 7808 lubricant Room temperature, 72 hours dry cleaned	170	135	155	170	260	280	300
	160	135	160	165	250	285	305
	170	135	160	185	250	260	295
	160	135	165	175	255	280	280
	<u>165</u>	<u>135</u>	<u>165</u>	<u>180</u>	<u>260</u>	<u>275</u>	<u>295</u>
Average	165	135	161	175	255	276	295

Note: Results reported are Mullen Burst Points

Table 4
Strengths of Fabrics Treated with Lubricants at Elevated Temperatures and Dry Cleaning

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon- Viscose
Fabric subjected to 160° F. 72 hours, dry cleaned	155	135	165	175	250	260	315
	160	140	165	170	250	240	310
	155	135	165	170	255	250	300
Average	160	140	160	175	255	240	305
	165	135	160	175	255	245	310
	159	137	163	173	253	247	308
Fabric soaked in di-2-ethyl hexyl adipate 160° F. - 72 hours dry cleaned	155	140	160	145	255	260	290
	145	140	155	140	255	260	305
	150	135	155	145	255	260	305
Average	155	135	160	135	255	260	300
	155	140	165	145	250	255	300
	152	138	159	142	254	259	300
Fabric soaked in di-2-ethyl hexyl sebacate 160° F. - 72 hours dry cleaned	140	135	160	160	255	255	315
	155	135	160	175	250	265	315
	160	135	160	165	255	265	305
Average	160	135	160	160	255	270	310
	150	140	160	160	250	255	300
	153	136	160	164	253	262	309
Fabric soaked in MIL-L-7808 lubricant 160° F. - 72 hours dry cleaned	155	145	160	165	250	265	315
	160	140	160	160	250	265	295
	165	135	160	170	250	275	300
Average	160	140	160	170	250	270	300
	140	140	160	155	245	240	310
	156	140	160	161	249	263	304

Note: Results reported are Mullen Burst Points

Table 5
Strengths of Fabrics Treated with Lubricants at Room Temperature and Laundering

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Fabric laundered no other treatment	160	130	165	190	255	265	290
	145	125	155	185	250	280	295
	140	120	165	180	255	275	290
	140	125	165	180	255	275	290
	140	125	165	185	260	270	300
Average	145	125	163	184	255	273	293
Fabric soaked in di-2-ethyl hexyl adipate room temperature, 72 hours laundered	140	130	160	190	255	260	300
	145	130	165	180	255	250	305
	135	135	160	195	255	250	300
	140	135	160	190	255	265	295
	150	135	165	175	255	240	300
Average	142	133	162	186	255	253	300
Fabric soaked in di-2-ethyl hexyl sebacate room temperature, 72 hours laundered	160	130	160	190	250	265	285
	140	135	165	195	250	260	280
	150	135	170	185	250	240	310
	145	135	160	170	250	260	295
	150	130	160	185	255	255	300
Average	149	133	163	185	251	256	294
Fabric soaked in MIL-L-7808 lubricant room temperature, 72 hours laundered	135	125	160	190	250	235	280
	145	125	160	170	255	260	285
	145	125	160	170	250	255	285
	125	125	160	165	245	260	315
	140	125	155	155	250	235	285
Average	138	125	159	170	250	249	290

Note: Results reported are Mullen Burst Points

Strengths of Fabrics Treated with Lubricants at Elevated Temperature and Laundering
Table 6

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon- Viscose
Fabric subjected to 160° F. 72 hours, laundered	160	130	160	200	250	265	295
	145	130	160	195	250	270	300
	150	125	165	190	255	245	280
	150	125	165	180	250	270	290
	<u>140</u>	<u>130</u>	<u>160</u>	<u>185</u>	<u>255</u>	<u>270</u>	<u>280</u>
Average	149	128	190	190	252	264	289
Fabric soaked in di-2-ethyl hexyl adipate 160° F. - 72 hours laundered	155	125	165	175	255	230	295
	160	125	165	165	255	260	295
	165	130	165	165	250	260	285
	155	130	165	155	255	250	285
	<u>150</u>	<u>130</u>	<u>165</u>	<u>165</u>	<u>255</u>	<u>255</u>	<u>295</u>
Average	157	128	165	165	254	251	291
Fabric soaked in di-2-ethyl hexyl sebacate 160° F. - 72 hours laundered	150	125	155	160	250	260	270
	135	130	160	175	235	240	275
	160	125	160	165	250	260	270
	160	125	160	170	250	270	280
	<u>155</u>	<u>125</u>	<u>160</u>	<u>175</u>	<u>250</u>	<u>260</u>	<u>270</u>
Average	152	126	159	169	247	258	273
Fabric soaked in MIL-L-7808 lubricant 160° F. - 72 hours laundered	155	125	155	185	250	235	305
	145	125	160	185	250	260	285
	155	130	160	185	250	255	295
	140	125	160	175	250	260	295
	<u>145</u>	<u>130</u>	<u>160</u>	<u>185</u>	<u>250</u>	<u>255</u>	<u>290</u>
Average	148	127	159	183	250	253	294

Note: Results reported are Mullen Burst Points