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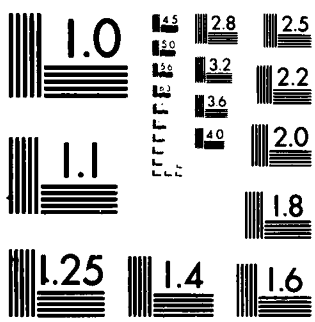

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DDC AD NO. __________
FUNDING PROJECT NO. 1L161101A91A
TECOM PROJECT (TRMS) 7-CO-IL1-AP1-001
TEST AGENCY REPORT APG-MT-5586
TEST SPONSOR US ARMY TEST AND EVALUATION COMMAND
TEST SPONSOR PROJECT NO. NOT AVAILABLE
TRADOC A.C. NOT AVAILABLE

FINAL REPORT

ILIR INVESTIGATION

OF

MIXED BRAKE FLUID CORROSION TESTS

BY

CHARLES B. JORDAN

SEPTEMBER 1981

[redacted]

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TECOM Project 7-CO-IL1-AP1-001	2. GOVT ACCESSION NO. AD-A111936	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ILIR INVESTIGATION OF MIXED BRAKE FLUID CORROSION TESTS		5. TYPE OF REPORT & PERIOD COVERED Final, January to September 1981
		6. PERFORMING ORG. REPORT NUMBER APG-MT-5586
7. AUTHOR(s) Charles B. Jordan		8. CONTRACT OR GRANT NUMBER(s) None
9. PERFORMING ORGANIZATION NAME AND ADDRESS Materiel Testing Directorate ATTN: STEAP-MT-G Aberdeen Proving Ground, MD 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS ILIR Task 001-K202
11. CONTROLLING OFFICE NAME AND ADDRESS Commander, TECOM ATTN: DRSTE-AD-M Aberdeen Proving Ground, MD 21005		12. REPORT DATE September 1981
		13. NUMBER OF PAGES 16
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) None		15. SECURITY CLASS. (of this report) [redacted]
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19. KEY WORDS (Continue on reverse si... ...essary and identify by block number)

Brake fluid
Silicone
Polyglycol
Compatibility
Corrosion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An investigation was conducted to determine the effect on corrosion properties of mixing silicone and conventional polyglycol brake fluid. More than 100 corrosion tests were conducted in accordance with procedures listed in the brake fluid specifications. It was concluded that there is some migration of corrosion inhibitors between fluids, but excessive corrosion would not result from mixing the two fluids.

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FOREWORD

This work was accomplished under the Army's In-House Laboratory Independent Research (ILIR) Program, TECOM Project No. 7-CO-IL1-AP1-001, Task 02.

Acknowledgement is extended to Mr. A. O'Brochta and Ms. R. Gibson for their assistance in the accumulation of laboratory data included in this report.

SECTION 1. INTRODUCTION

1.1 BACKGROUND

The US Army initiated research on silicone brake fluids in 1967. Satisfactory completion of a large number of laboratory and field tests (reported in ref 2 and 3) showed that the silicone fluids possessed many desirable physical and chemical properties with respect to power transmission in brake systems. Subsequently, a specification was published (ref 4) which replaced the three existing military brake fluid specifications (ref 5, 6, 7). Cost effectiveness studies showed that replacement of the three conventional brake fluids with a single all purpose fluid would be feasible. This also permitted simplification of logistics.

A retrofit procedure for implementing the use of silicone fluid (ref 8) involves a drain/bleed/fill procedure which often allows the retention of some residual conventional brake fluid in the brake system. Potential corrosion of metal brake components exists due to possible brake fluid corrosion inhibitor incompatibility. In order to resolve this possible area of concern, an in-depth study of corrosion properties of mixtures of silicone and conventional brake fluids was authorized by the Department of the Army's In-House Laboratory Independent Research Program. Results of this study will aid brake system engineers in their evaluation of the performance of the new silicone brake fluids, and establish the viability of the published retrofit procedure.

1.2 OBJECTIVE

The objective of this study was to locate possible problem areas which may arise as a result of mixing silicone and conventional brake fluids.

1.3 SUMMARY OF INVESTIGATION

More than 100 corrosion tests were conducted in accordance with procedures outlined in references 4 and 5, using combinations of four different silicone brake fluids and three representative conventional brake fluids. This report contains the results of all findings included in the study.

1.4 CONCLUSIONS

It is concluded that:

a. There will be no excessive corrosion of brake systems brought about by mixing silicone brake fluids and polyglycol brake fluids.

b. Instances of increased staining, slight etching, and weight change were found. These conditions verify that corrosion inhibitor migration sometimes occurs, but the loss in corrosion protection found in this study is not of sufficient magnitude to cause brake failure.

c. Rubber cups which were included in the test were not adversely affected. There was only a trace of sediment found in two of the test fluids.

1.5 RECOMMENDATIONS

It is recommended that:

a. The findings of this report be made readily available to members of the vehicle brake industry.

b. Mixing of fluids be minimized so that corrosion protection will be at the maximum level.

1.6 INTERPRETATION OF ACCOMPLISHMENTS

The data generated in this study substantiates the viability of military changeover from polyglycol brake fluids to silicone brake fluids. All testing accomplished by the Army to date shows conclusively that the advantages of silicone fluids are significant. There appears to be no valid technical reason to believe that silicone brake fluids will not give superior performance in military brake systems.

SECTION 2. DETAILS OF INVESTIGATION

2.1 MATERIALS TESTED

Tests reported herein were conducted on representative silicone and conventional brake fluids listed in table 2-1. Four silicone brake fluids were used representing qualified fluids from three silicone fluid manufacturers plus the SAE silicone compatibility brake fluid (SAE RM-70A). Three conventional fluids were used consisting of two fluids meeting reference 5, and the SAE conventional compatibility fluid (SAE RM 66-03).

TABLE 2-1. FLUIDS TESTED

Fluids	Type
Code A	Silicone
Code B	Silicone
Code C	Silicone
SAE RM-70A	Silicone
SAE RM 66-03	Conventional polyglycol
M9309	Conventional polyglycol
Code D	Conventional polyglycol

2.2 CORROSION TESTS

a. Corrosion tests were conducted on each of the conventional polyglycol fluids in accordance with the test procedure specified in reference 5. Corrosion tests were conducted on each silicone fluid in accordance with the test procedure specified in reference 4. Due to the immiscibility of silicone/conventional brake fluids it was necessary to develop a modified test procedure for fluid mixtures which would permit uniform exposure of the metal test specimens to each fluid. This procedure consisted of mixing equal portions of the silicone fluid and the conventional fluid with 5% water added, thoroughly shaking the mixture and placing the mixture in an oven at 100° C for 24 hours. The mixture was then shaken again and poured into a separatory funnel and allowed to separate. The separated layers were placed in separate corrosion jars. The corrosion test was then conducted on both fluids by the specified test procedure.

b. The tests which were conducted are itemized in table 2-2.

c. In each test evidence of corrosion, weight change, pH change, sediment formation, and other pertinent data were recorded. All tests were conducted in triplicate and the average of the three test results are reported herein. A comparison was made of the results received on the individual fluids and the fluids after mixing.

TABLE 2-2. TESTS CONDUCTED

Test	Fluid
A	SAE RM 66-03
B	SAE RM 70A
C	Code A
D	Code B
E	Code C
F	M9309
G	Code D
Mixture No. 1	RM 66-03/RM 70A
Mixture No. 2	RM 66-03/Code A
Mixture No. 3	RM 66-03/Code B
Mixture No. 4	RM 66-03/Code C
Mixture No. 5	M9309/RM 70A
Mixture No. 6	M9309/Code A
Mixture No. 7	M9309/Code C
Mixture No. 8	M9309/Code B
Mixture No. 9	Code D/Code C
Mixture No. 10	Code D/Code B
Mixture No. 11	Code D/Code A
Mixture No. 12	Code D/RM 70A

2.3 RESULTS

Results of all tests conducted in this program are tabulated in appendix A.

a. Effect on RM 66-03 (conventional). Results of tests on RM 66-03 showed increased staining on nearly every metal, after mixing with silicone fluids. Some etching was evident on the aluminum (1 test), cast iron (1 test), and steel (1 test) test specimens. Staining or etching was not severe in any of the tests. No pitting occurred. Weight losses increased on the brass and copper in some tests but these weight changes were not excessive.

b. Effect on M9309 (conventional). Only a very slight increase in staining was evident on any of the metals in tests involving mixtures of this fluid and the silicone fluids. Etching of the tin and aluminum was found in mixture No. 6 (M9309/Code A), along with borderline weight loss in the brass and copper. No pitting was evident.

c. Effect on Code D (conventional). This fluid showed very little change in appearance or weight in any of the tests. The only recordable changes were a slight increase in staining on the brass specimen in two tests and very slight etching of the steel and cast iron mixture No. 9 (Code D/Code C). No pitting occurred.

d. Effect on RM 70A (silicone). Except for a very slight increase in staining on some of the metals and slight etching of the cast iron in mixture No. 1 (RM 66-03/RM 70A), this fluid was not effected by mixing with conventional fluids. No significant weight changes occurred in any of the metals.

e. Effect on Code A (silicone). This fluid showed increased staining on several metals after mixing with conventional fluids. The stains were not excessive. The brass specimen in mixture No. 2 (RM 66-03/Code A) appeared to be moderately etched. There was no pitting or significant changes in weight.

f. Effect on Code B (silicone). Code B fluid showed increased, but not excessive copper staining in all tests involving mixtures of this fluid and conventional fluids. Very slight etching of steel (1 test) and cast iron (1 test) was recorded. No significant weight changes or pitting was observed,

g. Effect on Code C (silicone). Only a very slight increase in staining, and no etching, no significant weight change, or pitting was noted in any of the tests involving mixtures of Code C with conventional fluids.

2.4 ANALYSIS

a. In the military changeover from conventional brake fluids to silicone brake fluid, cost effectiveness studies showed that a retrofit procedure consisting of simply draining, bleeding, and filling the brake system was the most practical. Studies have shown that this retrofit procedure will sometimes allow retention of up to 20% residual polyglycol brake fluid in the brake system. A problem exists of potential metal corrosion in systems containing large quantities of residual fluid. Both the polyglycol and the silicone fluids have well balanced corrosion inhibitor systems built into their formulas. The fluids are immiscible when mixed; however, the possibility of migration of additives could occur, which would upset the corrosion inhibitor balance and cause corrosion.

b. The fluids for inclusion in the present study were selected as being representative of all combinations which would be found in the military vehicles after retrofit. The polyglycol brake fluids consisted of one fluid from stock (M9309), one commercial fluid known to have superior corrosion protection additives (Code D), and the SAE compatibility fluid (RM 66-03). The silicone brake fluids consisted of the three fluids now listed on the QPL for reference 4 and the SAE silicone compatibility fluid (RM 70A). The mixtures which were tested (50/50) should represent the maximum quantity of each fluid which would contribute to additive interchange. The criteria for passing/failing the corrosion tests were established in brake fluid specifications after years of study and, thus, are valid criteria for predicting excessive corrosion resulting from mixing the fluids.

c. Results of tests conducted show that there will be no excessive corrosion of metals in brake systems caused by mixing silicone brake fluids and polyglycol brake fluids. Instances of increased staining, slight etching, and weight change were found, showing that corrosion inhibitor migration sometimes occurs. The loss in corrosion protection demonstrated in this study, however, will not be sufficient to cause brake failure. There was no adverse effect on the SBR rubber cups which are included in the test. There was only a trace of sediment found in any of the test fluids after test.

APPENDIX A - TABLES

TABLE A-1. INDIVIDUAL BRAKE FLUIDS

	Conventional RM 66-03		Conventional M9309		Conventional Code D		Silicone Code A		Silicone Code B		Silicone Code C		Silicone RM 70-A	
Material	Weight Change	Appearance	Weight Change	Appearance	Weight Change	Appearance	Weight Change	Appearance	Weight Change	Appearance	Weight Change	Appearance	Weight Change	Appearance
Tin	0.00	OK	+0.02	OK	+0.01	OK	+0.02	OK	+0.01	OK	0.01	OK	0.00	OK
Steel	+ .01	OK	- .01	VSS	+ .01	SS	+ .02	OK	+ .02	OK	+ .02	OK	+ .01	OK
Aluminum	+ .01	VSS	- .003	VSS	+ .02	SS	+ .02	OK	+ .02	OK	+ .01	OK	+ .03	OK
Cast Iron	+ .08	SS	+ .10	SS	+ .04	SS	+ .03	VSE	+ .05	SS	+ .04	VSS	+ .07	SS
Brass	- .10	SS	- .09	MS	- .02	SS	+ .02	SS	+ .02	SS	+ .02	SS	- .01	MS
Copper	- .05	SS	- .14	MS	- .05	SS	+ .02	SS	+ .01	SS	+ .01	MS	+ .02	MS
pH Before	9.57		10.20		9.61		3.02		3.20		3.30		2.90	
After	8.93		7.41		7.39		5.22		5.09		4.73		4.53	

VSE = Very slight etching.
VSS = Very slight stain.
SS = Slight stain.
MS = Moderate stain.

TABLE A-2. BRAKE FLUID MIXTURES

Material	Mixture No. 1 RM 6603 - RM 70A Weight Change	Appearance	Weight Change	Appearance	Mixture No. 2 RM 6603 - Code A Weight Change	Appearance	Weight Change	Appearance	Mixture No. 3 RM 6603 - Code B Weight Change	Appearance	Weight Change	Appearance
Tin	0.00	OK	-0.01	OK	-0.01	OK	0	OK	-0.005	OK	+0.02	OK
Steel	+ .01	SS	+ .02	SS	+ .01	SS	+0.02	SS	+ .006	VSE	+ .03	VSE
Aluminum	- .02	MS	+ .01	SS	- .02	ME	- .02	SS	+ .01	VSS	+ .08	OK
Cast Iron	+ .06	SE	+ .03	SE	+ .05	SS	+ .04	SS	+ .05	VSS	+ .06	OK
Brass	- .17	MS	+ .01	SS	- .41	MS	+ .01	ME	- .11	MS	+ .02	SS
Copper	- .11	MS	+ .01	MS	- .26	SS	+ .01	MS	- .08	MS	- .003	MS
pH Before	9.26		8.06		9.42		8.09		9.59		8.25	
After	6.86		6.17		7.09		7.14		7.77		7.47	

Material	Mixture No. 4 RM 6603 - Code C Weight Change	Appearance	Weight Change	Appearance	Mixture No. 5 M 9309 - RM 70A Weight Change	Appearance	Weight Change	Appearance	Mixture No. 6 M 9309 - Code A Weight Change	Appearance	Weight Change	Appearance
Tin	+0.003	OK	+0.01	OK	+0.03	VSS	+0.01	OK	+0.01	VSE	+0.03	OK
Steel	+ .02	VSS	+ .03	VSS	- .01	VSS	+ .01	VSS	+ .002	VSS	+ .02	VSS
Aluminum	+ .004	MS	+ .06	VSS	- .01	SS	+ .02	VSS	- .01	ME	+ .04	VSS
Cast Iron	+ .06	SS	+ .04	VSS	+ .06	VSS	+ .07	VSS	+ .07	SS	+ .04	VSS
Brass	- .09	MS	+ .02	SS	- .06	MS	+ .03	VSS	- .47	SS	+ .01	SS
Copper	- .05	SS	- .02	MS	- .09	MS	+ .002	MS	- .33	VSS	- .02	MS
pH Before	9.63		8.83		9.96		7.42		9.62		7.98	
After	7.83		6.62		7.34		7.59		6.66		8.05	

Material	Mixture No. 7 M 9309 - Code C Weight Change	Appearance	Weight Change	Appearance	Mixture No. 8 M 9309 - Code B Weight Change	Appearance	Weight Change	Appearance	Mixture No. 9 Code D - Code C Weight Change	Appearance	Weight Change	Appearance
Tin	+0.02	OK	+0.03	OK	+0.03	OK	+0.04	OK	+0.01	OK	+0.01	OK
Steel	+ .004	VSS	+ .02	OK	+ .01	VSS	+ .03	OK	+ .02	VSE	+ .01	VSS
Aluminum	+ .02	VSS	+ .08	VSS	+ .02	VSS	+ .06	OK	+ .06	VSS	+ .02	VSS
Cast Iron	+ .08	SS	+ .06	VSS	+ .08	VSS	+ .08	VSS	+ .04	VSE	+ .07	VSS
Brass	- .02	MS	+ .02	SS	0	MS	+ .05	SS	+ .02	MS	- .04	SS
Copper	- .05	MS	+ .02	MS	- .09	MS	- .003	MS	+ .01	SS	- .03	MS
pH Before	10.25		8.65		10.10		8.85		9.66		7.00	
After	7.13		8.17		8.66		7.34		8.06		8.88	

Material	Mixture No. 10 Code D - Code B Weight Change	Appearance	Weight Change	Appearance	Mixture No. 11 Code D - Code A Weight Change	Appearance	Weight Change	Appearance	Mixture No. 12 Code D - RM 70A Weight Change	Appearance	Weight Change	Appearance
Tin	+0.01	OK	+0.004	OK	+0.004	OK	+0.01	OK	+0.002	OK	+0.01	OK
Steel	+ .03	VSS	+ .01	VSS	+ .03	VSS	+ .03	VSS	+ .01	VSS	+ .02	VSS
Aluminum	+ .02	OK	+ .02	VSS	+ .02	VSS	+ .05	OK	+ .03	VSS	+ .05	OK
Cast Iron	+ .05	VSS	+ .04	VSE	+ .05	VSS	+ .05	VSE	+ .05	VSS	+ .04	VSS
Brass	+ .02	MS	- .07	SS	- .12	SS	+ .03	SS	- .09	SS	+ .03	SS
Copper	- .01	SS	- .04	MS	- .07	SS	+ .01	MS	- .03	SS	- .002	MS
pH Before	9.58		8.39		9.31		6.76		9.44		7.63	
After	7.24		7.76		7.98		6.47		8.14		6.55	

VSE = Very slight etching.
SE = Slight etching.
SS = Slight stain.
VSS = Very slight stain.
MS = Moderate stain.
ME = Moderate etching.

APPENDIX B - REFERENCES

1. Authority: TECOM Task No. 7-CO-IL1-AP1-001, Agency Accession No. DA OM 1499, ILIR Work Unit 001 K2 02.

2. MERDC Report No. 2137, Silicone Brake Fluids: One Year Field Test, February 1975 (AD AO 12849).

3. MERADCOM Report No. 2164, Silicone Brake Fluids: Two Year Field Test, January 1976 (AD OZ 6180).

4. Military Specification, MIL-B-46176, Brake Fluid Silicone, Automotive, All-Weather, Operational and Preservative.

5. Federal Specification, VV-B-680, Brake Fluid Automotive.

6. Military Specification, MIL-H-13910, Hydraulic Fluid, Polar Type, Automotive Brake, All Weather.

7. Military Specification, MIL-P-46046, Preservative Fluid, Automotive Brake System and Components.

8. Technical Bulletin TB 43-0002-87, April 1981, Brake Fluid Silicone - Conversion of Tank - Automotive Equipment.

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