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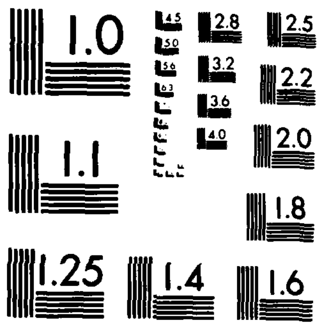
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REPORT NUMBER 83-34

M113 NEW VS. OVERHAUL

U.S. ARMY

Systems and Cost Analysis Directorate

TACOM

NOVEMBER 1984

DOUGLAS J. HACKENBRUCH

TACOM

SYSTEMS ANALYSIS DIVISION

U.S. ARMY TANK AUTOMOTIVE COMMAND

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER 83-34	2. GOVT ACCESSION NO. A149 127 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) M113 New vs. Overhaul	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Douglas Hackenbruch	8. CONTRACT OR GRANT NUMBER(s) None
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Tank-Automotive Command Systems and Cost Analysis Directorate (AMSTA-V) Warren, MI 48090	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE November 1984
	13. NUMBER OF PAGES 128
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

reliability, statistical analysis, M113, armored personnel carrier, SDC, data analysis, Multi-vari Methodology, linear regression, analysis of variance

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

The sample data collection on M113 FOV for 5 bases for 4 quarters in 1982 was analyzed to determine that depot processed vehicles are as reliable as new vehicles. Data base biases of period miles, vehicle age, base effect, vehicle type and others here removed by Multi-vari Methodology. Cost drivers and maintenance practices were evaluated.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ACKNOWLEDGEMENTS

This study was a group effort within the System and Cost Analysis Directorate. Lee Dowd who completed the sister report M60 New vs. Overhaul worked hand-in-hand with this effort. Arnold Solomon and Sam Tam contributed significant guidance on the statistical analysis procedures used herein. Albert Van Horn is to be especially commended for his efforts at researching, modernizing, and applying this reports main statistical analysis procedure, the Multi-vari methodology, without which no valid conclusions could be drawn.

The bulk of the work, sorting, correcting, organizing and manipulating the 68,000 M113 SDC records was successfully accomplished by two very bright and diligent co-op students, Mary Dimercurio and Laura Lamparski. These two spent countless hours at the computer terminals and in the process of compiled volumes of original and innovative software used to explore and manipulate the data base. They were told when they were hired that they were to do all the work and get none of the credit. Hopefully, this will compensate for some of that.

Lastly, the report typist, Karen Smith, is to be given many thanks for completing this report without the use of a text editor.

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NEW VS. OVERHAUL M113 FOV

OBJECTIVES

1. Determine the reliability performance differences of depot processed and non-depot processed (new) M113 FOV in a field environment.

2. Determine the effect of the depot process on the reliability of the M113 FOV.

3. Identify a methodology that will provide field data to evaluate changes in depot practices.

4. Provide guidance to a subsequent analysis (termed Phase II New vs. Overhaul) that will investiage depot processes to further enhance object 2 above.

INTRODUCTION

DARCOM was tasked by DA, on 26 July 1983 to determine the opt ial point of cost versus reliability performance for depot programs. The M6 was the initial targeted effort. DARCOM tasked AMSAA on 12 August to do a multiple study to include the M113 FOV. Systems and Cost Analysis partic pated in these planning meetings and was tasked by AMSAA in February 1984 to conduct this study on the M113 FOV.

The original objective of the DA tasking could not be addres d. That is, the optimal funding level to invest in the depot processing to minimize life cycle costs, could not be answered. Records on depot c anges to individual vehicles processed through the depot and a field bac loop of reliability performance on these vehicles does not exist.

The question of how well the depot processed vehicles are doing i relation to new vehicles can be answered on a fleet basis. Cost drivers can also be identified. This report can then be used as an aid for a Phase II investigation in which the depot effects can be addressed in answ r to the original DA objective.

SUMMARY ND MAJOR CONCLUSIONS

There are two data bases use for this study. Initial Rebui 1 Test (IRT) anc Initial Production Tests (I T) at either Aberdeen Proving round (APG) or 'uma Proving Ground (YPG) is ne source of data. The other the Sample Dat Collection on M113 Family of Vehicles (FOV) from 17 Nov ber 1981 to 30 ovember 1982.

The test site data analysis shows that depot processed vel cles are as re able as non-depot processed vehicles.* It also shows tha the M113A2 ha better reliability performanc than the M113A1. This data is tatistically lir ted in that these conclusions are not statistically significar .

The SDC M113 data base anal sis reflected the same conclus ns, however the conclusion of both depot and on-depot vehicles having the san reliability pe ormance is statistically si nificant. The A2 versions, hc ever do not pe orm that much better than the 1 version to be statistically s pportable.

The M113 SDC data base pro ed to have several flaws. Th se are: (1) The data had 17.5% of the un cheduled maintenance incidents reported as inc pendent when the parts were, n fact, replaced in the process of repairing the independent part. (2) Th data base is totally unscore . That is, the e parts that failed due to driver/operator error and/or a ident could not be filtered out. (3) The ata contained a small percentag of mismatch (p t number, NSN or nomenclatu) that required correction. ( ) The data co ection and reporting proce ures showed indications of ir onsistencies fr the five different bases nvolved. (5) The data has rong biases th are unbalanced or not in pendent among vehicle type, se location or epot effect.

In spite of the above, it i felt that the conclusions dra herein are va d. Those that are not statis ically supporatable are caviatec as requiring ve fication in Phase II analysis

Since the M113 SDC data ba was not balanced (i.e., less than exact) fr biasing effects, an historic l data analysis technique (Multi vari method) wa upgraded with current stati tical methodology and used to dentify and rer ve these biasing effects. n untreated data analysis sh s that the de t vehicles were performing regard to reliability signifi ntly better th non-depot vehicles. Howe r, the Multi-vari methodology successfully rer ved the biasing effects and r sulted in the above conclusion.

*A lepot vehicle is a vehicle t at has been processed by a dep . This can be rebuilt, overhauled through n inspect and repair process. A non-depot vel cle is one that has some les accumulated but has no be n through a de t process.

The M113 SDC data was analyzed to see if the year that the vehicle was processed through the depot had a significant effect on vehicle field reliability. This is of special interest since the depot process went from complete overhaul thru an Inspect and Repair process. Also of interest would be the effect of various depots on field reliability and how many times the vehicle went through a depot process. These were not possible due to the lack of definition within the SDC data base.

The year of depot processing has no significant impact on reliability performance. This is significant since the depot process changed from complete overhaul through an I&R process with no degradation in reliability performance.

The effect of both frequency and thoroughness of the scheduled quarterly service was assessed. It has no significant impact for non-depot vehicles but as vehicles age after going through one or more depot processes, it becomes an important effect on vehicle reliability.

Subsystem reliability of depot and non-depot vehicles are statistically the same except for three systems, fuel, track, and springs/shocks. A significantly higher number of fuel and track failures were present for the depot vehicles. No explanation of why is evident from the data. Depot replaced springs/shocks are performing better than new.

Cost drivers were identified that were either high dollar items or high volume items (high labor cost). The cost driver items were periscopes and telescopes and power train components from engine thru track pads. A few nuts and screws and washers were identified as cost drivers. This is due to the fact that a disproportionate labor cost was associated with the replacement of these parts. A listing by cost is enclosed in Appendix C.

Object 3 was deferred to Phase II because this phase with its planned in-depth analysis of depot practices will have a better understanding of measuring impact of depot process changes on field reliability.

Several measures of vehicle reliability performance were used: A MMBI (Mean Mile Between Failure Incident) with and without dependent incidents and a MMBFF (Mean Miles Between Actual Vehicle Failures). This latter measure removed the random start and random finish nature of the M113 SDC data.

An attempt on a first failure analysis was performed. This analysis would be of interest in evaluating depot processed components against new components. As the vehicles fail and get repaired in the field, they tend to become homogeneous, that is lose their depot/non-depot identity. This analysis was not possible.

Thirty-nine detailed conclusions are present in the detailed conclusion section. These are followed by recommendations to improve the validity and utility of the data collection process.

The SDC unscheduled maintenance data was grouped into Federal Group Classification (FGC) and data analyzed to see if there were any significant differences in major component reliability performance.

An attempt was made to address the question of maintenance ratio between depot and non-depot vehicles. It was concluded that the manhour charges against particular parts were not consistent with base to base or part to same part to draw valid conclusions. In fact, the way of recording manhour charges to each and every part replaced including fasteners was questioned as to its validity.

Detailed description of the above areas of investigation are contained within the appropriate section within this report with supporting data contained in the appendicies.

DATA ANALYSIS METHODOLOGY

The data for this analysis comes from two sources. The APG/YUMA test results on Initial Rebuild Test (IRT) or Initial Production Tests (IPT) for new vehicles and from Sample Data Collection (SDC) for four quarters on a fleet of 408 vehicles at five bases. Each data source was analyzed separately because of their incompatibility.

The main analysis in this report was done using the M113 SDC data base which contained over 68,000 records. The M113 SDC reporting procedure mixed independent (actual failed parts) failures and dependent (parts replaced to get at the independent failed part) failure. An elaborate analysis isolated and identified these parts. In addition, an analysis was performed to see if the failure incident reporting procedures were consistent at each base. Indications are that they were not.

Data required to support the analysis was extracted from the M113 SDC records, blocked into various formats reflecting vehicle depot effect, base location and vehicle type. A two and three way Analysis of Variance (ANOVA) was attempted to determine these effects. However, vehicle age and how many miles the vehicles were driven during the SDC reporting period (termed period miles) and possibly other effects displayed strong biasing effects in the unmodified data. No valid conclusions could be drawn from this analysis.

A Multi-vari technique (an older statistical technique useful for unstructured data analysis) was resurrected and up-dated using modern statistical package techniques to perform the required analysis on the M113 SDC data. Biasing effects from unbalancing and dependent results were systematically measured and removed.

Test Site Results

The test on new or depot vehicles that were run at APG or YPG from 1963 to 1980 are shown in Table 1. This table does not include all M113 FOV testing completed at these sites. It includes only the new production vehicles and/or vehicles that were processed at Red River Army Depot (RRAD). The history of each RRAD vehicle is unknown as well as what exactly was done to the vehicle to process it through the depot. Thus no measure of depot effect is possible.

Table 1 shows two RAM performance measures, a measured mean miles between failure for mission failures and a mean miles between unscheduled maintenance actions. An unscheduled maintenance action is any incident that requires corrective action. It does not necessarily cause vehicle downtime from inability to commence operation, by degradation of performance or safety related incident. This measure is approximately equivalent to the MMBI measure used in the SDC data analysis in this report.

Graphs of these two performance measures shown in Figures TS1-4 indicate interesting trends. The depot vehicles have maintained an increasing MMBF mission over time (Figure TS1) with one exception, the 1980 test of one M113A2, as well as an increasing MMBUMA (Figure TS2). It should be noted that because of the low numbers of mission failures in each MMBF data point, a statistical confidence band for each mean shown would be large. Thus the true mean of the MMBF measure could be quite different than the sample MMBF shown in the graph. For this reason, the MMBUMA would be a more significant RAM performance measure. It has substantially more actions charged against the system although its measure of variability is still large.

The MMBUMA RAM performance measure on new M113 vehicles (Figure TS3) shows that the vehicles have been performing fairly constantly over time within the variability limits on the means. The possible exception is the one M113A2 test in 1980 which shows an improvement.

The MMBUMA for the depot vehicles (Figure TS2) shows an increasing mean over time up to the same approximate level shown in Figure TS4 for the new vehicles. The one M113A2 depot vehicle shows the same MMBUMA level of RAM performance as the new M113A2.

These graphs tend to show that in the 1979-1980 era, the depot vehicles perform as well as the new vehicles in Initial Production Tests (IPT) or Rebuild Verification Tests (RVT) or their equivalent at YPG or APG. It should be noted that this trend observation cannot be substantiated by statistical significance testing due to a large variability in the data and/or a low number of observations.

TEST VEH	TEST ERA	TEST MILES	QTY VEH	TEST TYPE	MMBF MISSION	MMBUMA	MTTR HRS	MPH AVG
M113A1	63-70	4000	5	ALL	1007	142	-	-
M113A1	75-76	3300	1	IRT	1101	66	1.79	28.6
M113A1	76	2190	4	OT	1688	151	.76	-
M113A1	77-78	6291	4	IPT	1678	123	1.17	22.6
M113A1	77	6576	4	PIT	1461	116	.93	-
M113A1	78	5022	2	IRT	1674	79	1.00	21.9
M113A1	78	5928	2	PIT	2371	104	-	20.6
M113A1	78-79	2068	2	ICT	4137	109	.96	18.8
M113A1	79-80	2088	1	RVT	2088+	131	.99	17.9
M113A2	80	3883	1	IRT	1942	100	-	-
M113A2	80	5888	1	TFT	5888	235	-	-
M113A2	80	2011	1	RVT	1006	223	.67	19.9
M548	79	2061	1	ICT	1031	74	.50	16.2
M548	79-80	6233	2	PIT	1385	129	-	-
M548	80	6199	1	PIT	775	83	-	-
M577A2	79	4587	2	TFT	2293	92	1.23	16.5

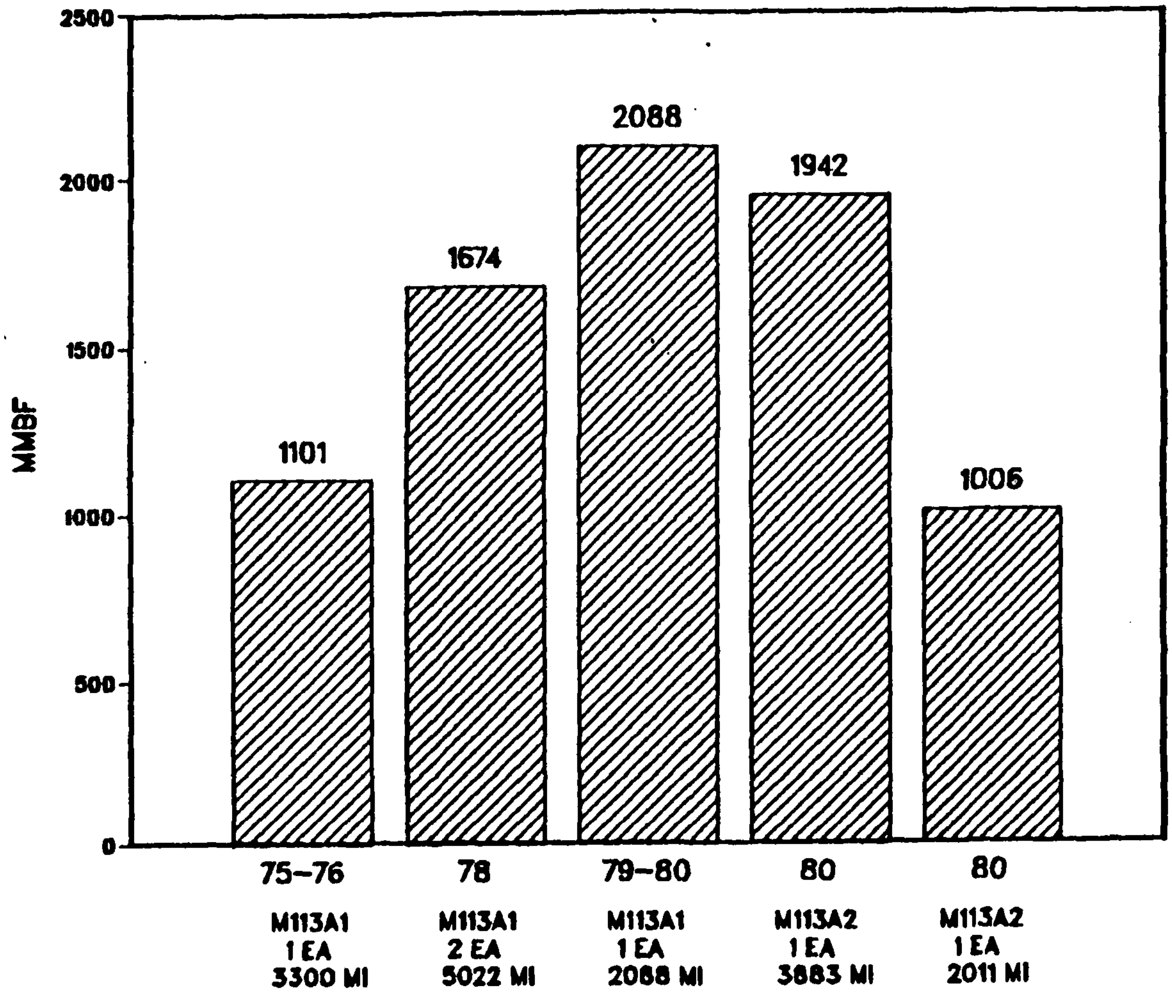
LISTING DOES NOT INCLUDE M113A1E1 AND OTHER VEHICLES THAT WERE NOT NEW OR DEPOT.

IRT = Initial Rebuild RRAD
OT = Operational Test
IPT = Initial Production Test
PIT = Production Improvement Test
RVT = Rebuild Verification Test RRAD
TFT = Tech Feasibility Test
MMBF = Mean Time Between Failure
MMBUMA = Mean Time Between Maintenance Action.

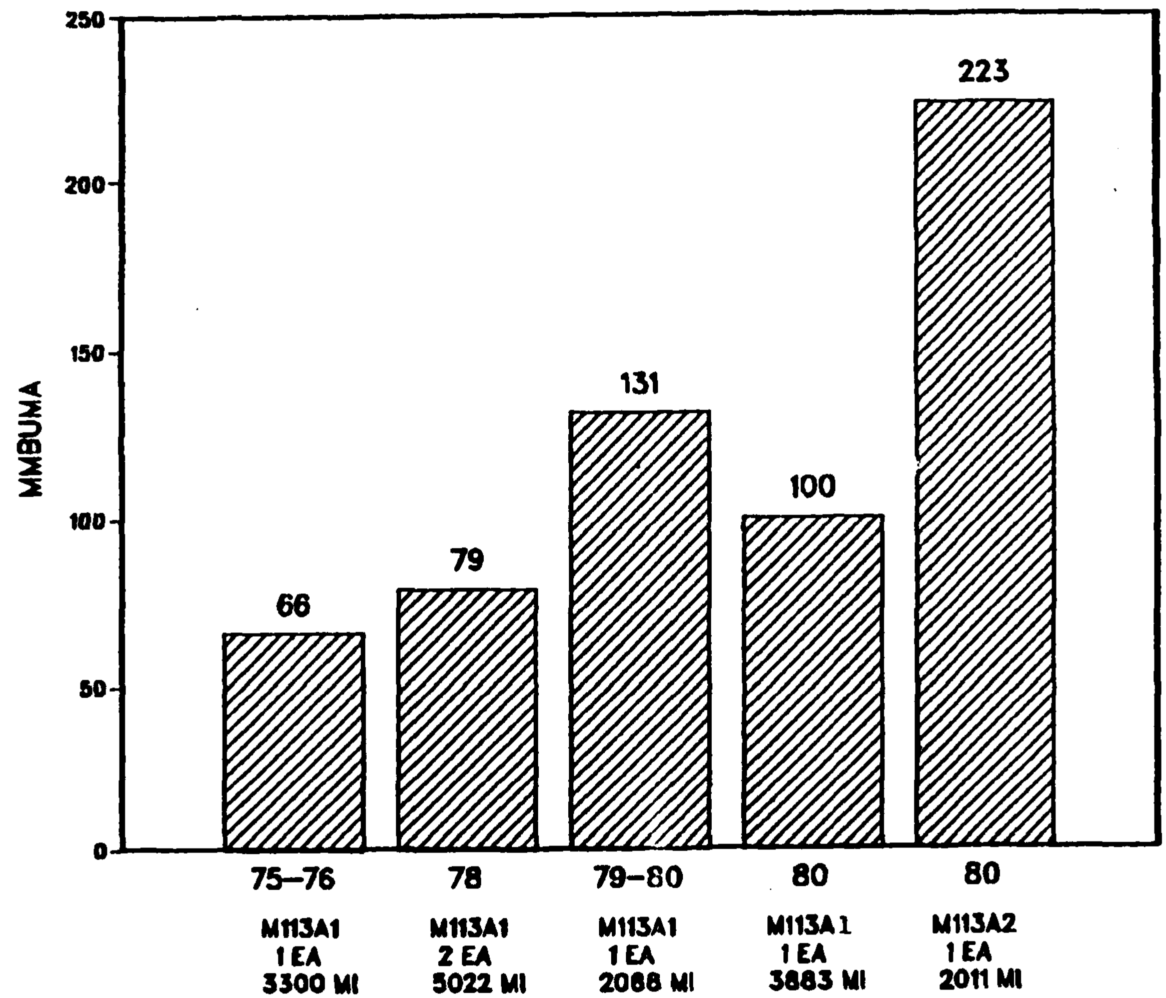
Summary of new or depot M113 FOV tests at APG or YUMA from 1963 to 1980.

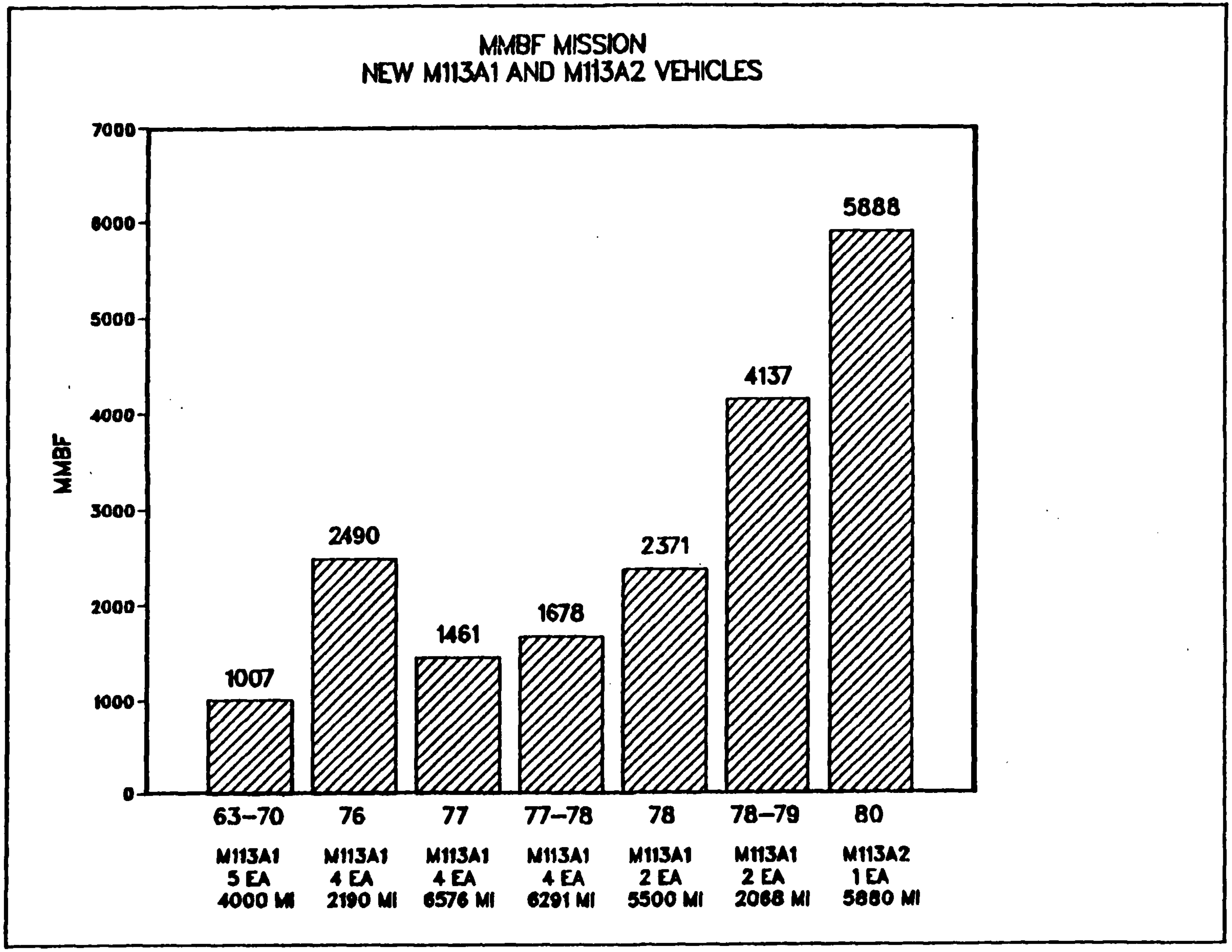
TABLE 1

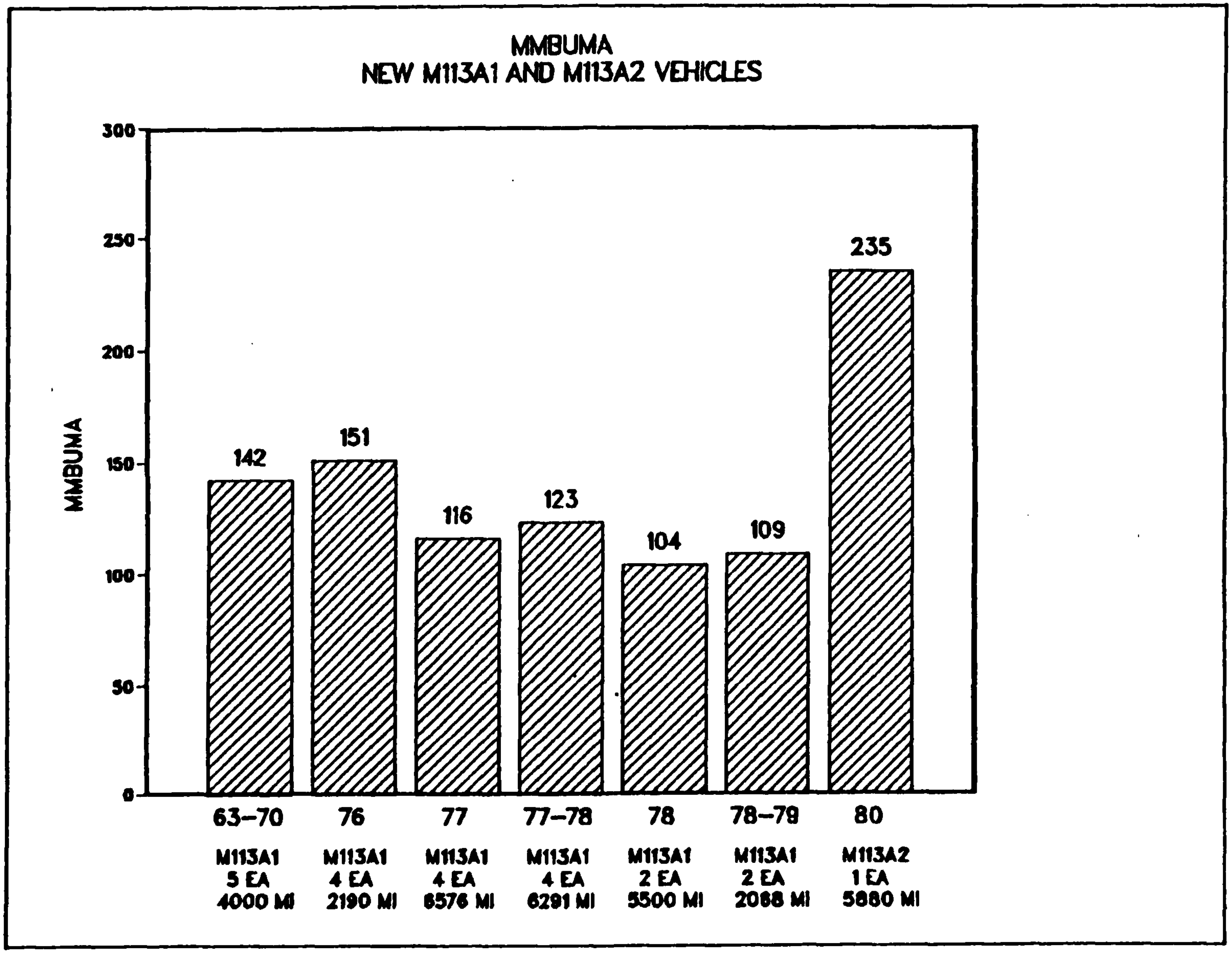
MMBF MISSION
M113A1 AND M113A2 DEPOT VEHICLES



MMBUMA
M113A1 AND M113A2 DEPOT VEHICLES




MMBF MISSION
NEW M113A1 AND M113A2 VEHICLES
MMBF
7000
6000
5000
4000
3000
2000
1000
0
1007
2490
1461
1678
2371
4137
5888
63–70
76
77
77–78
78
78–79
80
M113A1 5 EA 4000 MI
M113A1 4 EA 2190 MI
M113A1 4 EA 6576 MI
M113A1 4 EA 6291 MI
M113A1 2 EA 5500 MI
M113A1 2 EA 2068 MI
M113A2 1 EA 5880 MI


MMBUMA
NEW M113A1 AND M113A2 VEHICLES
MMBUMA
300
250
200
150
100
50
0
142
151
116
123
104
109
235
63–70
76
77
77–78
78
78–79
80
M113A1 5 EA 4000 MI
M113A1 4 EA 2190 MI
M113A1 4 EA 6576 MI
M113A1 4 EA 6291 MI
M113A1 2 EA 5500 MI
M113A1 2 EA 2088 MI
M113A2 1 EA 5880 MI

M113 SDC DATA BASE DESCRIPTION

The M113 SDC DAta Base consists of 68,127 records as shown in the following tabulation. Each record contains space for 450 alpha numeric digits for a total of 30,657,150 digits, each one-hand entered. Fortunately, most of them are zero or blank. The 68,127 records are broken out as follows:

Code	Type of Record	Count
A1	Historic Reports	2188
A2		0
B1	Unscheduled and Scheduled	17280
B2	Independent Maintenance	17280
B3	Incidents	17280
C1	Supplementary Dependent	12061
C2	Maintenance Incidents	0
D	Quarterly Reports	2038
E1	Narrative Reports	0
E2		0
F		0
Total		68,127

The M113 sample data collection started and ended at five locations in accordance with the following tabulations:

Start Date	Base Description	End Date
17 Nov 81	Support Co of the 1/2 Inf Bn, A and B Co of 1/28 Inf Bn, 1 Inf Div (Mech) at Ft. Riley, KS	30 Nov 82
20 Nov 81	2/19 Inf Bn, 24 Inf Div (Mech) at Ft. Stewart, GA	30 Nov 82
3 Dec 81	1/7 Inf Bn, 31D, VII CORPS, Aschaffenburg USAREUR	30 Nov 82
5 Dec 81	2/13 Inf Bn, 81D, V COPRS Mannhein USAREUR	30 Nov 82
5 Jan 81	2/7 Cav, 1st Cav Div, Ft. Hood, TX	30 Nov 82

Nine types of M113 family of vehicles (FOV) were reported in accordance with the following tabulation:

NSN	MODEL	NOMENCLATURE
2350-00-968-6321	M113A1	Carrier, Personnel, Full tracked, Armor
2350-00-068-4077	M113A2	Carrier, Personnel, Full tracked, Armor
2350-00-056-6808	M577A1	Carrier, Command Post, Light, Tracked
2350-01-068-4089	M577A2	Carrier, Command Post, Light, Tracked
2350-00-076-9002	M106A1	Carrier, Mortor 107mm, Self-propelled
2350-00-069-6931	M106A2	Carrier, Mortor 107mm, Self-propelled
2350-00-071-0732	M125A1	Carrier, Mortor 81mm, Self-propelled
2350-01-068-4087	M125A2	Carrier, Mortor 81mm, Self-propelled
2350-01-045-1123	M901	Combat Vehicle, Anti-tank, improved

A total of 408 (164 non-depot and 244 depot) vehicles were under the M113 SDC plan in accordance with the following base distribution:

Vehicle Type		Ft. Riley	Ft. Stewart	As-chaff	Mann-heim	Ft. Hood	Totals
M113A1	Depot	28	17	16	17	43	121
	Non depot	7	6	8	4	12	37
M113A2	Depot	1	5	25	36	2	69
	Non depot	0	31	14	0	0	45
M577A1	Depot	0	1	0	0	2	3
	Non depot	1	0	0	0	4	5
M577A2	Depot	0	0	0	7	0	7
	Non depot	0	5	8	0	0	13
M106A1	Depot	0	0	4	2	0	6
	Non depot	3	1	0	1	0	5
M106A2	Depot	2	4	0	2	4	12
	Non depot	0	0	0	0	0	0
M125A1	Depot	0	2	6	8	9	25
	Non depot	5	7	3	1	0	16
M125A2	Depot	0	0	1	0	0	1
	Non depot	0	0	0	0	0	0
M901	Non depot	0	0	21	22	0	43
Totals	Depot	31	29	50	72	60	244
	Non depot	16	50	54	28	16	164

The 17,280 B records and 12,061 C records are broken out as follows:

	B Records	C Records
Q-Service	1,241	-
O-S	4,576	-
Lub	1,070	6,446
Remainder	10,393	5,515
	17,280	12,061

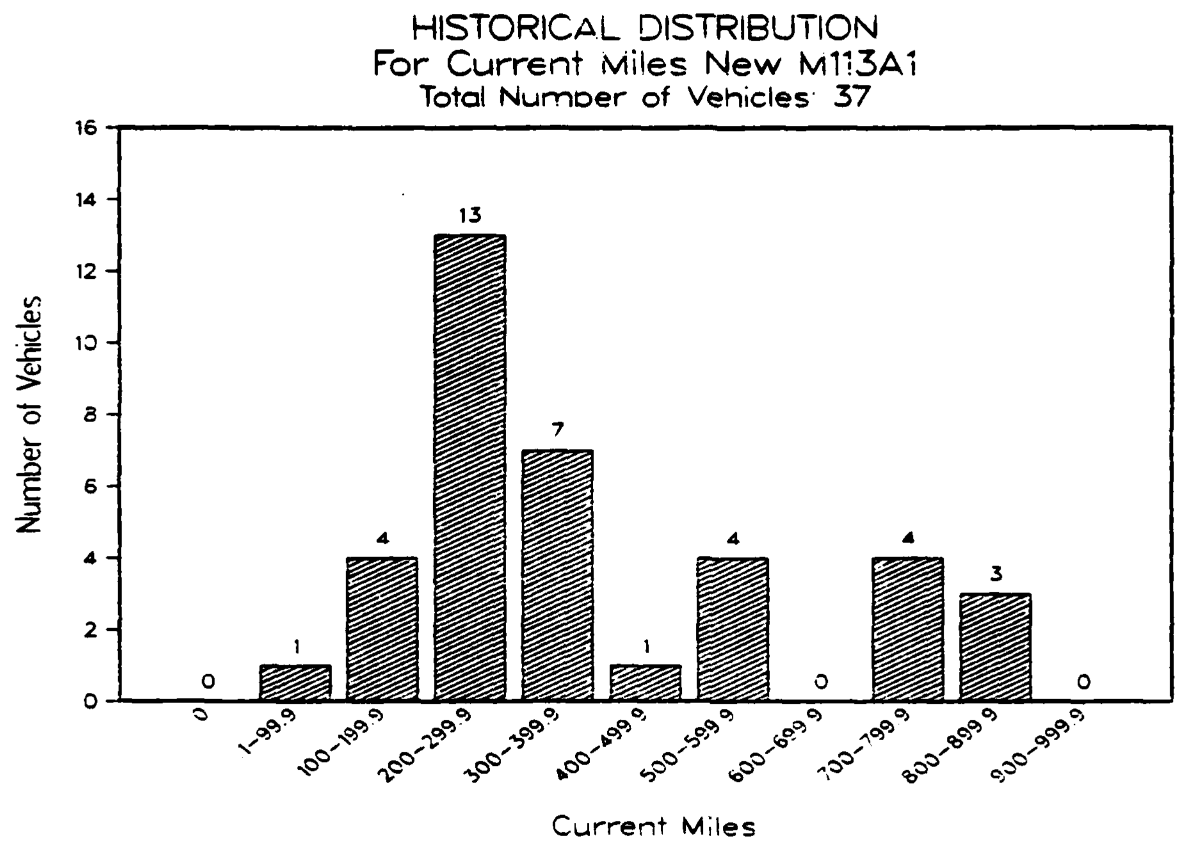
The Q-service records are quarterly service that is scheduled to be performed on a 3-month basis. They are not always performed or not always reported.

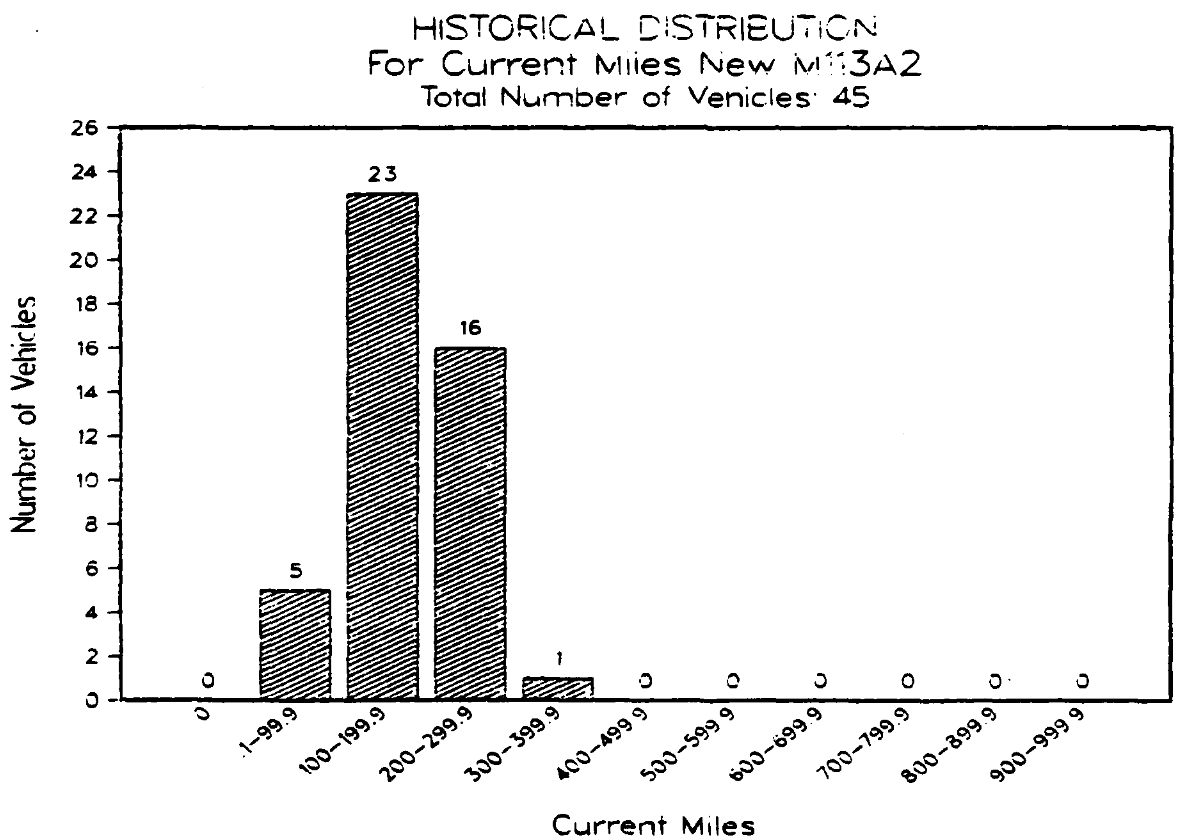
The O-S records are inspection procedures on the engine, transmission and final drive that are scheduled to be performed on a monthly basis. They are not always performed or not always reported.

The lub files contain all records on replacement lubricating oils (all types), greases (all types), filters (all types), and antifreeze (scheduled and unscheduled).

The remainder contains records of parts receiving some maintenance action either unscheduled or scheduled, independent or dependent, and replaced or serviced.

The historical distribution of odometer miles on the 408 vehicles at entry into the M113 SDC program are shown in Figures DB 1 thru DB 9. Within these graphs, "New" should read "non-depot" and "Rebuild" should read "depot vehicles". The observation can be made from these graphs that the M113A1 is the only vehicle with a reasonable distribution of starting miles for depot and non-depot vehicles. Another observation is that from a statistical point of reference, these vehicles all have a random starting point (and a random finish) as opposed to the more desirable uniform starting miles. Unlike most SDC data bases, there are no vehicles that have a lifetime data record.


HISTORICAL DISTRIBUTION
For Current Miles New M113A1
Total Number of Vehicles: 37
Number of Vehicles
16
14
12
10
8
6
4
2
0
13
7
4
4
4
3
1
1
0
0
0
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9
Current Miles


HISTORICAL DISTRIBUTION
For Current Miles New M113A2
Total Number of Vehicles: 45
Number of Vehicles
26
24
22
20
18
16
14
12
10
8
6
4
2
0
23
16
5
1
0
0
0
0
0
0
0
0
1-99.9
100-199.9
200-299.9
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400-499.9
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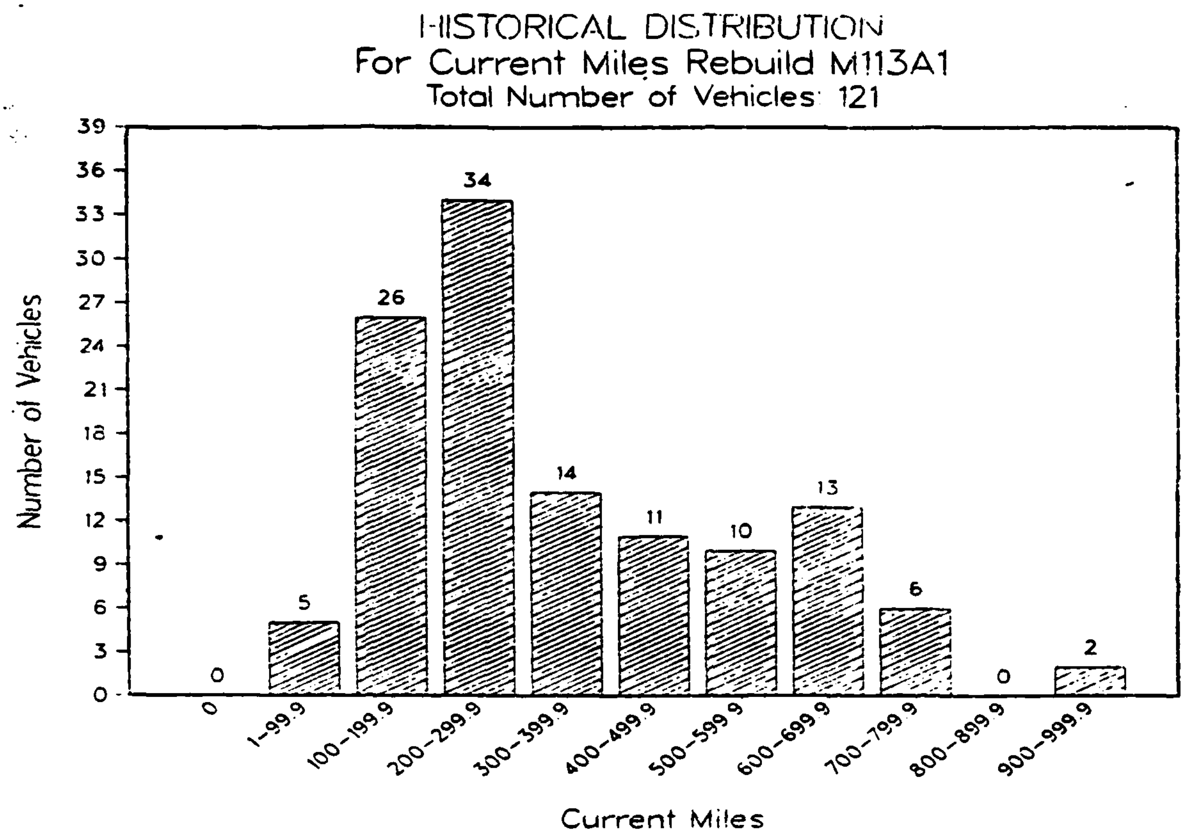
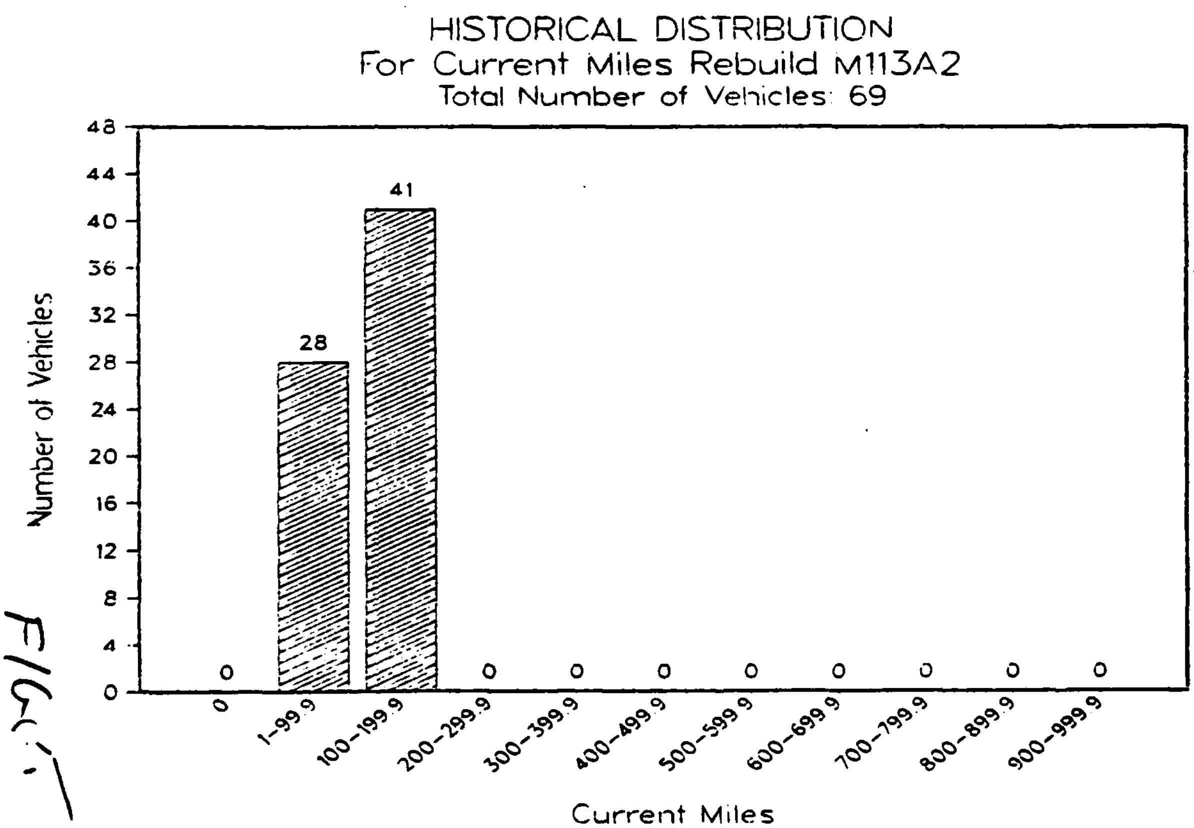
600-699.9
700-799.9
800-899.9
900-999.9
Current Miles

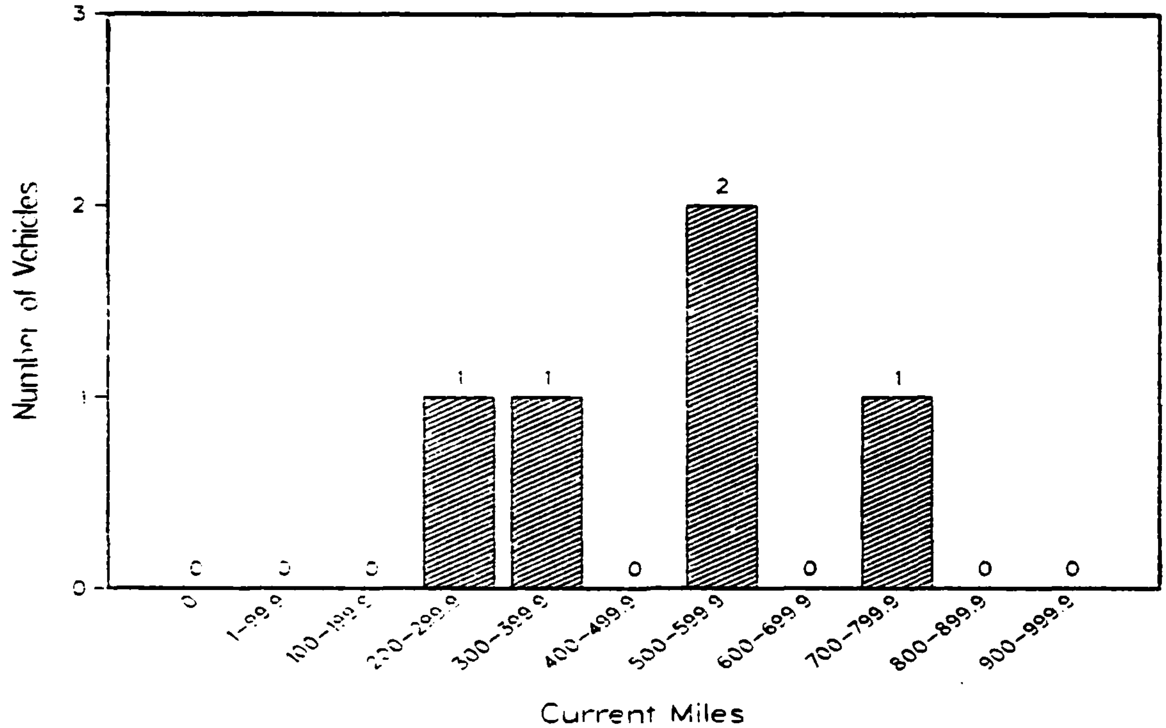




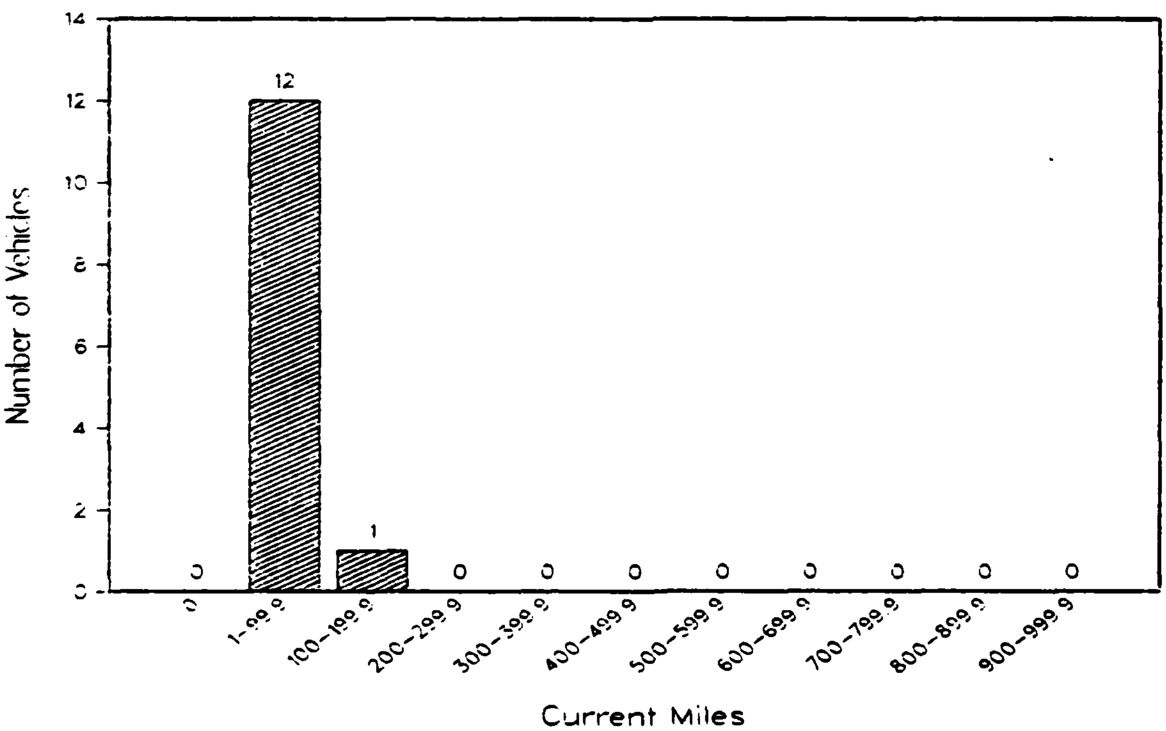
VEHICLE CONDITION AT START OF SDC

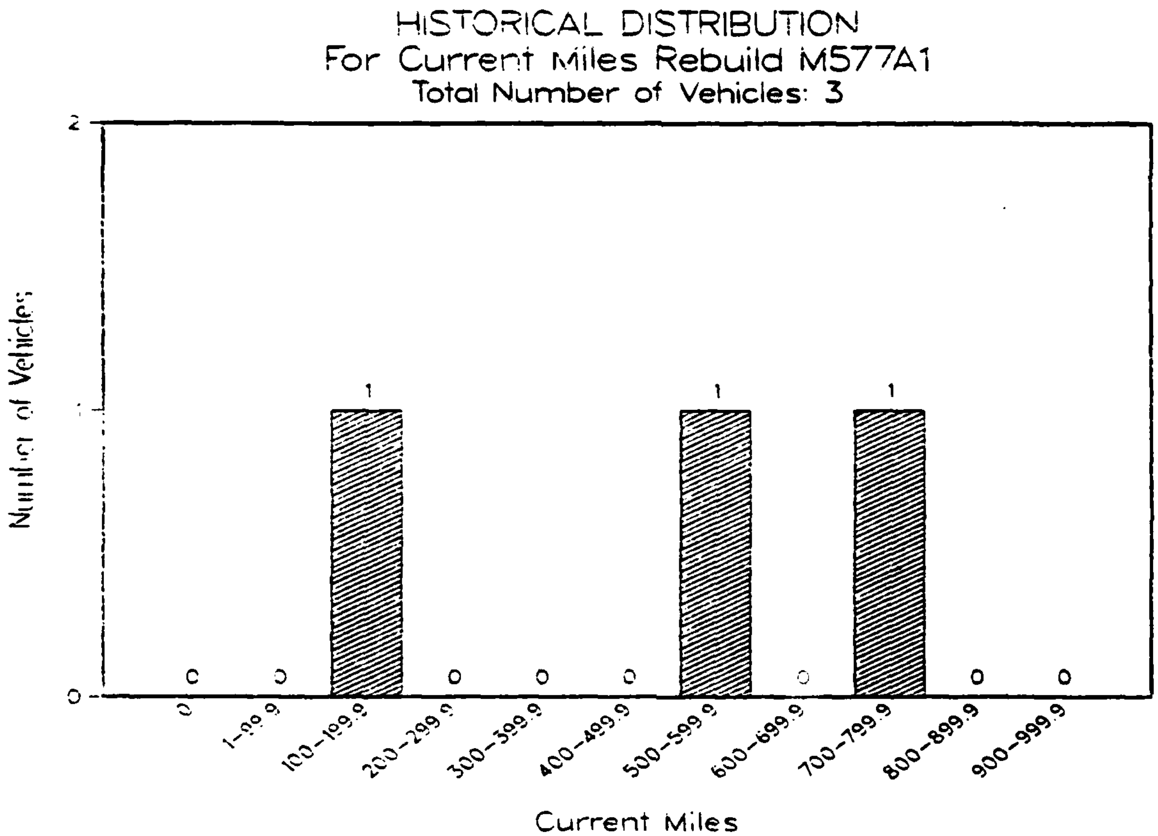
FIG 1

HISTORICAL DISTRIBUTION
For Current Miles New M577A1
Total Number of Vehicles: 5

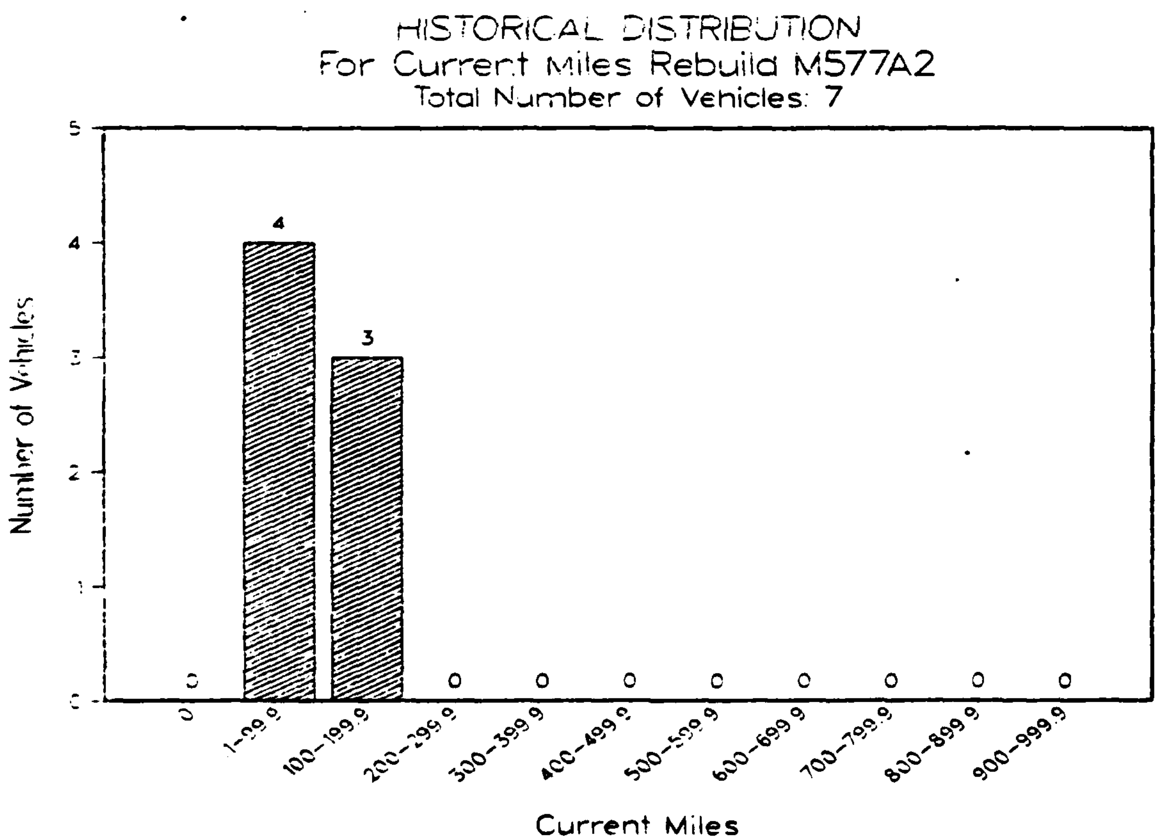


HISTORICAL DISTRIBUTION
For Current Miles New M577A2
Total Number of Vehicles: 13



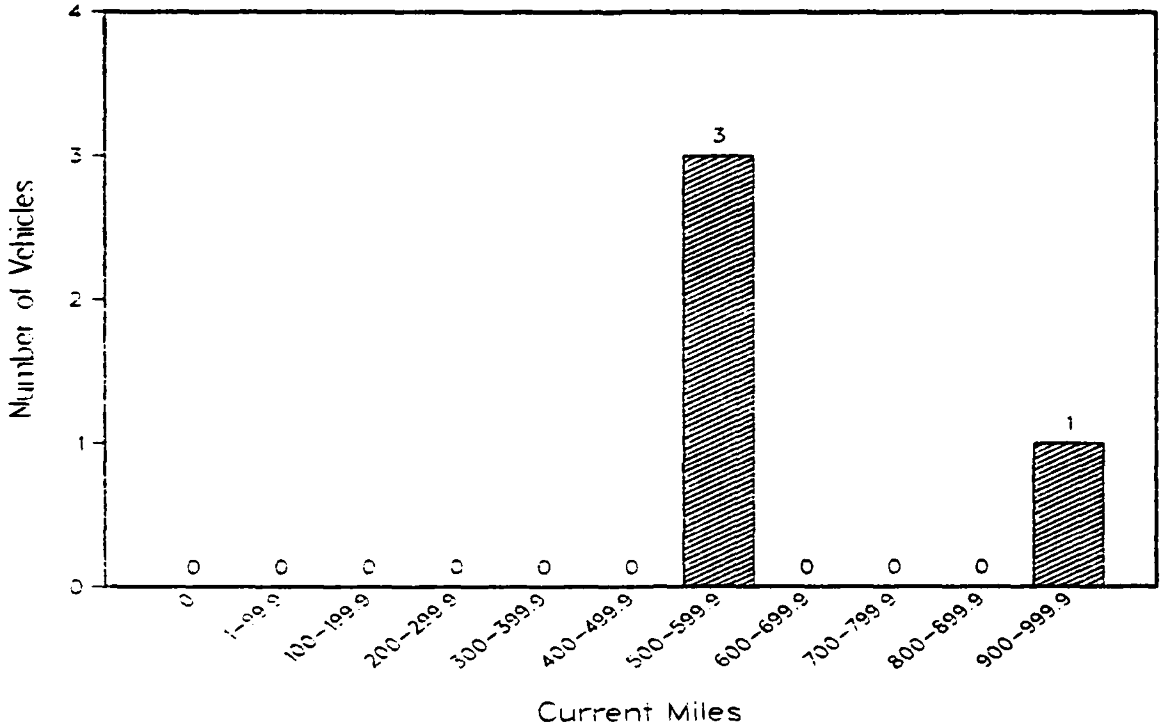


HISTORICAL DISTRIBUTION
For Current Miles Rebuild M577A1
Total Number of Vehicles: 3
Number of Vehicles
Current Miles
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9

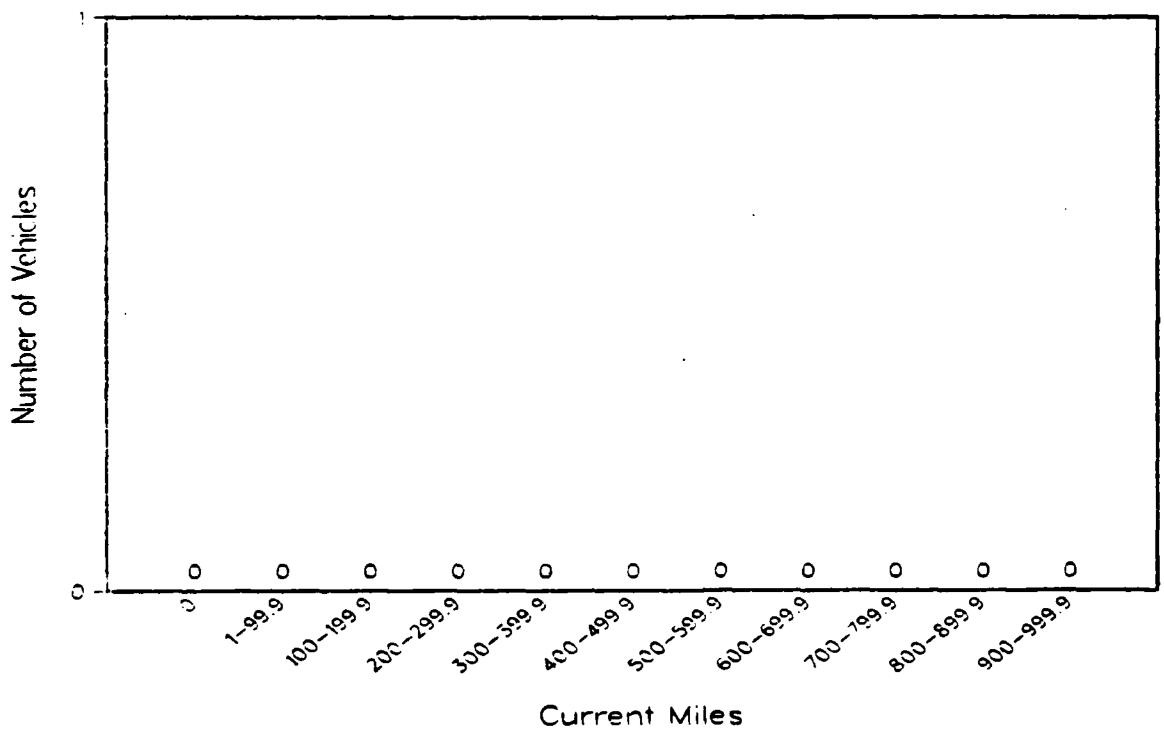


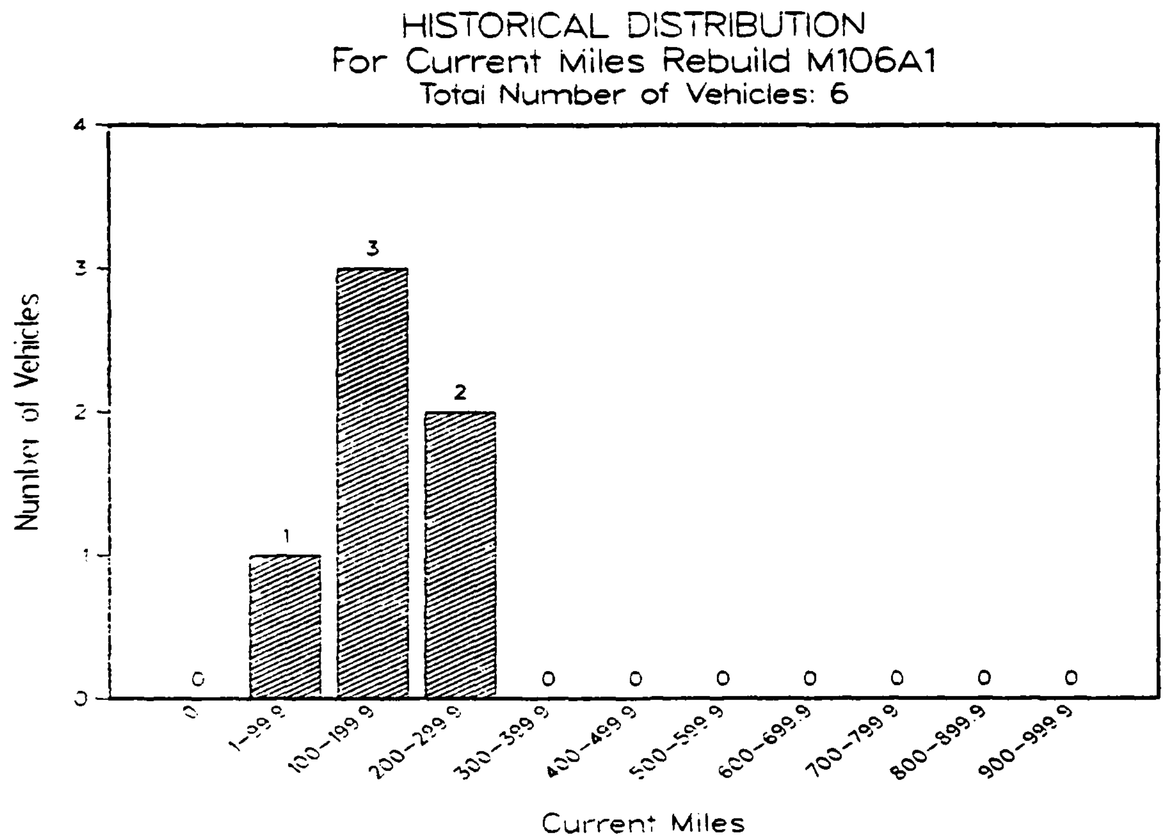
HISTORICAL DISTRIBUTION
For Current Miles Rebuild M577A2
Total Number of Vehicles: 7
Number of Vehicles
Current Miles
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9

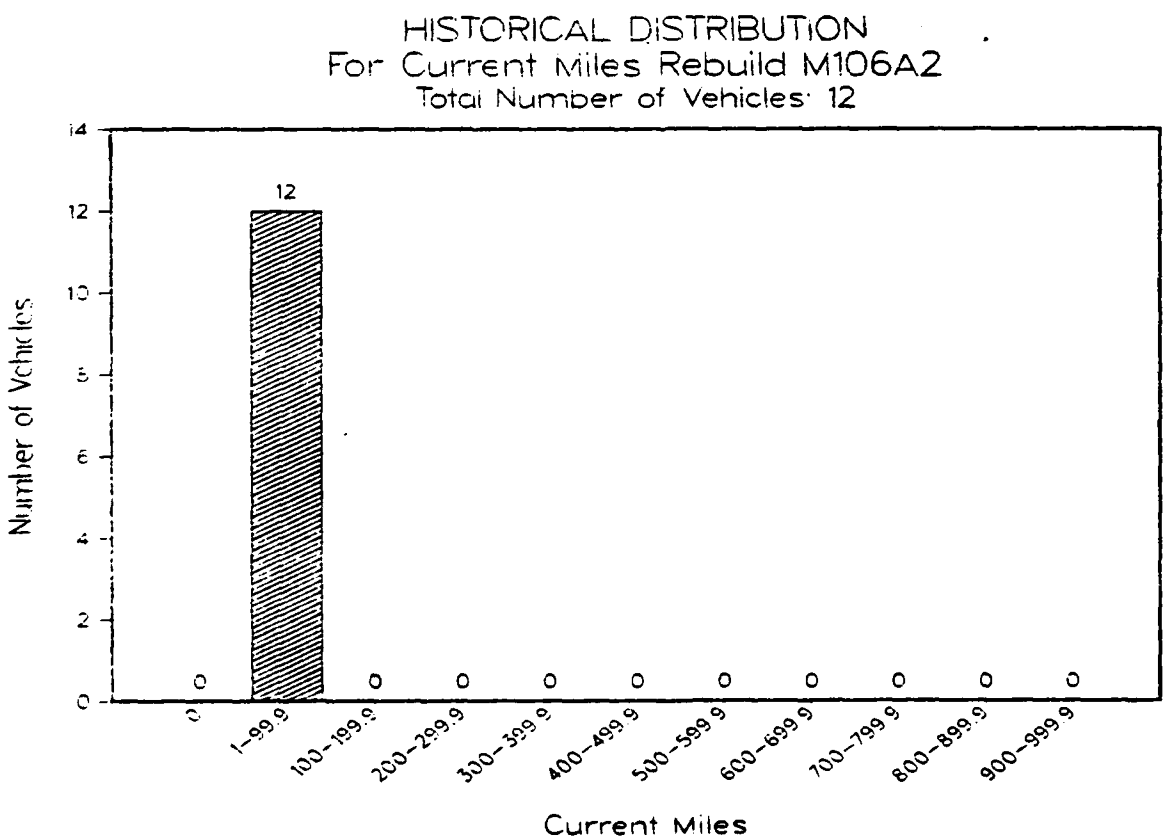
HISTORICAL DISTRIBUTION
For Current Miles New M106A1
Total Number of Vehicles: 5



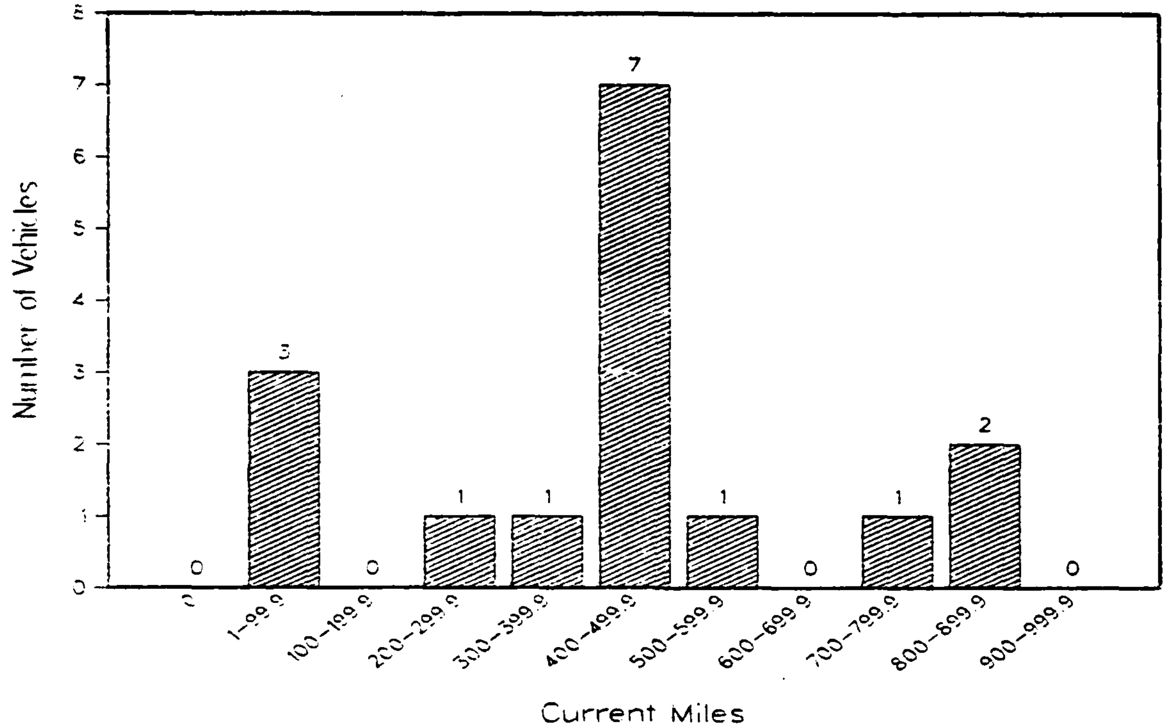
HISTORICAL DISTRIBUTION
For Current Miles New M106A2
Total Number of Vehicles: 0



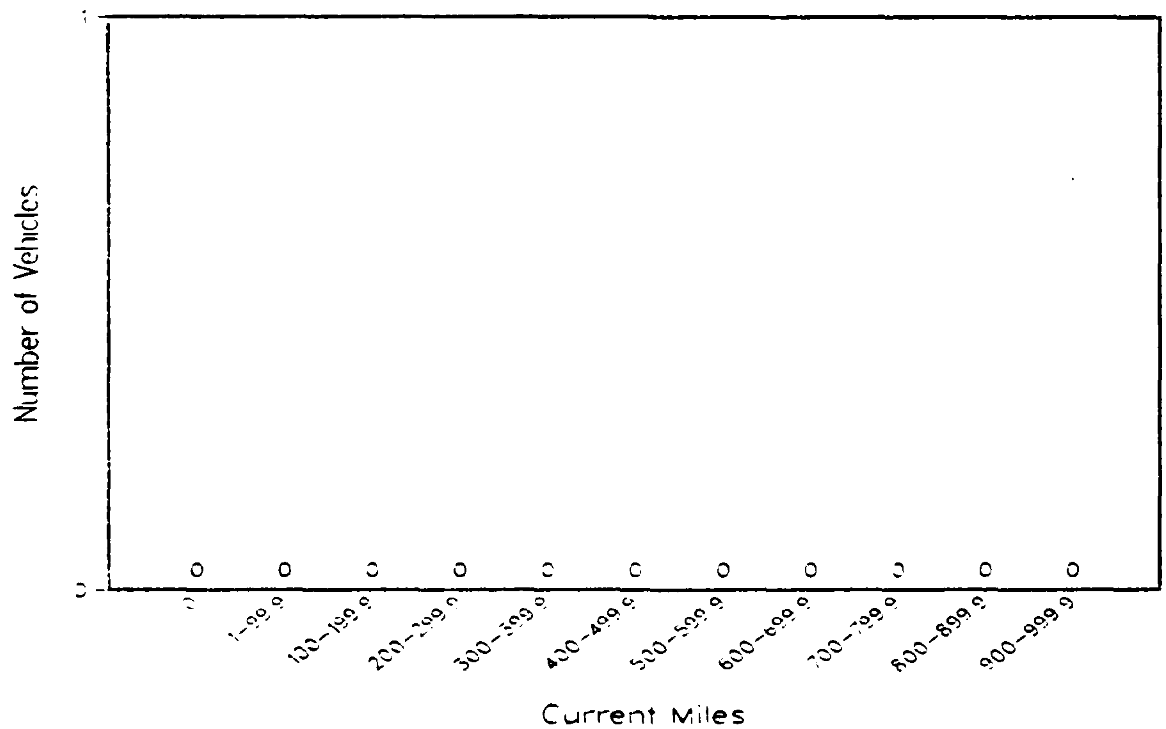

HISTORICAL DISTRIBUTION
For Current Miles Rebuild M106A1
Total Number of Vehicles: 6
Number of Vehicles
Current Miles
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9

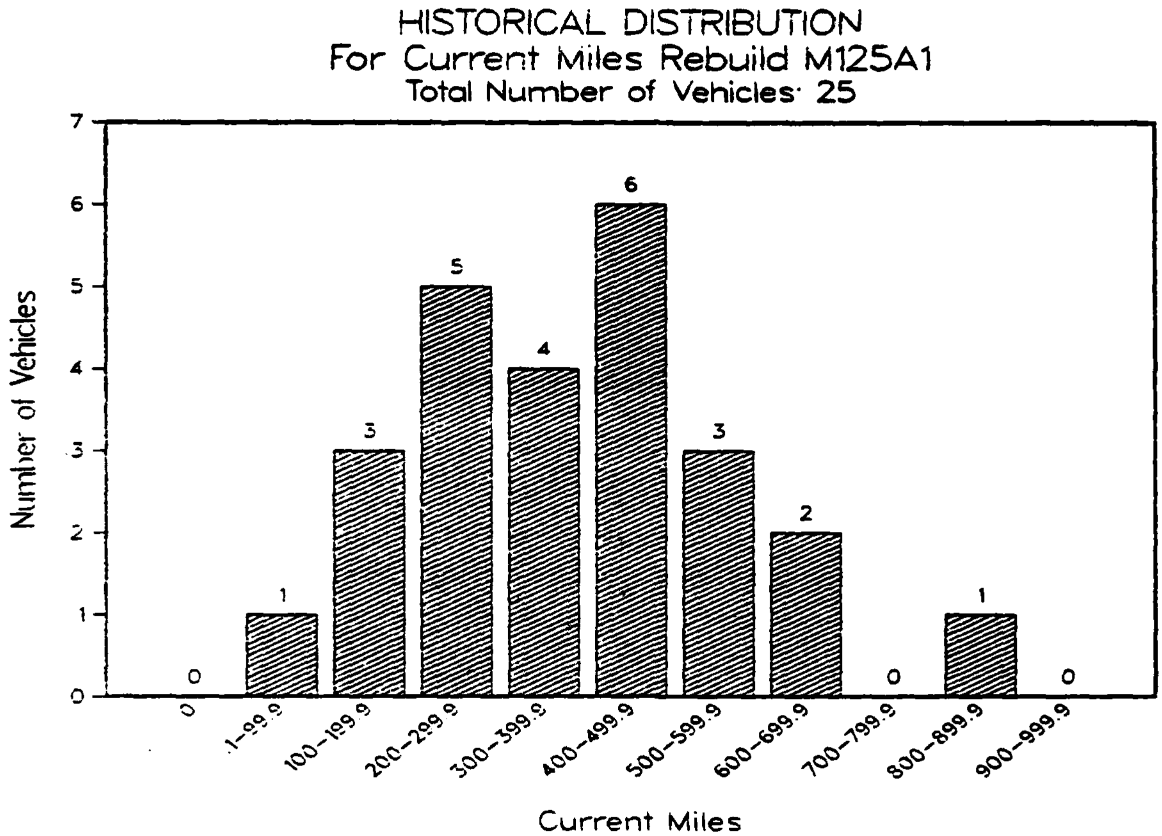

HISTORICAL DISTRIBUTION
For Current Miles Rebuild M106A2
Total Number of Vehicles: 12
Number of Vehicles
Current Miles
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9

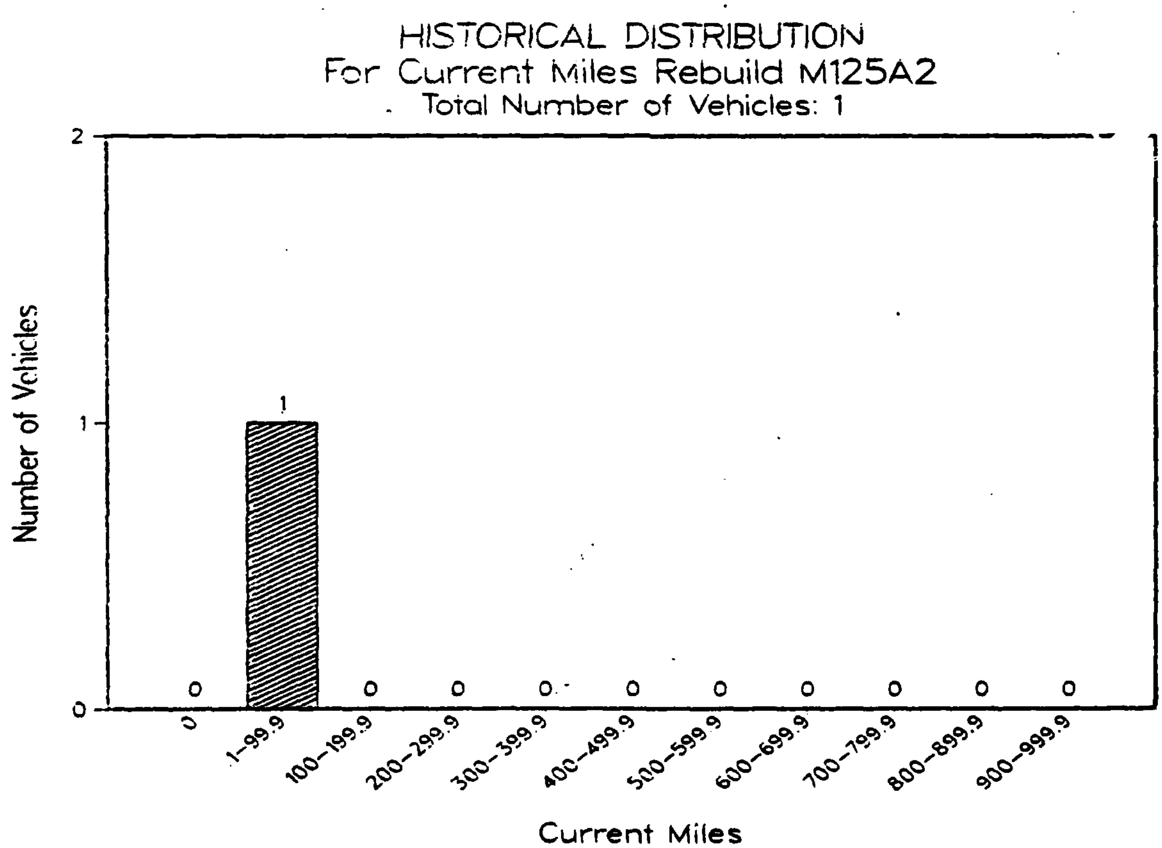
HISTORICAL DISTRIBUTION
For Current Miles New M125A1
Total Number of Vehicles: 16



HISTORICAL DISTRIBUTION
For Current Miles New M125A2
Total Number of Vehicles: 0




HISTORICAL DISTRIBUTION
For Current Miles Rebuild M125A1
Total Number of Vehicles: 25
Number of Vehicles
0
1
3
5
4
6
3
2
0
1
0
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9
Current Miles


HISTORICAL DISTRIBUTION
For Current Miles Rebuild M125A2
Total Number of Vehicles: 1
Number of Vehicles
0
1
0
0
0
0
0
0
0
0
0
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
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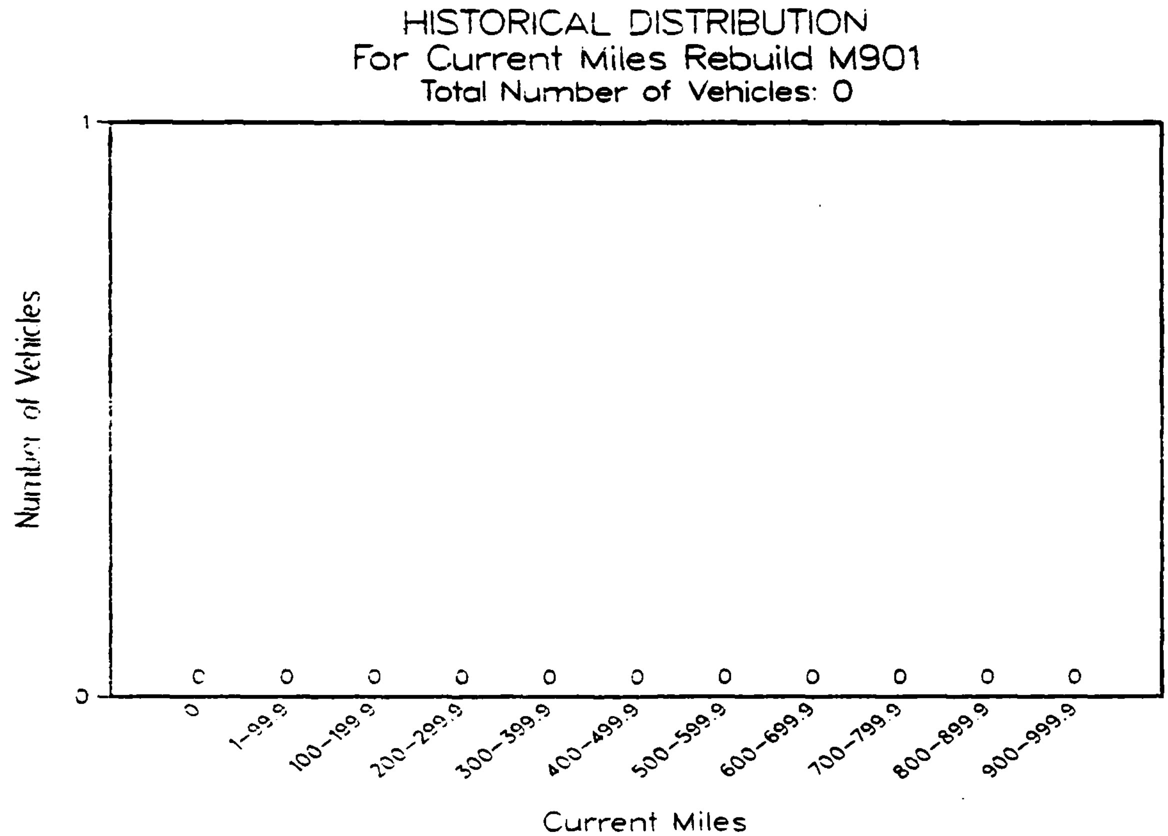
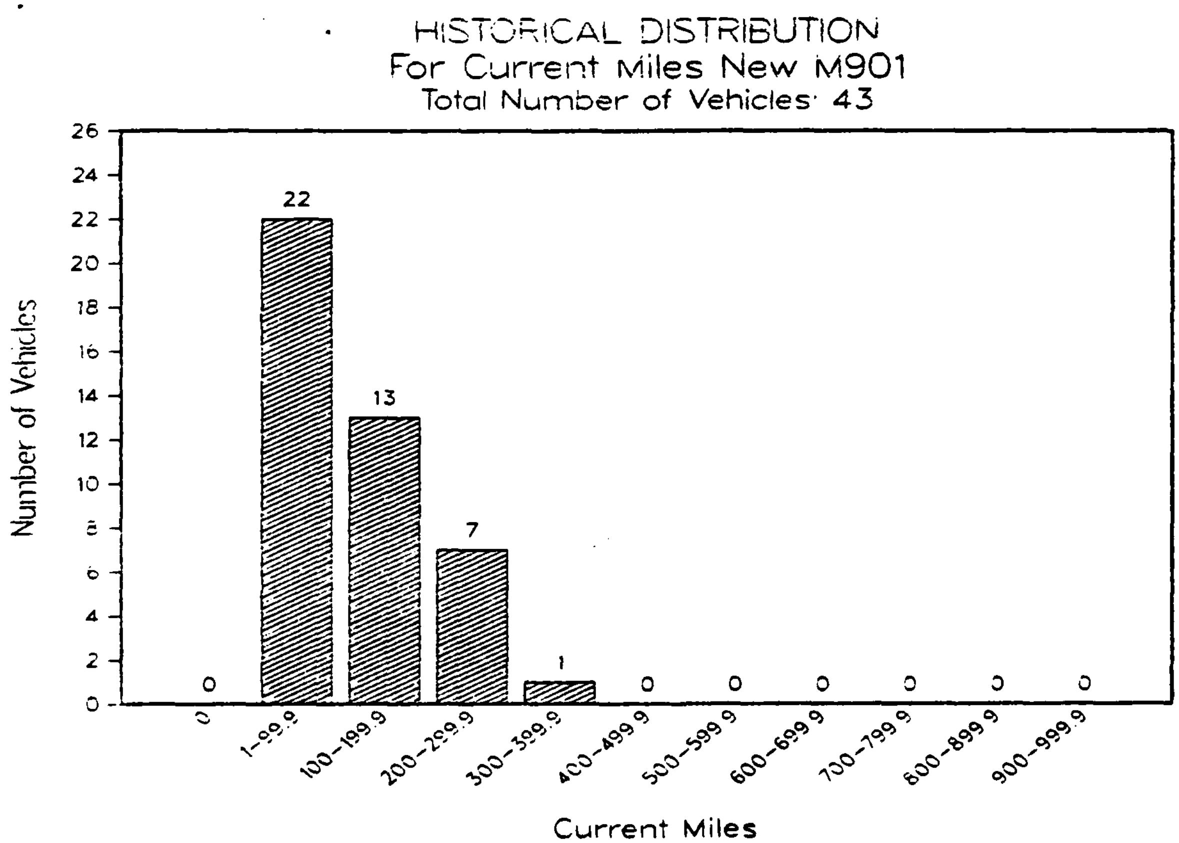
600-699.9
700-799.9
800-899.9
900-999.9
Current Miles


HISTORICAL DISTRIBUTION
For Current Miles Rebuild M901
Total Number of Vehicles: 0
Number of Vehicles
Current Miles
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9


HISTORICAL DISTRIBUTION
For Current Miles New M901
Total Number of Vehicles: 43
Number of Vehicles
Current Miles
22
13
7
1
0
1-99.9
100-199.9
200-299.9
300-399.9
400-499.9
500-599.9
600-699.9
700-799.9
800-899.9
900-999.9

M113 SDC DATA FORMATTING

The 10,393 failed parts with the 1,070 lub records in the B data base and all those in the C data base were sorted on a vehicle type and incident date basis. For each reported incident, the following information was extracted and tabulated:

INFORMATION	REMARKS
Vehicle type	M106A1
Vehicle serial number	15 digit alphanumeric
Incident report date	Julian date 5 digits
Incident report number	6 digit alpha numeric unique number
Nomenclature	20 digits
NSN	16 digits
Part number	15 digits
Qty of parts	Total number of parts replaced in each incident report
Clock hours	No. of hours vehicle was in active maintenance (AM)
Crew hours	No. of manhours that the crew used in AM
ORG hours	No. of AM hours at organizational level
DS hours	No. of AM manhours at DS level
GS hours	No. of AM manhours at GS level
DS hours	No. of manhours at DS level
Depot hours	No. of manhours at depot level
Engine miles	Odometer reading at time of maintenance action
Engine hours	Engine reading at time of maintenance action
FGC	Federal Group Classification Code, 4 digits
MC	Maintenance type Code A thru E (repair/replace, etc)
MAC	Maintenance action code (mission, safety, other)

The Q-service and O-S records in the B data base were similarly extracted and tabulated.

Vehicle starting miles (when vehicle entered the SDC reporting period) were taken from the historical A files. Ending miles (when vehicle was removed from SDC or when SDC was completed) was taken from the last D record report for each vehicle. All data was checked to insure that the mileage and corresponding dates in A, B, and D records were in an increasing relationship.

Any SDC data base analysis can be done using either engine hours or vehicle odometer in miles. Both are a measure of vehicle use over time. A plot of engine hours vs vehicle odometer readings at the start of SDC collection is shown in Figure DA 1. A regression line was fit thru this data which has a low level confidence band as can be seen from Figure DA 1. There is a very low level of correlation between odometer miles and engine hours. Why this is the case is not known. Hence, odometer miles was chosen as the measure of RAM performance and no analysis was performed in engine hours.

The FGC grouping was used to categorize each failed incident into vehicle sub-groups.

The MC code was used to determine whether the part was replaced or repaired on the spot.

The MAC code was intended to be used to score the failure incidents. However, a sample check of those parts showed that the same part replaced was not consistently scored a mission failure or a safety failure. It seems reasonable that if a particular part was judged to cause a vehicle mission failure once, it should be consistently judged the same. This was not the case, hence the M113 SDC data was used as is, that is unscored to remove those parts that failed due to driver/mechanic error/vehicle accident, etc.

The B record (unscheduled) data was observed to be composed of 20% single incident reports with unique vehicle and incident report date. The other 80% had two or more (up to 80) incidents in a grouping with the same vehicle odometer mileage and report date. This suggested that the vehicle failures were being discovered and repaired in bunches, or repair was postponed (if possible) until a more convenient time which could be a time for scheduled maintenance. The other possibility is that the reported failure incidents were related, that is not independent.

The SDC reporting format specifies that the independent failed part should be reported in the B records and any parts replaced during that maintenance action that were destroyed/lost or replaced due to good maintenance action (dependent parts) should be reported in the supplemental C records. An investigation disclosed that there were independent incidents in the C records and dependent incidents in the B records. A procedure was develped to identify those incidents that were judged dependent in the B records. No procedure was developed to identify independent records in the C records (See Dependent Incidents Investigation within this report). Approximately 17.5% of the unscheduled B record incidents are dependent. Less than 5% of the C records are independent.

Failure incident data was then collected and tabulated for each vehicle in the following format.

ITEM	REMARKS
Vehicle type	
Vehicle SN	
Date in	Date first entered into M113 SDC plan
Start miles	Odometer reading at start date
First failure	Date and mileage at first time vehicle stopped for repair
2nd failure	Date and mileage at 2nd time vehicle stopped for repair
	Date and mileage at 10000 time vehicle stopped for repair
nth failure	Date and mileage at nth time vehicle stopped for repair
Total incidents	Total number of failure incidents charged against vehicle
Total indep incid	Total incidents less dependent incidents
Total failures	Total number of times vehicle stopped for repair
End miles	Odometer reading at end date
End date	Last date under M113 SDC plan
Base location	Where the vehicle was used while under M113 SDC.

This date formatting for each vehicle allowed four measures of reliability performance to be developed for each vehicle. They are:

RELIABILITY MEASURE	DESCRIPTION
MMBI	Mean miles between incidents = total incidents = (End miles - Start miles)/Total incidents
MMBII	Mean miles between independent incidents = (End miles - Start miles)/Total independent incidents
MMBF	Mean miles between failures (End miles - Start miles)/Total vehicle failures
MMBFF	Mean miles between failure within failure mileage $\frac{\text{(Last failure mileage - First failure mileage)}}{\text{(Total vehicle failures -1)}}$

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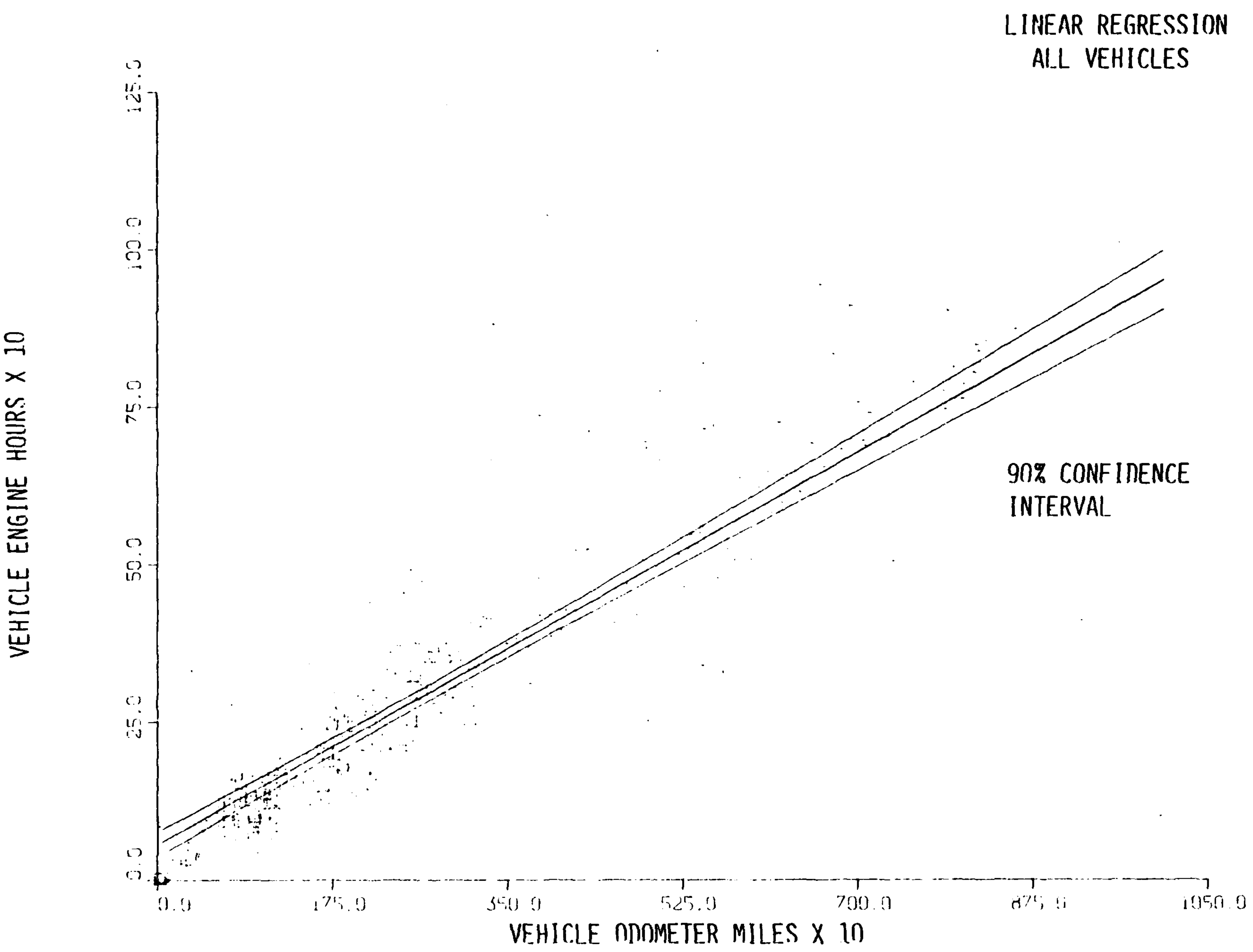
LINEAR REGRESSION



CORRELATION OF VEHICLE ENGINE HOURS A' VEHICLE ODOMETER MILES IN THE SDC M113 D A

DEPENDENT INCIDENTS

The structure of the sample data collection (SDC) plan allows for reporting of all maintenance incidents whose object is to return to or keep the vehicle at 100% operational mode. These incidents are any maintenance actions such as replacing/replenishing oils, greases and other fluids as well as adjusting, repairing, replacing or otherwise working on vehicle parts. These maintenance incidents are divided into scheduled maintenance actions and unscheduled maintenance actions.

A subgroup of the unscheduled maintenance actions are replacing failed parts or removing, repairing/adjusting and replacing out-of-spec parts. Both of these are herein referred to as a failed part. In the process of removing and replacing these primary failed parts, other non-failed parts have to be removed to gain access to the failed parts. These secondary parts are sometimes damaged requiring replacement and/or replaced as good maintenance procedures. Matched set of V-belts, fluids, gaskets, lock washers, clamps and tie downs are examples of these secondary parts.

The SDC allows for reporting of both types of failed parts. The B records format is for reporting the primary or independent failed part and the C report format is for reporting all scheduled oil/grease/fluids and all secondary or dependent parts replaced to replace the independent failed part.

The M113 SDC data base shows that there are groupings of incident reports in the B records that have the same vehicle SN and report date. This by itself is to be expected. The grouping counts are shown in the following tabulation. The 12,704 records exclude O-S records.

Grouping Length	Quantity of each	Total No. of records
1	2165	2165
2	757	1514
3	371	1113
4	217	868
5	138	690
6	107	654
7	71	497
8	53	424
9	42	378
10	32	320
11	32	352
12	24	288
13	23	299
14	13	182
15	17	255
16	15	240
17	16	272
18	14	252

19	13	247
20	12	240
21	5	105
22	5	110
23	2	46
24	7	168
25	6	150
26	1	26
27	2	54
28	3	84
29	2	58
30	1	30
31	2	62
33	1	33
35	2	70
36	1	36
37	2	72
38	1	38
41	1	41
45	2	90
55	1	35
56	1	56
80	1	80
Totals		12,704

This tabulation shows that only 2,165 (out of 12,704) records were single stand alone incidents and there were as many as 80 separate incidents charged to one vehicle at one time. An investigation of these groupings disclosed that there are both independent and dependent incidents reported within these groupings. In addition, incidents for parts replaced were reported in the C records that do not have a corresponding B record incident. The C parts were likely replaced during scheduled maintenance actions when the failed part was discovered. Hence, the B records which should contain all unscheduled independent incidents contain a percentage of dependent parts. The C r cords, which should contain dependent parts replaced (as well as scheduled maintenance replacements parts), contain a percentage of independent parts.

The percentage of dependent parts in the B records was estimated by using an elaborate, time intensive effort that involved cross referencing the 34P manuals and assembly figures. (See appendix B for example methodology). Each set of two or more related independent and dependent parts in the B groupings were found and recorded. No procedure was established to identify the independent incidents in the C files.

The following tabulation is the number of sets of two or more related B record incidents. Each set contains one independent incident with the remainder of related incidents in the set being dependent. No determination was made to classify which incident in the set was the independent incident.

Set Size	Number of Sets	Number of Independent Incd.	Number of Dependent Incd
2	739	739	739
3	160	160	320
4	72	72	216
5	37	37	148
6	22	22	110
7	14	14	84
8	7	7	49
9	2	2	16
10	2	2	18
11	1	1	10
12	1	1	11
13	1	1	12
15	2	2	28
16	2	2	30
28	1	1	27
			1818

There are 10,393 unscheduled incidents in the B records (not including those incidents involving fluids and lub replacements). Hence, approximately 17.5% of the unscheduled B records incidents are dependent. Less than 5% of the C records were estimated to be independent incidents. This leads to a new reliability measure in addition to mean miles between incident (MMBI). That is, mean miles between independent incidents (MMBII).

GROUP MEAN MILES ANALYSIS

The data formatting allowed the mileage readings to be grouped into three divisions. They are:

Group	Remarks
1	Start mileage to first incident failure miles
2	First failure miles to last incident failure
3	Last incident failure miles to end miles

This data grouping allowed statistical test of significance of the three groups to see if they were drawn from the same population. This analysis resulted in the following data on mileage means.

Vehicle Groups	Group 1	Group 2	Group 3
Entire Fleet	114	82	50
Non depot	105	75	41
Depot	119	87	56
Stewart-WAQ	65	113	52
Non depot	81	114	39
Depot	39	113	74
Riley-WAH	3	85	52
Non depot	1	117	32
Depot	3	74	62
Hood-WAG	59	89	4
Non depot	39	86	0
Depot	65	90	5
Aschaf-WAM	209	62	100
Non depot	220	62	64
Depot	191	113	32
Mannheim-WAP	146	84	30
Non depot	31	50	26
Depot	191	114	32

Group 1 "entire fleet mean miles" appears much higher than group 2 mean miles. Group 2 "entire fleet mean miles" appear much higher than group 3 mean miles. There also appears to be some extreme mean variations within each group (especially group 1 and group 3). Group 1 means range from 1 to 220 and group 3 means range from 0 to 139.

Statistical significance tests show that due to the large variation from vehicle to vehicle, the differences in the entire fleet and depot/non-depot fleet are not significant. However, the subdivisions of the vehicle into base location have some means that are significantly different.

This suggests that there are significant variations in the way the data was recorded on the M113 SDC base at the five locations. It suggests, for example, that at Fort Hood the data collection was started immediately with possibly some repairs postponed until vehicle entered SDC. At Aschaffenburg, failure data was possibly not collected for some time into the SDC reporting period and for some time prior to ending the SDC. This possibility exists for other bases as well. It is not known if failure data was just omitted or reported on a different date.

Due to the fact that the entire fleet and the depot/non-depot fleets mean miles are not significantly different, the MMBI and MMBII measures have validity and any biasing effects from data reporting procedure can be attributed to a possible base effect.

2-WAY AND 3-WAY ANALYSIS OF VARIANCE

There are several effects on the M113 SDC data that would be of interest in knowing. These are vehicle type, base effect and vehicle age effect as well as the prime interest effect of depot vs non-depot. A cursory look at the data shows that the vehicle age effect may be considered as balanced from a statistical design of experiment point of view. That is there are most vehicles ages represented across vehicle types and base locations.

The number of vehicles can be seen in a blocking of the other three effects as follows:

New Depot	Locations	M106A1	M106A2	M113A1	M113A2	M125A1	M125A2	M577A1	M577A2	M901
	Mann	1		4		1				22
	Asch			8	14	3	1		8	21
Non-depot	Hood			12				4		
	Riley	3		7		5		1		
	Stew	1		6	31	7			5	
	Mann	2	2	17	36	8			7	
	Asch	4		16	25	6				
Depot	Hood		4	43	2	9		2		
	Riley		2	28	1					
	Stew		4	17	5	2		1		

Due to the large number of block voids, it is not possible to run a complete 3-way ANOVA on the M113 SDC data. Data can be consolidated into a 2-way ANOVA and a 3-way ANOVA as follows:

2-WAY ANOVA

DEPOT	M106A1	M113A1	M113A2	M125A1	M577A1	M125A2	TOTALS
Non-depot	5	37	45	16	5	13	121
Depot	6	121	69	25	3	7	231
Totals	11	158	114	41	8	20	352

3-WAY ANOVA

	LOCATION	M113A1	OTHER VEHICLES	TOTALS
	Mann-WAP	4	24	28
	Asch-WAM	8	47	55
Non-depot	Hood-WAG	12	4	16
	Riley-WAH	7	9	16
	Stew-WAQ	6	44	50
	Mann-WAP	17	55	72
	Asch-WAM	16	34	50
Depot	Hood-WAG	43	18	61
	Riley-WAH-N	28	3	31
	Stew-WAQ	17	12	29
		158	250	408

The 2-way ANOVA can be used to measure vehicle type effect and depot effect. The 3-way ANOVA can be used to assess base location effect and can be used to see if the M113A1 is different than the rest of the vehicles.

The 2-way ANOVA was run using all four reliability performance measures MMBI, MMBII, MMBF, and MMBFF. All four proved to have no significant vehicle effect and will not be discussed further.

The 3-way ANOVA did show some significant effects. The ANOVA results for the MMBI measure are tabulated as follows:

Source of Variation	Sum of Squares	Deg of Freedom	Mean Square	F Ratio	F 0.5 Code	F Valve	Significance
A. Base	4068	4	1017	20.1	(4,4)	6.39	Yes
B. Vehicle type	88	1	88	1.74	(1,4)	7.71	No
A x B	737	4	184	3.64	(4,4)	6.39	No
C. Depot	592	1	592	11.72	(1,4)	7.71	Yes
A x C	1862	4	465	9.21	(4,4)	6.39	Yes
B x C	1	1	1	0	(1,4)	7.71	No
Residual	202	4	50	0	-		
Totals	7552	19	397				

This concludes that there is a significant difference in the means for the base effect, no significant difference between the M113A1 and the remainder of the vehicles and a significant depot effect. The lack of significance in the vehicle type effect is in agreement with the 2-way ANOVA results.

The MMBII reliability measure results echoed the MMBI results as should be expected since they are only a small percentage difference. There was no significant difference shown for either of the MMBF and MMBFF measures. This result was not expected because the MMBFF measure was felt to reflect the true failure rate of the M113 family of vehicles. This MMBFF measure excludes the mileage contributing to the random start/random finish nature of the M113 SDC data (it eliminates group 1 and group 3 miles). It also only reflects a true measure of when the vehicle was rendered inoperable, that is, how long could the driver expect the vehicle to operate once started. This 3-way ANOVA concludes that all vehicles can be expected to be rendered inoperable at the same rate regardless of vehicle type or base location or depot type. Measures of this expected failure will be discussed in a subsequent analysis.

The expected mean miles for each of the four reliability measures from each 3-way ANOVA is as follows:

	MMBI	MMBII	MMBF	MMBFF
Depot	35.2	38.9	92.3	85.7
Non-depot	24.3	27.3	81.3	81.7

The 3-way ANOVA analysis shows that the depot vehicles are significantly better than non-depot vehicles in two categories, MMBI, and MMBII. This result is counter intuitive. A vehicle from a new production assembly initially has all new components whereas for a depot processed vehicle, very few parts are replaced in a new condition, some are replaced as reconditioned and some (most) are not replaced at all retaining their prior use history. A new vehicle is subject to infantile type of failures which would make it appear to have an initial higher failure rate. However, the M113 SDC data has very few vehicles that can be considered in this infantile failure range. Additionally, as the vehicles progress in the field, the high failure rate components (components usually replaced in a depot process) are again subject to be replaced in the field for both non-depot and depot vehicles alike, making them tend to become homogeneous as field usage progresses.

A possible cause of the difference in the depot and non-depot vehicles is the apparent unbalance and biasing effects in the data base itself. The fact that this is true is shown as follows.

The 3-way ANOVA concludes that there is a significant base effect as well as a significant depot effect. The means for each base from the 3-way ANOVA are as follows. An average miles driven at each base is also included in the tabulation.

	Mann WAP	Asch WAM	Stew WAQ	Hood WAG	Riley WAH
MMBI	50.1	40.7	28.5	18.5	10.9
Ave miles driven					
Depot	1043	1058	804	609	476
Non-depot	861	819	834	572	482

As a consequence to this parallelism between base mean and average miles the validity of the base effect and the depot effect results are questionable. At this point, the only valid conclusion is that another method of analysis has to be used to determine the true reliability of depot and non-depot vehicles. This alternate analysis measure must be capable of assessing and removing the underlying effects of miles driven, base effect, vehicle type (if any), and vehicle age regardless if these effects are balanced or independent or otherwise.

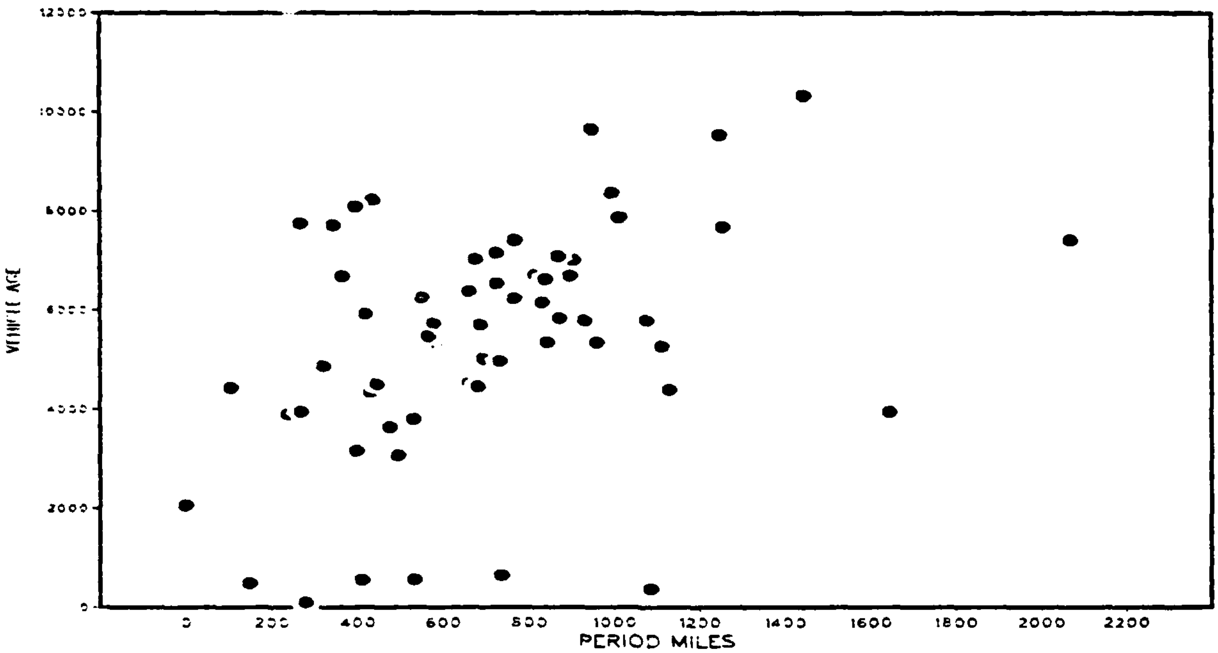
Base-Age-Mileage Effect Analysis

The 3-way ANOVA analysis on vehicle-base-depot effects, and subsequent trend analysis on vehicle age (miles registered on odometer at mid-point in SDC reporting period) and the analysis on miles driven show a possible strong relationship may exist for a base effect, an age effect and a mileage effect. Miles accumulated during SDC reporting period were adjusted to account for the actual days under the SDC reporting period to give a miles driven per unit time measure, termed period miles.

An analysis to quantify their exact effect would be desirable. This could be obtained by using a 3 or 4 way ANOVA including depot effect as an additional effect. This ANOVA requires that the data on each effect be blocked into Depot (2 treatments), Base (5 treatments), Age (1,000 mile increments = 9+ treatments) and mileage effects (200 mile increments = 10+ treatments). This requires data to fill 2x5x10x10 or 1000 blocks which is impossible with only 408 vehicles. Even if the mileage and age effects were reduced to 5 increments, the probability of having 250 blocks filled with 408 vehicles in an unplanned experiment is near zero. This fact is evident when observing the distribution of vehicles over vehicle age and period miles shown in Figures BA1 to BA5. Even blocking the data in 2000 mile age increments are void of data entries. Hence, an ANOVA cannot be conducted and some other means of measuring the effects will have to be pursued.

An interesting observation can be made by this method of data presentation. There is no strong tendency to use the lower mileage vehicles over the higher mileage vehicles. This is evident at all bases for both depot and non-depot vehicles. The only possible exception is non-depot vehicles at Mannheim (WAP) shown in Figure BA5. Here the majority of non-depot vehicles at this base are around 2000 miles vehicle age. The 5 higher mileage vehicles are used less.

AGE/MILEAGE EFFECT ANALYSIS
DEPOT VEHICLES
BASE: WAG



AGE/MILEAGE EFFECT ANALYSIS
DEPOT VEHICLES
BASE: WAH

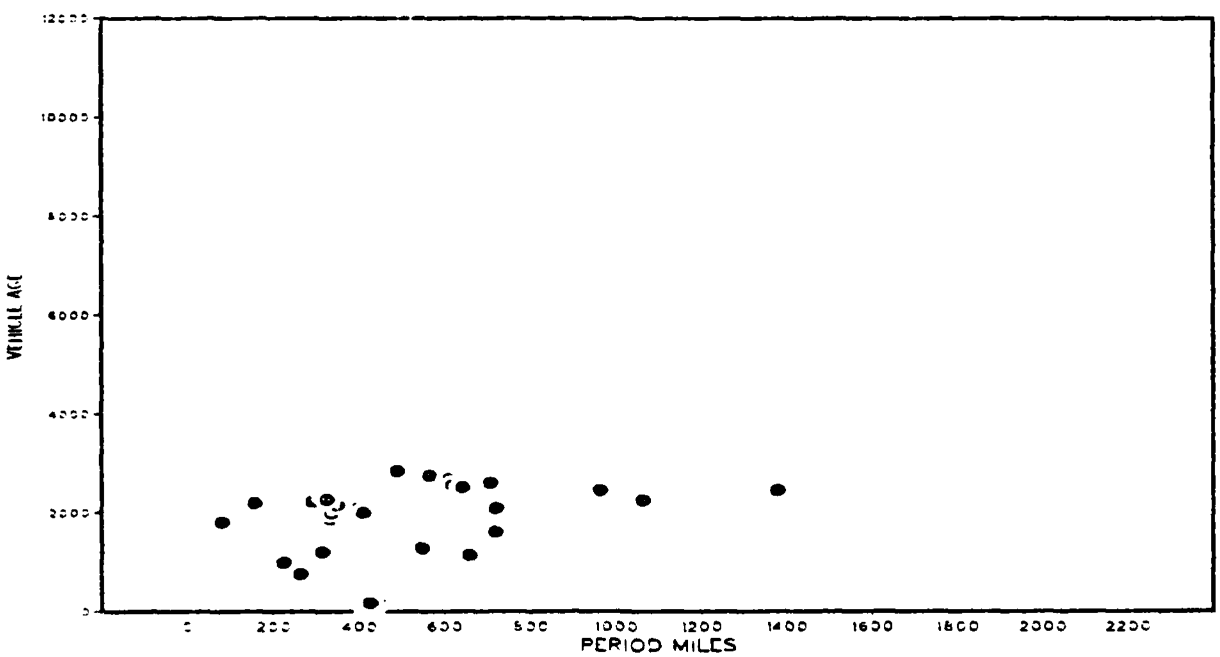
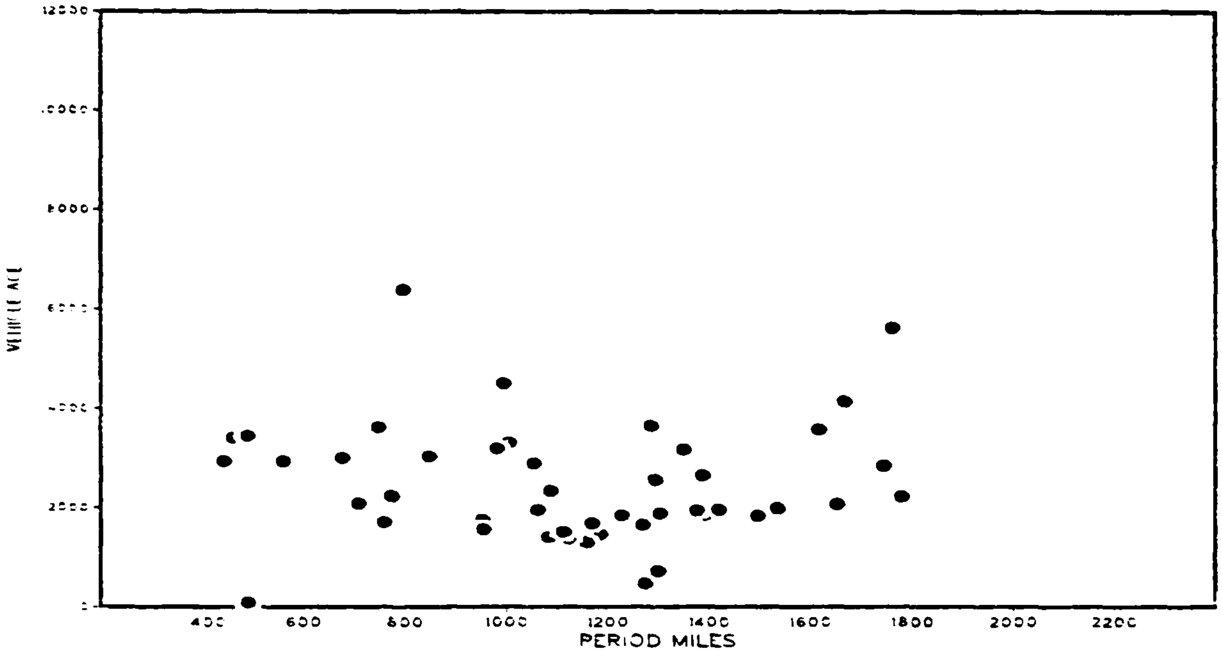


FIG DA1

AGE/MILEAGE EFFECT ANALYSIS
DEPOT VEHICLES
BASE: WAM



AGE/MILEAGE EFFECT ANALYSIS
DEPOT VEHICLES
BASE: WAP

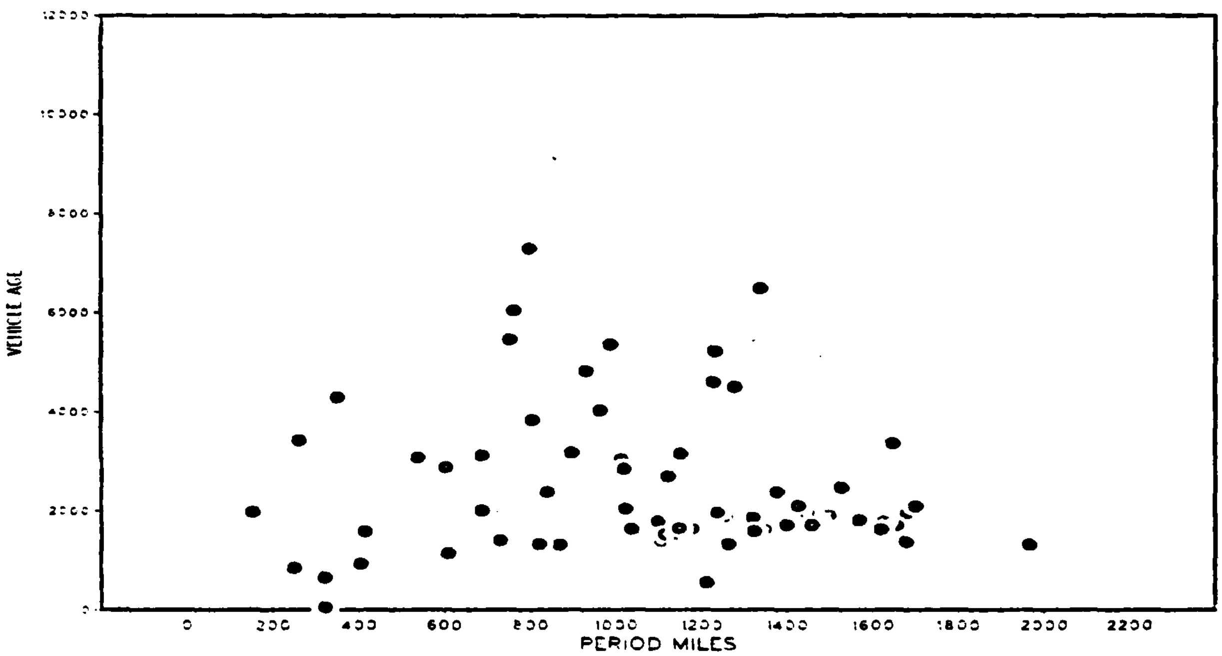
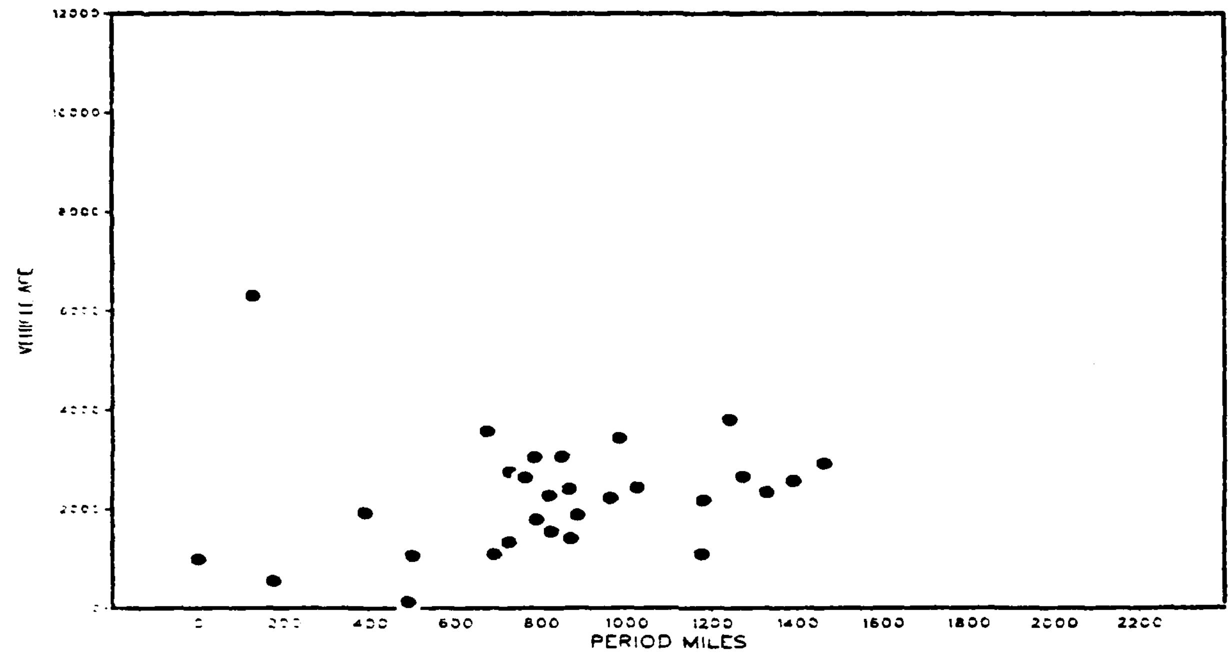


FIG-BA2

AGE/MILEAGE EFFECT ANALYSIS
DEPOT VEHICLES
BASE: WAQ



AGE/MILEAGE EFFECT ANALYSIS
NONDEPOT VEHICLES
BASE: WAG

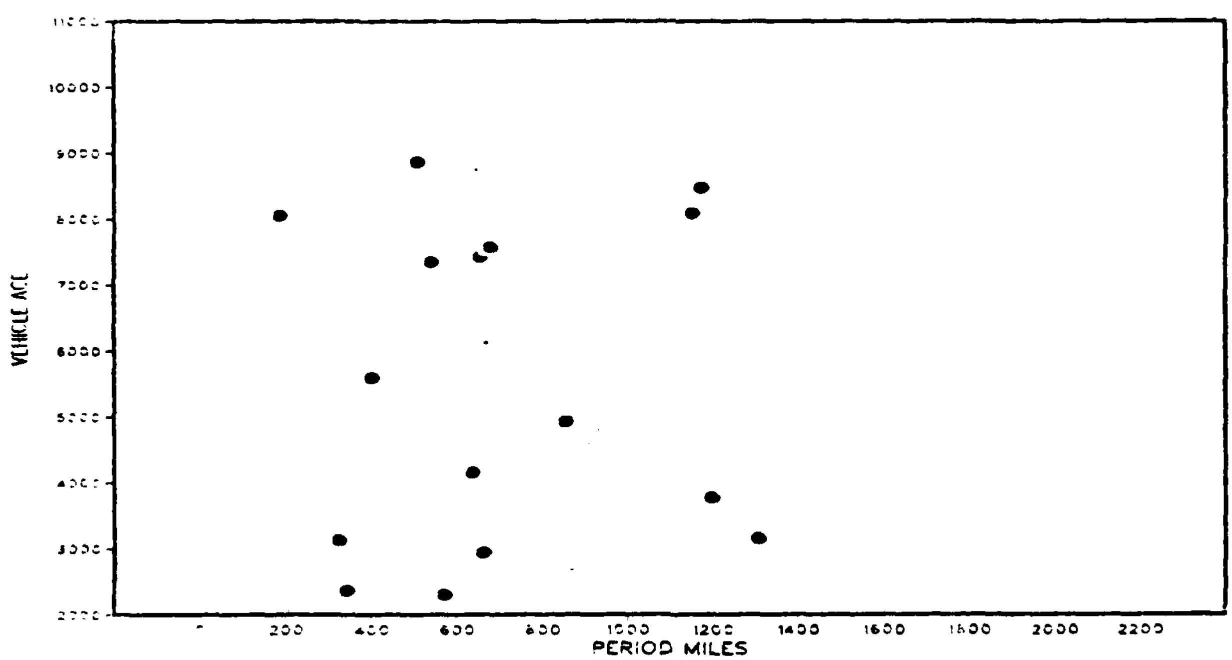
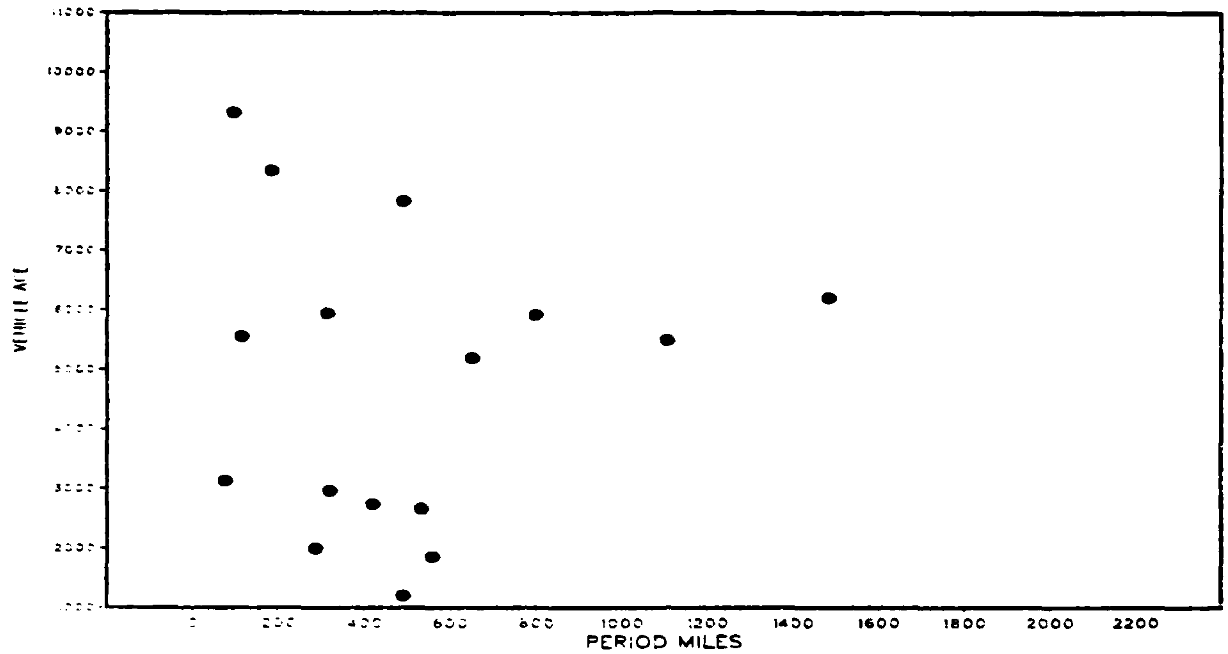
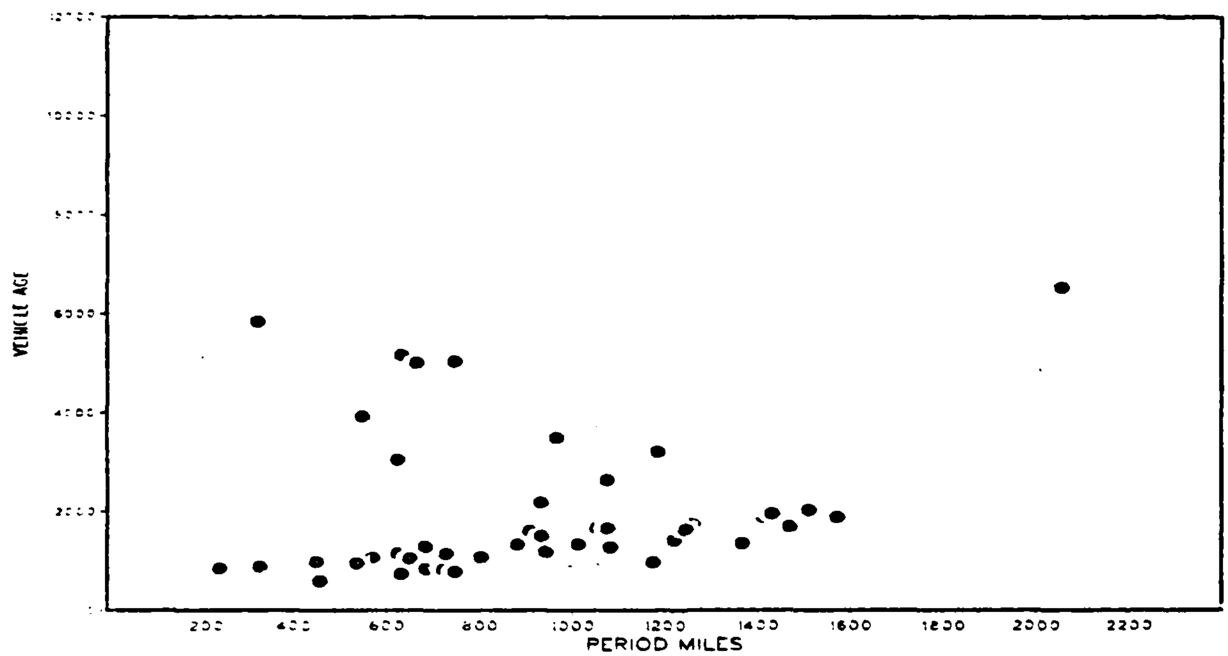


FIG DA3

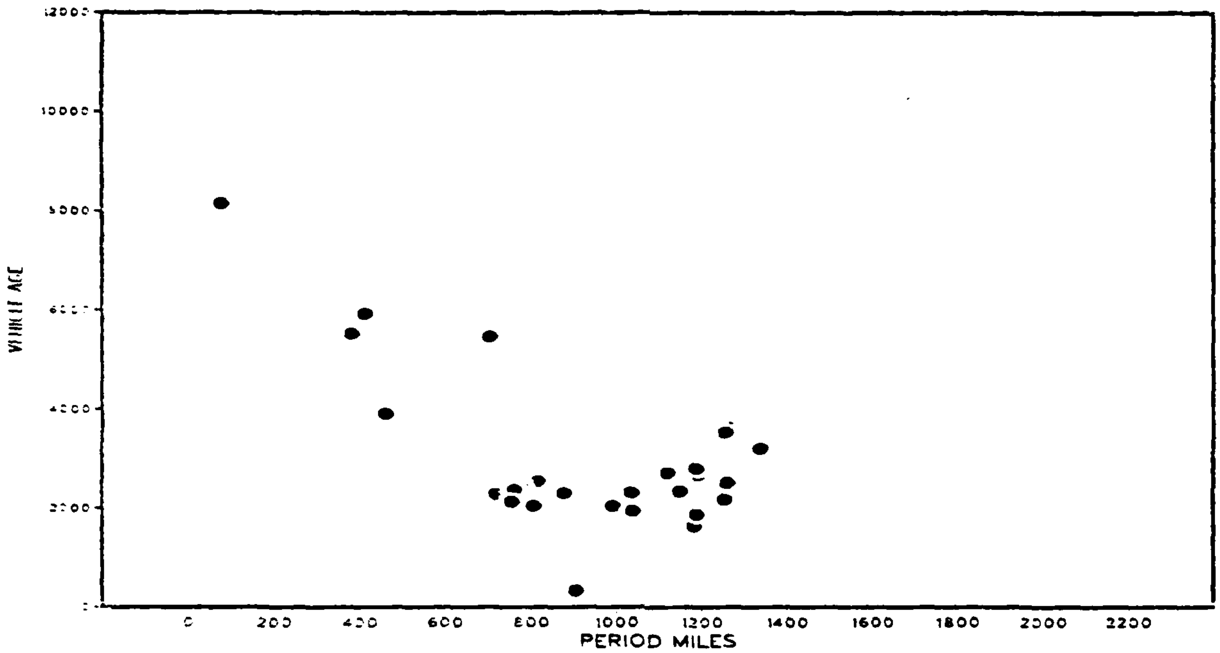
AGE/MILEAGE EFFECT ANALYSIS
NONDEPOT VEHICLES
BASE: WAH



AGE/MILEAGE EFFECT ANALYSIS
NONDEPOT VEHICLES
BASE: WAM



AGE/MILEAGE EFFECT ANALYSIS
NONDEPOT VEHICLES
BASE: WAP



AGE/MILEAGE EFFECT ANALYSIS
NONDEPOT VEHICLES
BASE: WAQ

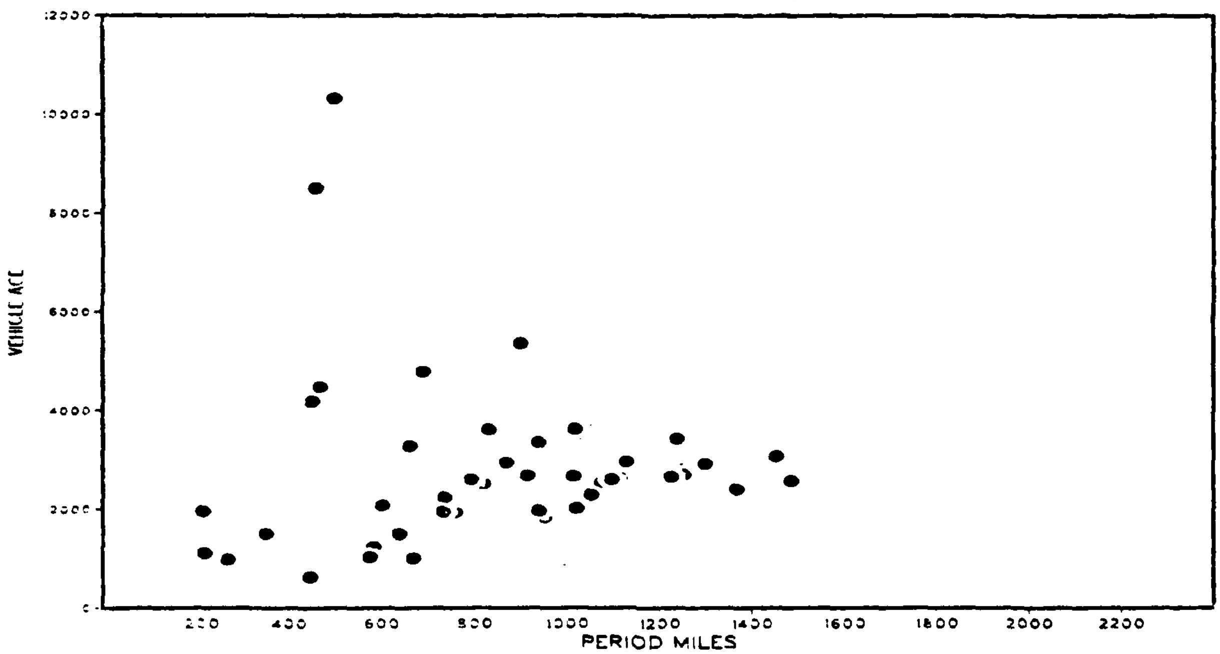


FIG-DAS

MULTI-VARI METHODOLOGY

This Multi-vari technique is a graphical method of viewing scatter plots of any one (or all, one at a time) of the suspected effects on the data. It involves the application of linear (or non-linear) regression to best fit a line through the data sorted to show the desired effect.

The strongest effect on the dependent variable (herein, MMBI, MMBII, MMBF, or MMBFF) is thus estimated and then subtracted out of the data. This results in a modified dependent variable within which the second strongest effect can be viewed on a scatter plot, estimated and then removed. This technique can be continued until the last effect of interest, (herein, depot effect) remains free of the possible bias of the previous effects.

This Multi-vari methodology does not assume that the effects are independent. That is, one effect does not influence another's outcome. However, it does assume a hierarchy of influence exists, that is, a stronger effect can influence a less stronger effect, but the less stronger effect does not appreciately influence the stronger effect. This gives validity to the method of first subtracting out the strongest effect purifying the lesser effects.

In a true planned design of experiments, the biasing effects of those known or unknown influencing factors that are not to be measured are balanced out. That is, the experiment is set up such that the expected mean value of each factors biasing effect of its influence on the dependent variable is zero. This balancing requires that the error mean of each biasing effect not only be zero over all, but also be zero for each division of the data. This is required to eliminate possible bias in fitting regression lines to the data.

The Multi-vari methodology does not assume that the effects are balanced. It does assume that the presence of these effects are known or at least suspected. The M113 SDC data base is far from balanced. Period miles, vehicle age, vehicle type, base location, etc. can be biasing the main interest effect, the depot effect. This is to say that a straight average of all the depot or non-depot vehicles from all locations may not represent the true effect due to the potential biasing effects from unbalanced or not independent factors such as period miles and/or others.

The first step in applying the Multi-vari methodology is to see how well the dependent variable (MMBI, etc) fits a normal curve. This is shown in Figure MV1. The figure shows that the fit is a skewed normal with a skewness factor of 2.02 (1.00 would be perfect normal) and a kurtosis measure of height vs. spread, of 4.6. All in all, not a good fit. However, it is judged to be capable of influencing the statistical analysis used herein due to violating the assumption that the underlying distribution be normal, but not to the extent that it can't be useful. The results using this skewed distribution would be valid but less than exact. The M113 SDC data does not merit a more exact technique because of other inconsistencies in the data.

The second step in applying the Mulit-vari methodology is to eliminate any vehicles that are suspect as erroneous or not representative of the data base or are statistical outliers. Eleven of the 408 vehicles were eliminated or purged from the data base. One for erroneous high miles, three because they were non-runners, four because they were not in the data base long and had no failures reported against them and three because they were classified as statistical outlines. The breakout of these vehicles is in Appendix A along analysis of other vehicles investigated but not purged. This leaves 397 vehicles (238 depot and 159 non-depot) in the data base.

The large standard deviation shown in Figure MV2 around both depot and non-depot means is not a measure of the confidence limits around the means. Because of the large number of samples (238 depot and 159 non-depot) in each estimate, the confidence interval around each mean is considerably less than the standard deviation shown. So much so that the means shown are statistically significantly different in any null-hypothesis tests.

The next step in applying the Multi-vari methodology is to treat each effect as if it were independent and/or all the other effects balanced out. Depot (depot vs. non-depot) effect is shown in Figure MV2. Here, as in the 3-way ANOVA, the depot vehicles are shown to be better (higher mean miles between incidents) than non-depot vehicles. The 3-way ANOVA showed a ratio of 24/35 respectively for non-depot vs. depot MMBI, where as here, as straight average shows a ratio of 37.6/51.5 MMBI. Part of the difference between the 3-way ANOVA and the straight average is due to the vehicle purging. The 3-way ANOVA used 408 vehicles. The other difference is due to the vehicle type effect and base effect are accounted for with the 3-way ANOVA statistical treatment. A note of caution should be expressed here. Neither method accounts for the possible biasing effect of vehicle age or period miles.

The vehicle type effect is shown in Figure MV3. The means for each vehicle type along with the upper and lower one-standard deviation show that there is statistically no difference in MMBI for vehicle type. This is in agreement with the 3-way ANOVA results. The only possible exception is the M113A2 which recorded a 73.6 MMBI as compared to a 35.6 MMBI for the M113A1. Notice that in all cases, the A2 version performed better (higher MMBI) than its A1 counterpart. The only exception, the M125A1, is not a valid point because of only one data point. This suggests that the upgraded A2 versions perform better than their A1 counterparts, but it cannot be statistically supported using this method due to the large variance in the data. There is a tendency to use the A2 versions more than the A1 versions especially in the M113. This, because of the period mile bias, would make the A2 versions appear better.

The base location effect is shown in Figure MV4. This one-way ANOVA shows a strong base effect that is statistically significant, the same as shown in the 3-way ANOVA. However, it should be pointed out that here, as in the 3-way ANOVA each base has possible biasing effects of unbalanced or dependency on vehicle age and/or period miles. Possible vehicle age inbalance exists because not all age groups are equally represented at each base. Possible period miles unbalance effect because the vehicles were driven less or more at each base. And possible period miles dependency effect because of a peculiar practice, method or mission in applying the vehicle mileage. This period mile and vehicle age effect will have to be subtracted out of the dependent variable prior to assessing this base effect.

The vehicle age effect is shown in Figure MV5A and B. Figure MV5B was obtained by computing the mid data collection age ½ (start miles plus end miles) and grouping these mileage into 1000 mile cells. These figures show a significant down trend as vehicle age increases showing an increasing maintenance burden with age. The curve in Figure MV5B also shows a possible classical bath tub effect with a high failure rate at low mileage (MMBI is the inverse of failure rate) and an increasing high failure rate at the higher miles. The 9000-9999 data grouping has too few vehicles to be considered a valid point. This effect was investigated, but the data variance does not justify fitting anything but a straight line.

Figures MB5A and MB5B show the strength of each visual graphical approach of the Multi-vari approach. In viewing the data scatter in Figure MB5A, the tendency is to conclude that the data is a true shotgun pattern. That is, it has no trend. Blocking the data into 1000 mile increments and plotting means and standard deviations shown in Figure MB5B gives reassurance that the means have a decreasing trend with age increase. Thus the linear regression fit shown in Figure MB5A may not have a good correlation of fit, but it does represent a reasonable measure of the true data mean. This type of data with its large standard deviation tends to give the impression that it obscures the true mean but with enough sampling (vehicle count) a reasonable estimate of this mean can still be made.

A vehicle age effect can be combined with the depot effect to see if the depot or non-depot vehicles have separate means and/or separate down trend slopes. This data was scatter plotted as shown in Figures MV6 and MV7. The linear regression fit for both sets of data were replotted in Figure MV8. The 95% confidence limits were also graphed for the depot vehicles. This shows that the difference between the means is statistically significant. The non-depot vehicles show a lower mean MMBI (greater maintenance burden) and a slightly steeper decreasing slope with vehicle age showing a tendency to have a faster increasing maintenance burden as the vehicle ages. However, this slope variation is not statistically significant.

The last single effect investigated in this data is the period miles effect. That is, how many miles the vehicles were driven during the SDC reporting period. Some vehicles were used very little and some were driven quite frequently. The reasons for each vehicle driving pattern is not known however, why some are hanger queens and not driven frequently can be speculated to be one or more of the following; driver/commander preference, base mission, base maintenance policy, base requirement and quantity available, hard to get parts availability and possible mirid of other reaons. This measure is not directly concerned with how many miles the vehicle is driven once started, but the accumulation of total miles over the entire SDC reporting period of 406 days. This would be of interest, but this information is not present in the SDC data base.

The SDC M113 data base contains vehicles that were not driven at all to those that accumulated over 2000 miles. Since not all the vehicles were under the SDC reporting period the full 406 days, their mileage was normalized to the 406 day period. This normalized figure was labled period miles. A bar distribution chart of period miles is shown in Figure MV9. Period mile effect is seen in a scatter plot shown in Figure MV10. It is by far the strongest effect. The more miles the M113 is driven, the higher the MMBI (lower the maintenance per mile ratio). The number of failure incidents occuring during the reporting period may increase because of the increased usage miles. That is, the failure incidents per unit time may increase, but the failure incidents per mile will decrease as the vehicles are driven more. It is not known what is the casue or effect at this point. That is, are the vehicles driven more because they are runners or are they runners because they are driven more? It is possible because of the fact that scheduled maintenance actions are on a time (not mileage) basis that some failure incidents are more time dependent than mileage dependent.

The period miles were placed into 200 mile cells and plotted with one standard deviation upper and lower limits as shown in Figure MV11. This shows that the data is statistically significant. The linear regression fit for this period miles effect shown in Figure MV10 was:

$$(MMBI)_{PM} = 12.14 + 6.7 \times 10^{-2} \; (\overline{PM})$$

The period mile effect is not balanced for the depot effect, or the base effect, or the vehicle type effect. Hence, to get a more accurate estimate of these effects, the period miles effect will have to be subtracted out first. This is accomplished by calculating the $(MMBI)_{PM}$ from the above equation for each vehicle point and subtracting that value from the original MMBI and adding that to the overall period mile mean. Thus modifying each MMBI point.

$$MOD\ (MMBI)_i = MMMBI_i = MMBI_i - (MMBI)_{PMi} + \overline{PM}$$

where i = 1 to 397 vehicles.

This, in effect, balances out the period mile effect as if all vehicles were driven at the average period mile mileage rate ($\overline{PM}$). The results of this period mile removal action on the MMBI data are shown in Figure MV12. As planned, the linear regression fit to this scatter plot data is flat. Interesting observations can be made on this scatter plot. First, the MMBI data goes negative in a few cases. This has no significant interpretation, but does not subtract from the validity of the approach. To avoid these negative values, a higher constant than the average period miles effect ($\overline{PM}$) in above equation, could be added. This would rid the scatter plot of negative values, but would not significantly change the following analysis results.

The second observation is that the deviation (scatter) of the data increased as period miles increase. This effect is shown by putting the period miles in 200 mile cells and plotting $\pm$ one standard deviation as shown in Figure MV13.

The data in each cell does not have a constant distribution, that is, it is not homoscedastic. This is alarming to statisticians because it greatly complicates the analysis methods. In our case, it could be a source of error at the higher period mile data points, but this potential error will not prevent obtaining more valid measures of the remaining effects. Part of the problem of the increasing variance with increasing period miles comes from the nature of the data. There can be no high MMBI readings at the lower period miles because the averaging technique used herein forces those into higher MMBI data points. This in effect limits the variance in data at the lower period mile data points. This gives the upper bound in the data. The lower bound comes from the fact that the unmodified MMBI data points had to be greater than zero. When the period mile mean was added to the data point in subtracting out the possible mile effect, the zero lower bound was transitioned to a decreasing lower bound starting from the period mile mean. This is evident from the expanding horizontal V-shape to the scatter in the scatter plot shown in Figure MV12.

A data transformation of log (MMBI) was applied which successfully eliminated this non-homoscedastic nature of the data. Subsequent analysis using this log transformation resulted in the same conlcusions thus demonstrating that no significant error was introduced into this analysis method.

The vehicle age effect can now be removed. Since there was no significant slope difference between the depot and non-depot vehicles, the vehicle age effect will be removed without combining it with the depot effect. This is done the same way as with the period miles effect. The vehicle age scatter plot is shown in Figure MV14. The least square regression fit is as follows:

$(MMBI)_{VA} = 50.71 - 1.6 \times 10^{-3}$ VA with a mean of 45.96

The vehicle age effect with the unmodified MMBI shown in Figure MV6 was expressed with the following regression equation:

$(MMBI)_{VA} = 63.18 - 3.0 \times 10^{-3}$ VA with a mean of 53.87

Adjusting for the difference between the Y intercepts and the associated mean and comparing this with the changes in the slope constant (-1.6×10^{-3}), it can be concluded that the vehicle age effect was not completely independent from the period mile effect. The downward trend still exists indicting an increasing maintenance burden as the vehicle accumulates mileage. However, it is not as strong as what would normally be expected for a tracked vehicle. This and the large variance in the data would tend to indicate that the past practice of overhauling the M113 at 6000 miles is not valid and would also give emphasis to the present procedure of inspecting each vehicle on an as-needed basis to determine if the vehicle requires depot attention. It also gives credibility to the Inspect and Repair (I&R) depot procedure currently in practice as opposed to a complete overhaul.

The variance in the MMBI with vehicle age and period mile effect removed is shown in Figure MV15. The upper and lower limits shown are one standard deviation. The assumption of constant variance is shown to be valid here. The slight variation in means at each age is due to the 200 mile cell effect. The cells are not balanced within themselves so some effect on the mean should be and is present.

The five vehicles showing a large change at 9000 to 9999 mile block is caused from forcing the data to be a linear fit. It indicates that at this extreme end, the best fit may not be linear but represent an incrasing failure rate due to a different failure phenomenon. This is possibly the wear-out phase of the classical bath tub failure curve. However, the data base is not strong enough to statistically support this observation.

The vehicle type effect is shown in Figure MV16A. Comparing this figure results with Figure MV3, the same general shape can be observed. The biggest change is lowering the M113A2 MMBI. Vehicle age effect period mile effect would have a large impact in this variable. The newer A2 versions, especially the M113, tend to be used more than the A1 version. The better performance (higher MMBI) of the A2 vehicles over the A1 vehicles is still present. Again in the M125A2 data point is not valid. The large variance in each data precludes statistical verification of this observation

The MMBI is again modified to remove this vehicle type effect (as well as vehicle age and period miles) and plotted in Figure MV16B. As can be expected, the mean is the same. The variance is different but does not violate the assumption of constant variance.

The last effect to be removed is the base effect. It is plotted in Figure MV17. There is no significant difference in any base except for the 99 vehicles at Mannheim (WAP). Comparing these results to the results shown in Figure MV4, the observation can be made that the lower MMBI shown for the 46 vehicles at Ft. Stewart (WAH) was not due to a base effect, but due to the biasing effect of vehicle type, vehicle age and period mile effects. However, something is being done at Mannheim to gain better recorded performance out of their vehicle fleet.

The modified MMBI (with Base, Vehicle type, vehicle age and period mile effect removed) is shown in Figure MV18. It is a straight line mean as is expected and the variance does not violate the constant variance assumption

The last effect of interest is the depot effect. The modified MMBI with all effects removed is shown in Figure MV19. This shows that there is no difference in the reliability performance of non-depot and depot vehicles. This is quite a different conclusion than that which would have been drawn from looking at the unmodified data.

The change in mean MMBI for both depot and non-depot vehicles as each effect is removed as shown in Figure MV20. Each effect eroded some of the difference with the period miles and base effect having the stongest bias.

FIG. MV1 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI)
DISTRIBUTION OF UNMODIFIED SDC DATA
397 VEHICLES, ALL BASES

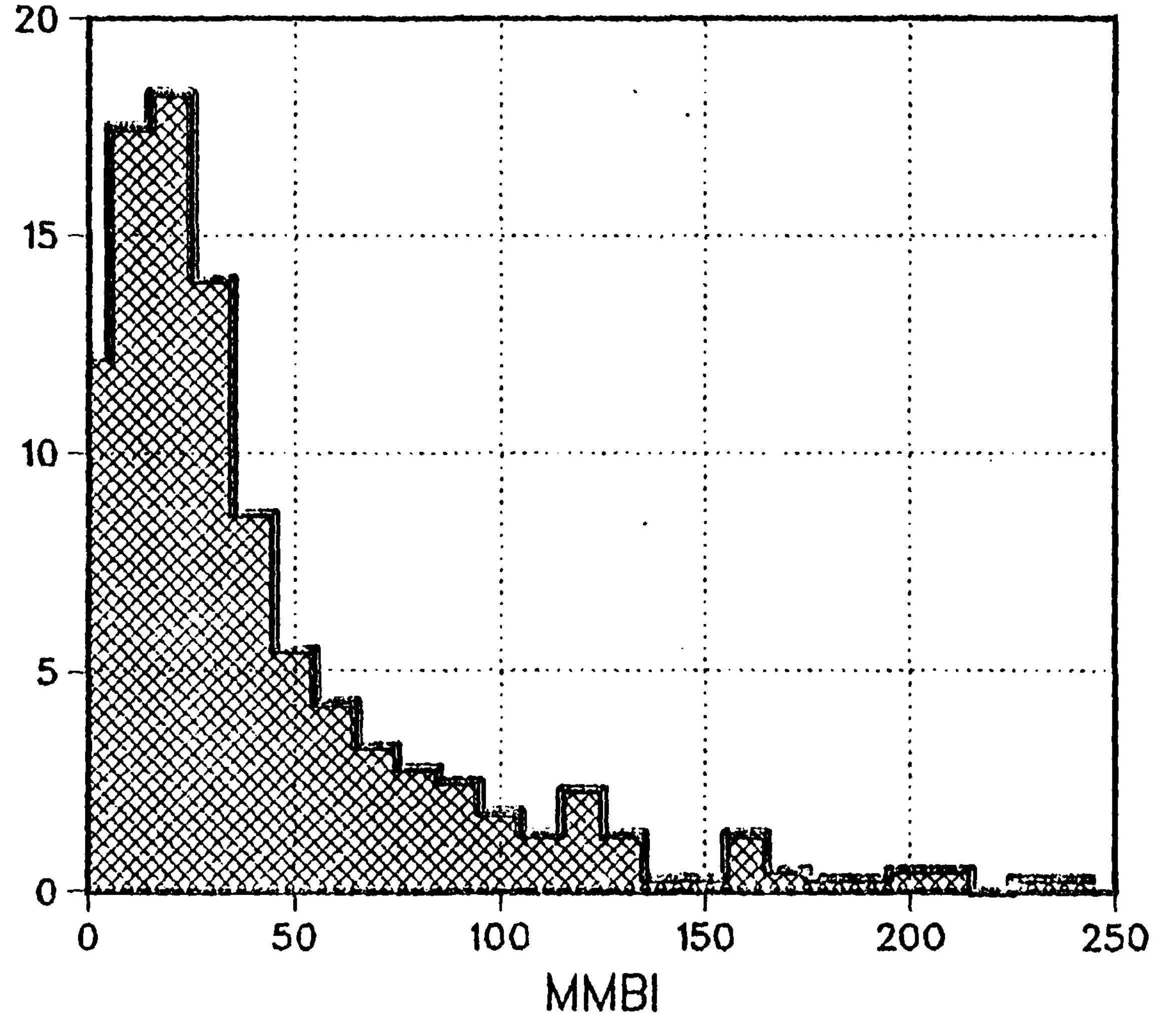


FIG. MV2 MMBI/DEPOT EFFECT
UNMODIFIED SDC DATA
397 VEHICLES ALL BASES

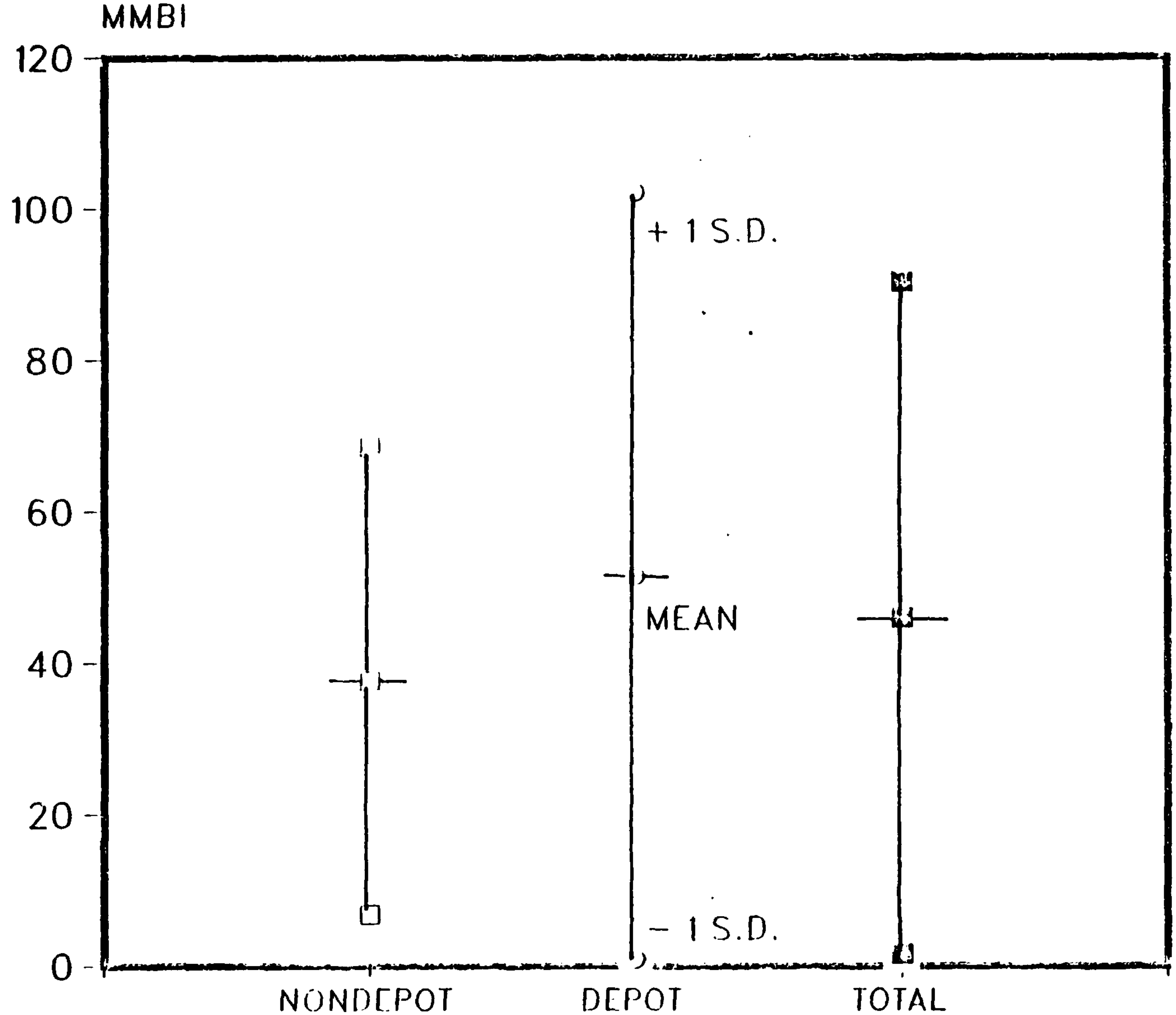


FIG. MV3 MMBI/VEHICLE EFFECT
UNMODIFIED SDC DATA
ALL BASES

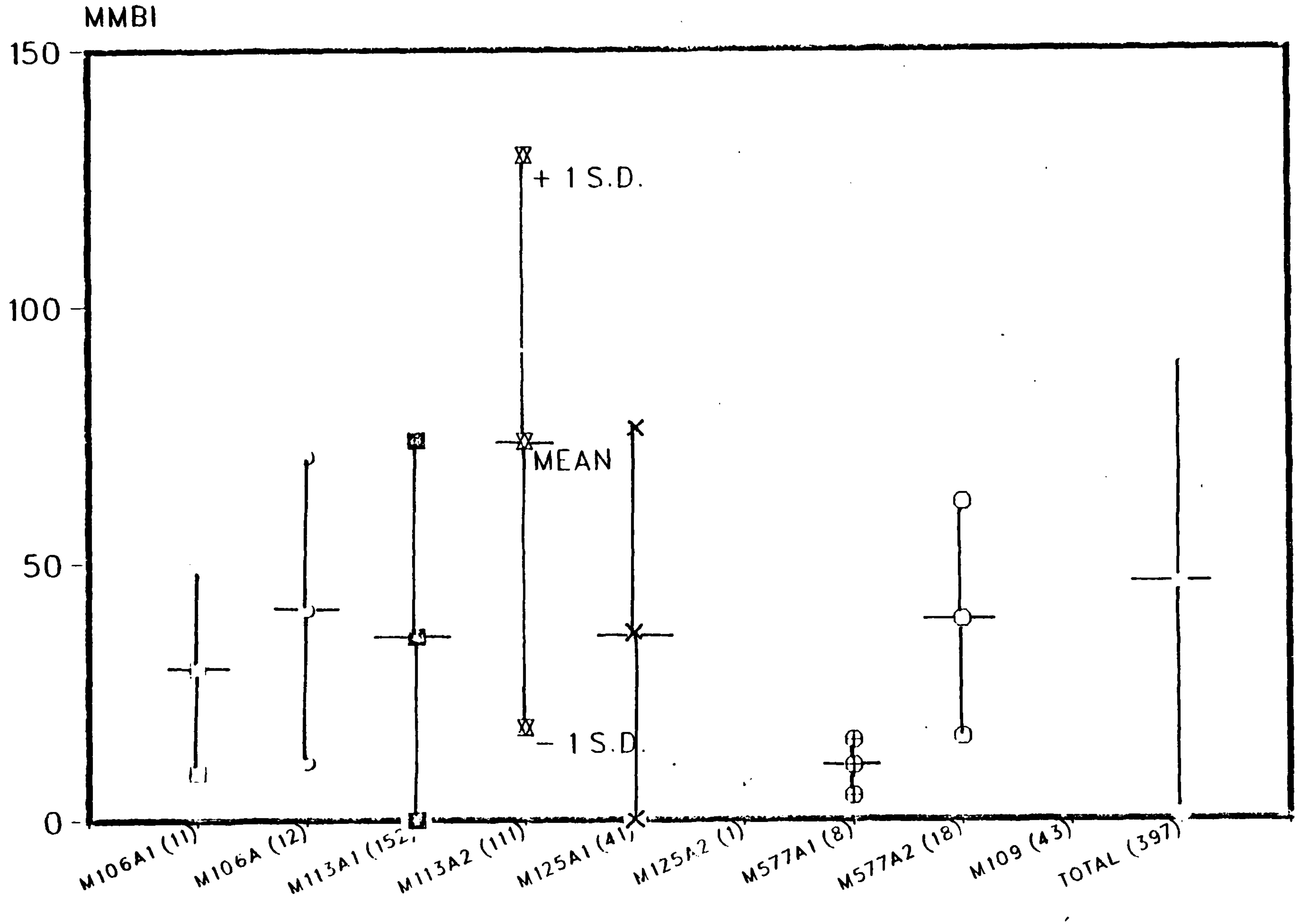
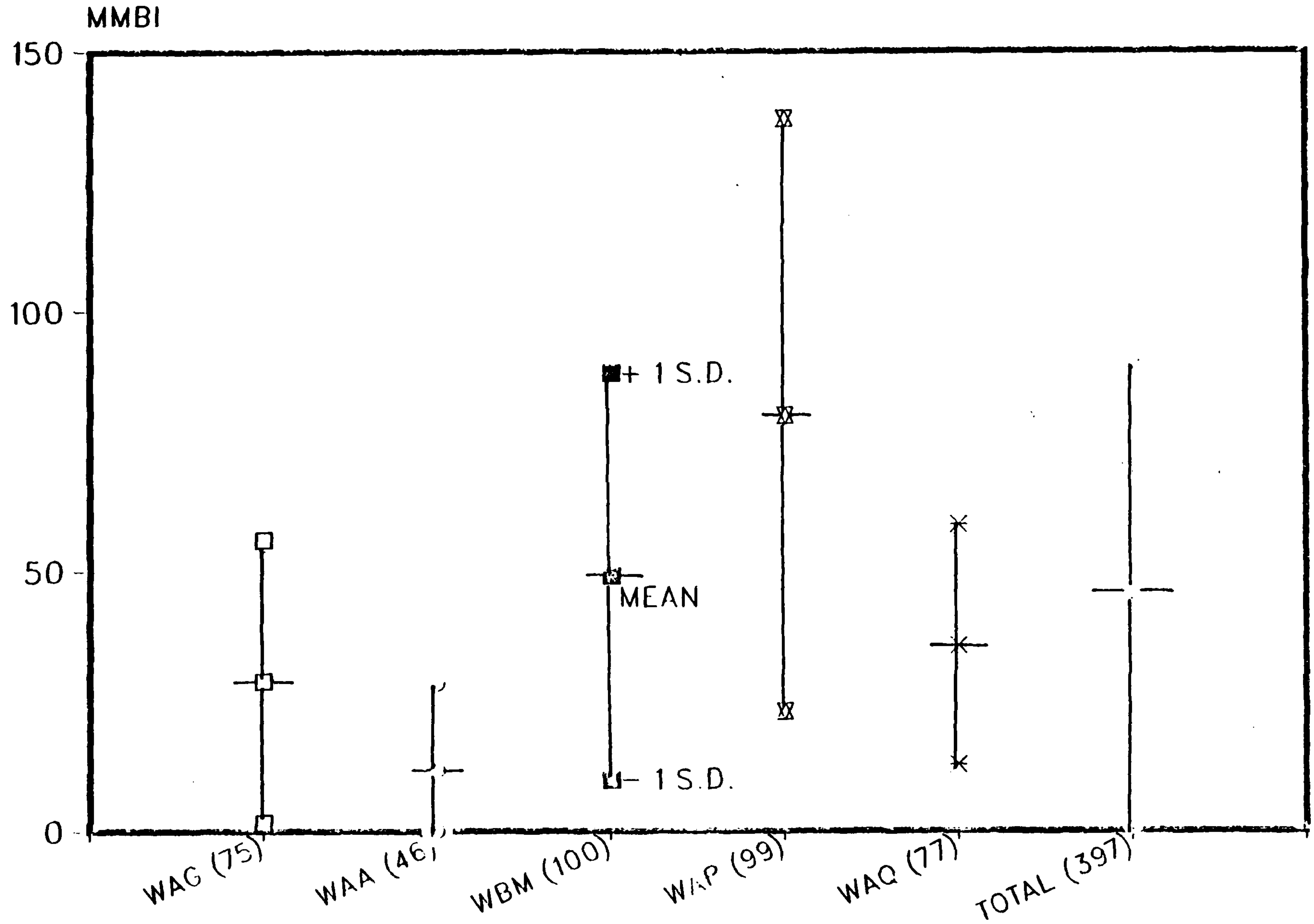
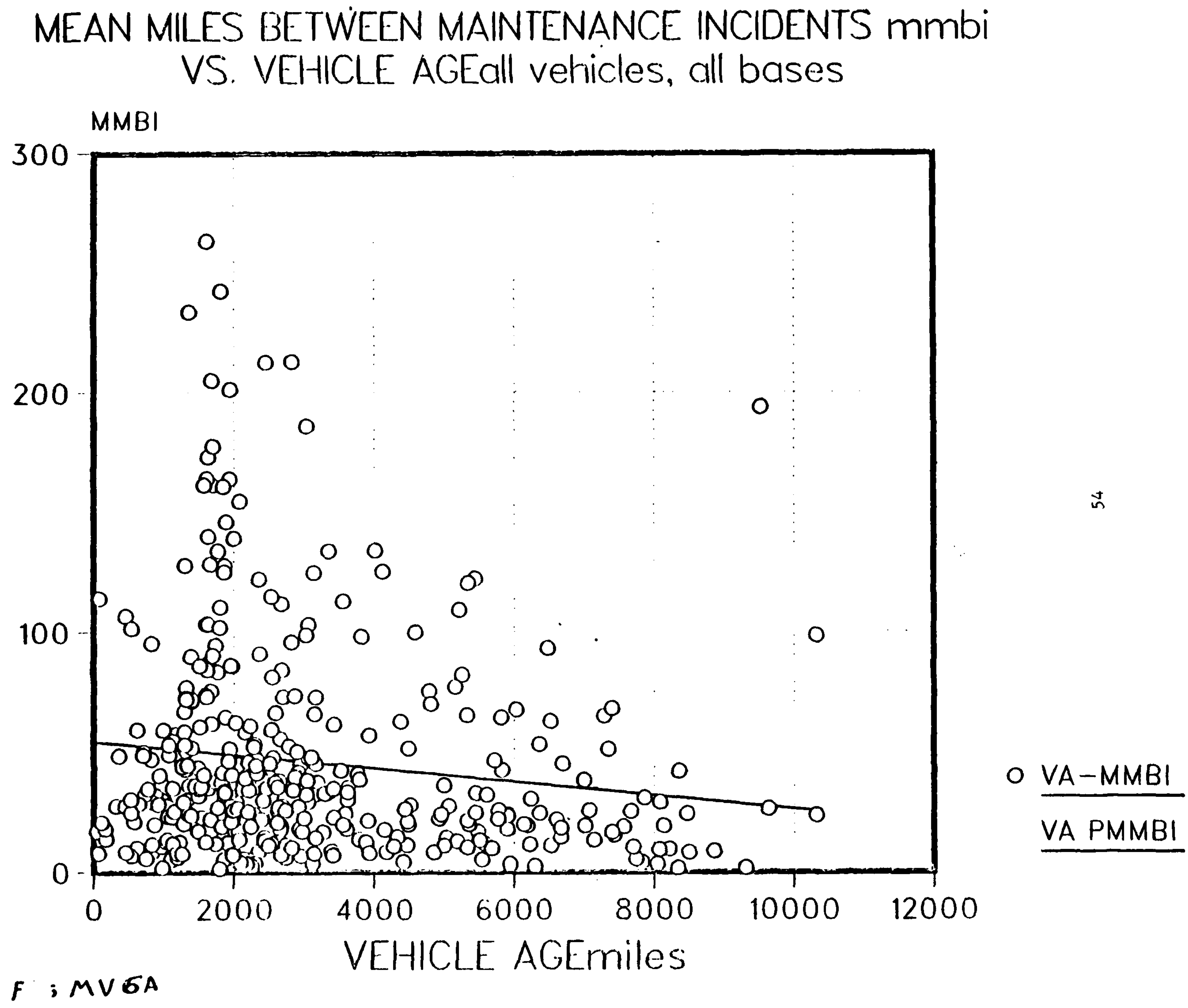


FIG. MV4 MMBI/BASE EFFECT
UNMODIFIED SDC DATA
397 VEHICLES





MEAN MILES BETWEEN MAINTENANCE INCIDENTS mmbi
VS. VEHICLE AGEall vehicles, all bases
MMBI
300
200
100
0
2000
4000
6000
8000
10000
12000
VEHICLE AGEmiles
VA-MMBI
VA PMMBI
F ; MV6A

FIG. MV5b MMBI/VEHICLE AGE IN 1000 MILE CELLS
UNMODIFIED SDC DATA
397 VEHICLES, ALL BASES

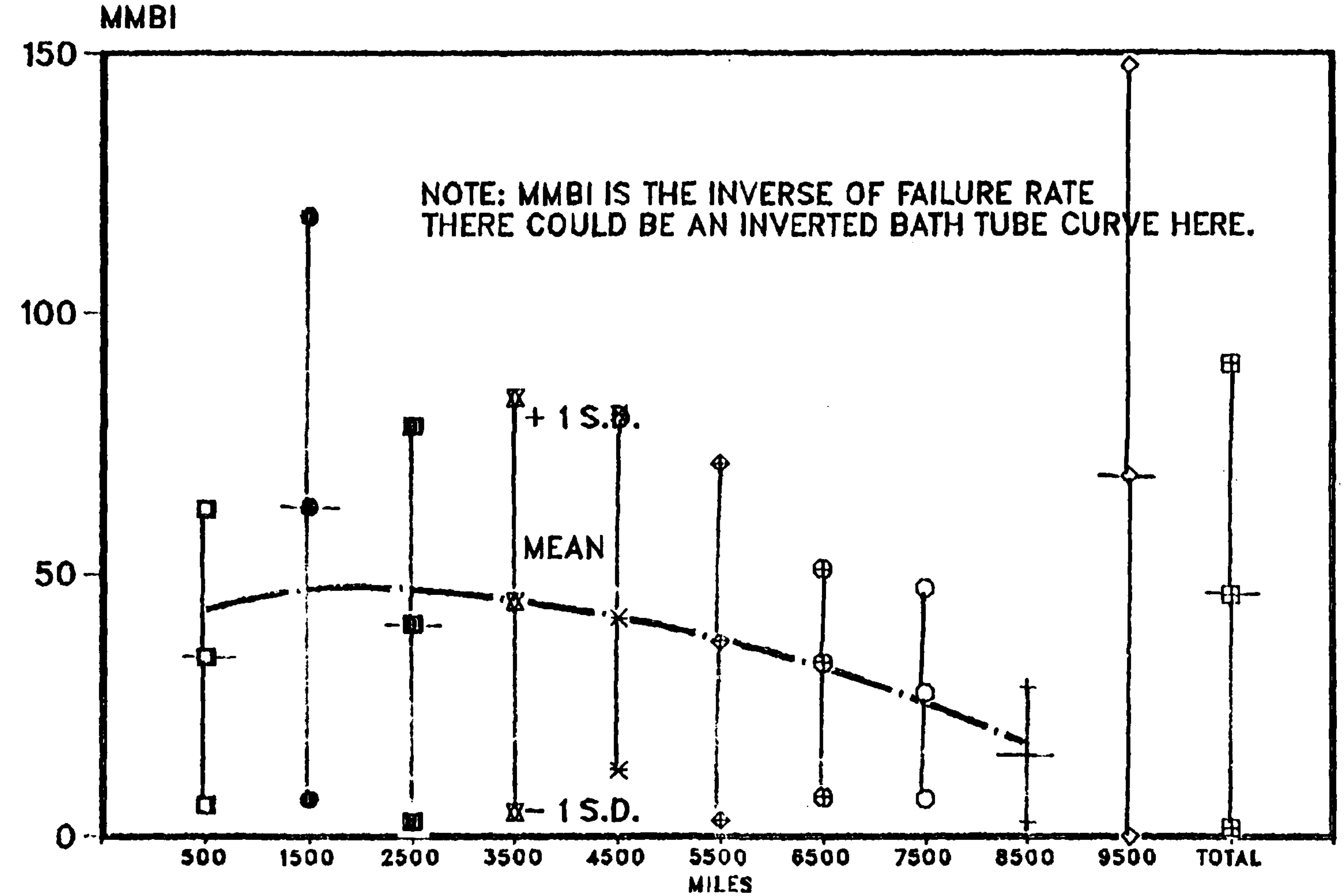


FIG. MVG MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI) VS. VEHICLE AGE (240 DEPOT VEHICLES, ALL BASES) UNMODIFIED SDC DATA

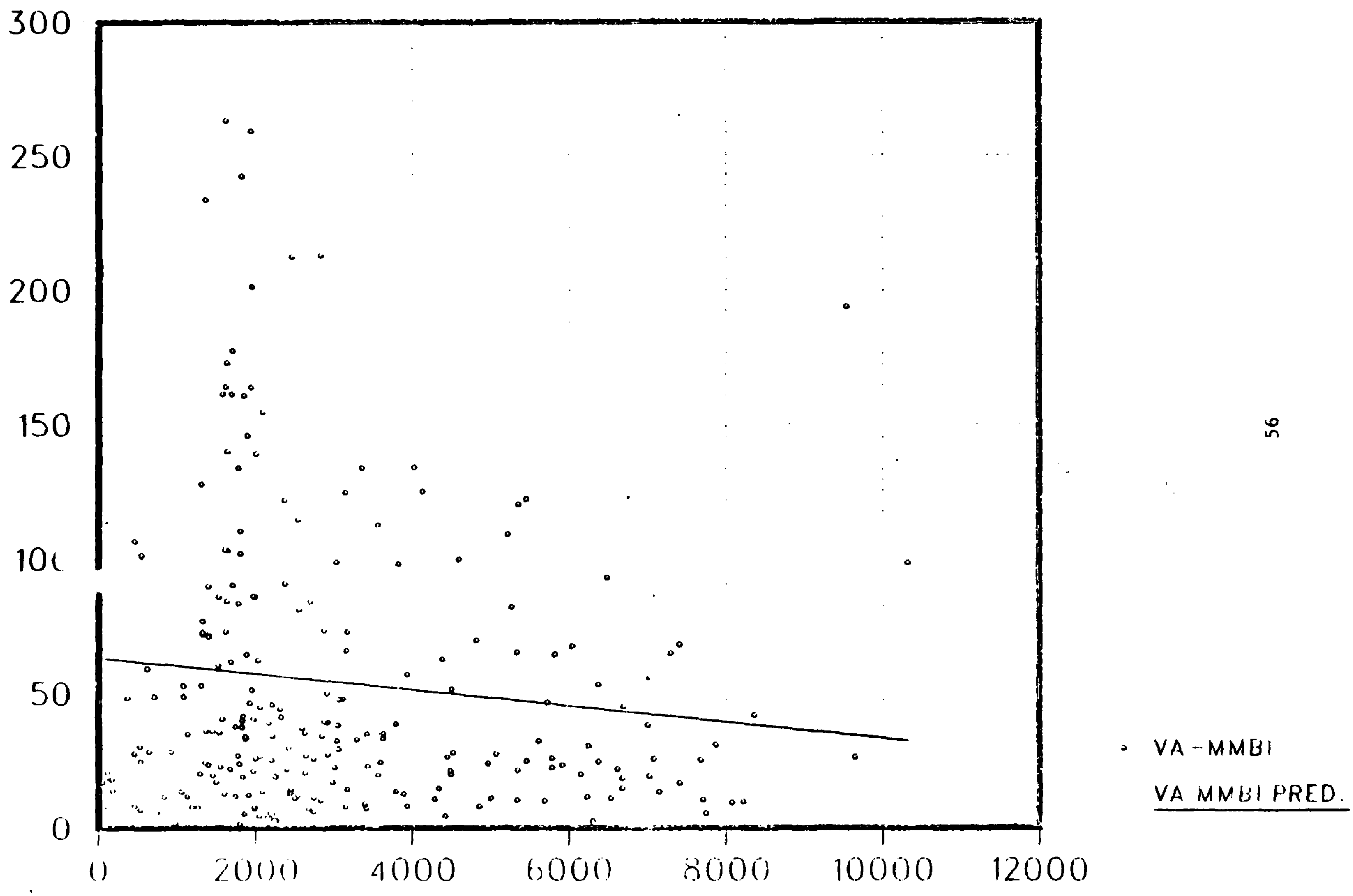


FIG. MV7 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI) VS. VEHICLE AGE(160 NON-DEPOT VEHICLES, ALL BASES) UNMODIFIED SDC DATA

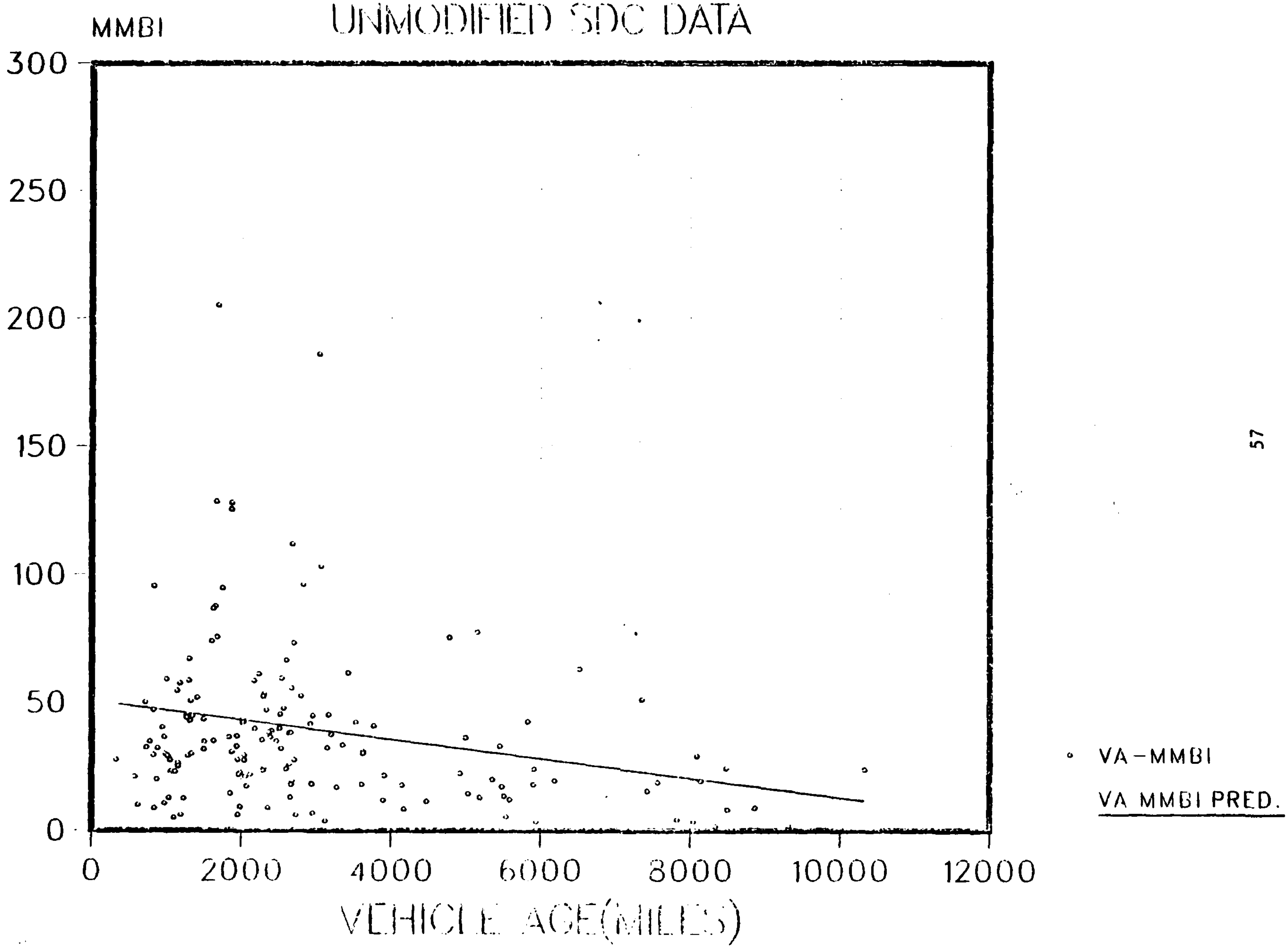
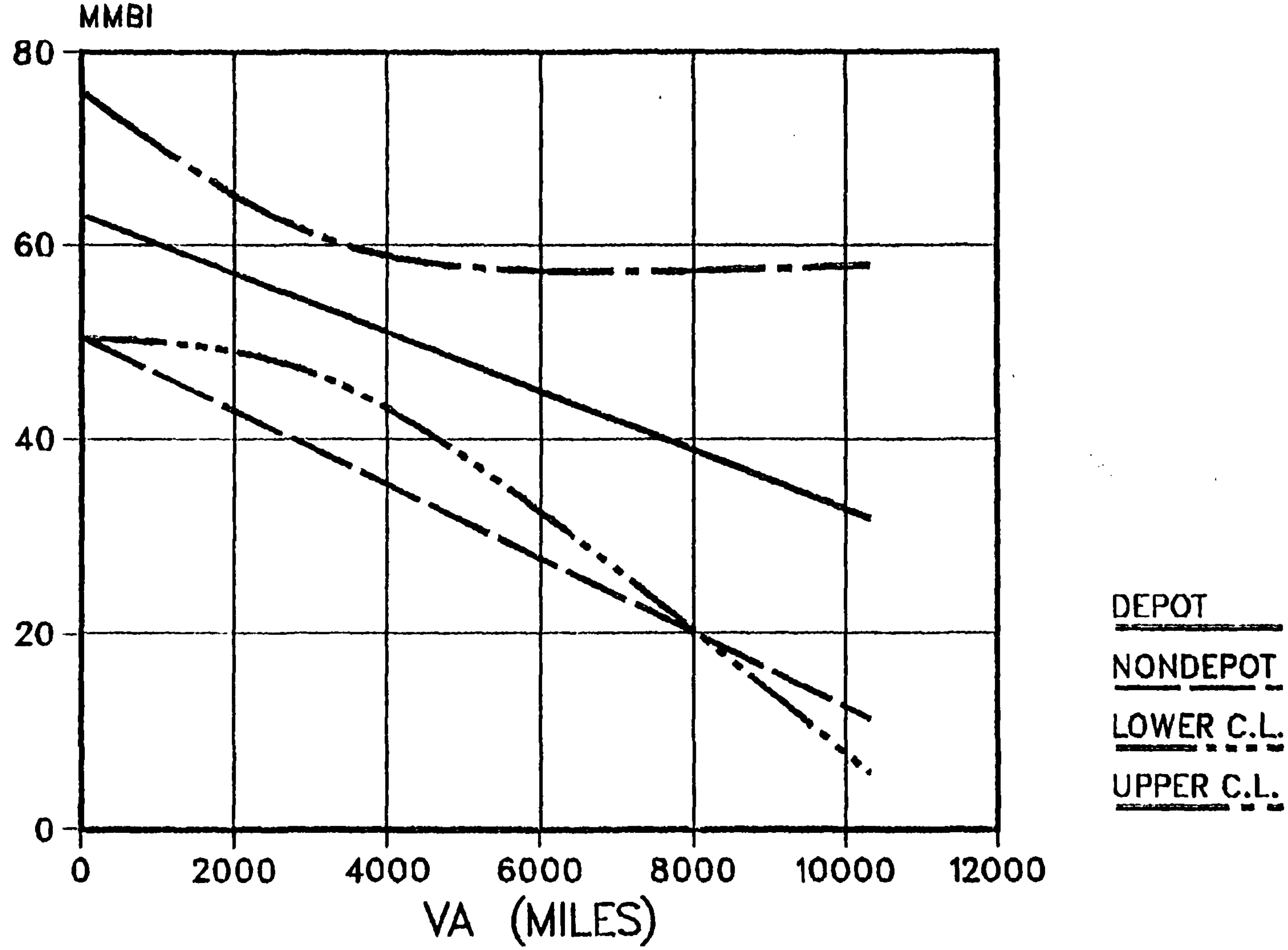


FIG. MV8 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI) VS. VA IN 1000 MILE CELLS(ALL VEHICLES, ALL BASES)



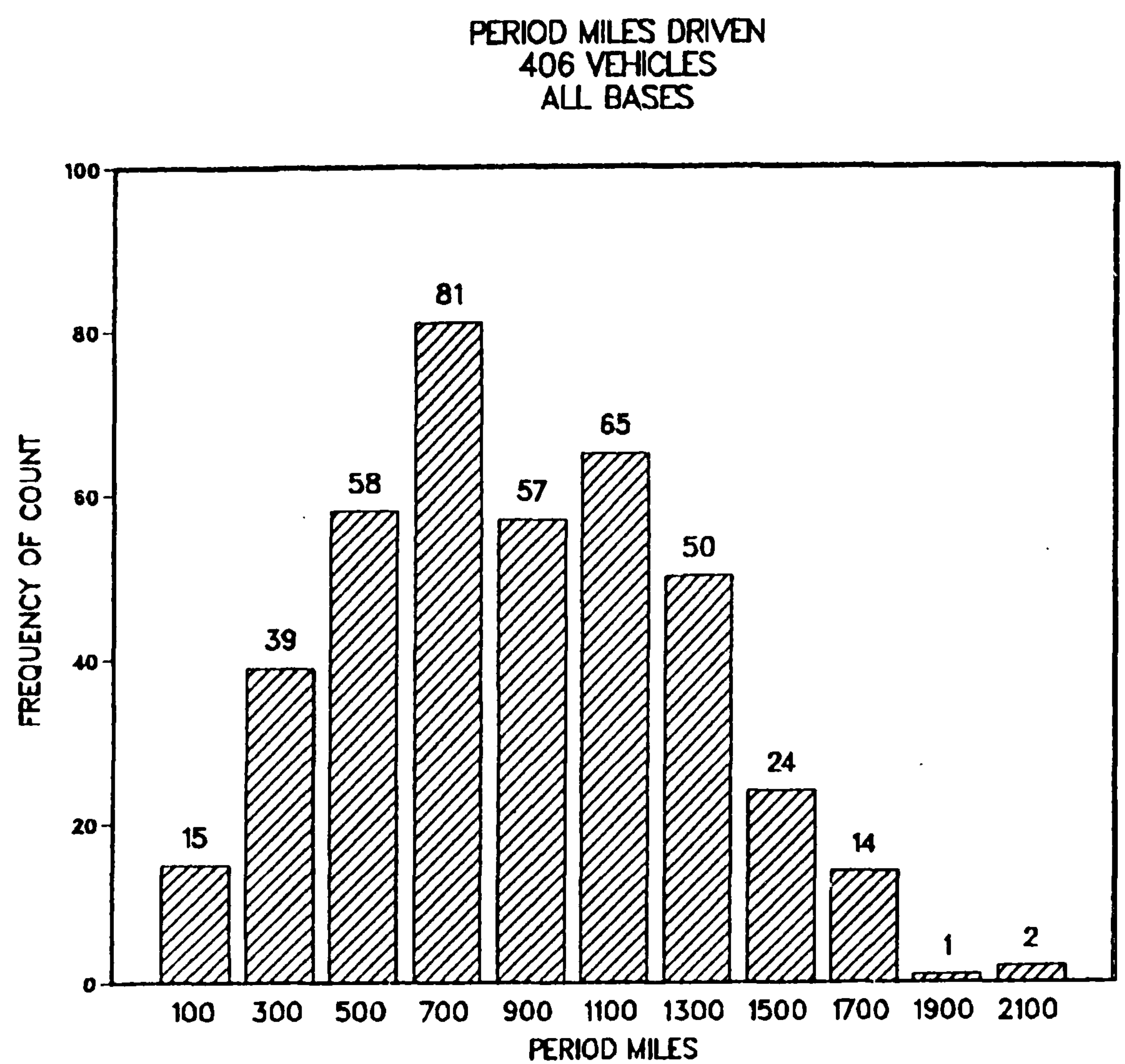

PERIOD MILES DRIVEN
406 VEHICLES
ALL BASES
FREQUENCY OF COUNT
0
20
40
60
80
100
15
39
58
81
57
65
50
24
14
1
2
100
300
500
700
900
1100
1300
1500
1700
1900
2100
PERIOD MILES

FIG MV9

FIG. MV10 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI)
VS. PERIOD MILES(397 VEHICLES, ALL BASES)
UNMODIFIED SDC DATA

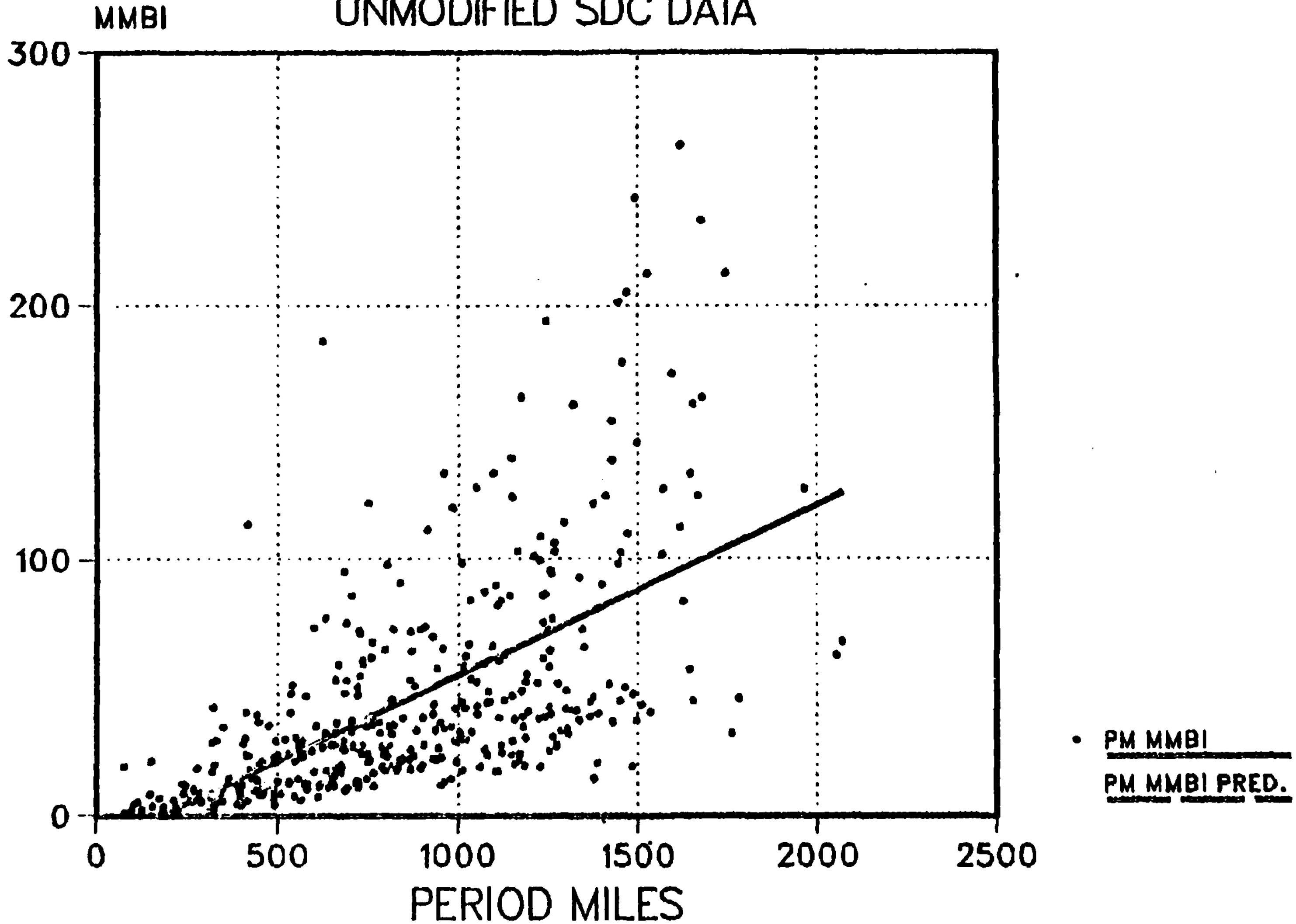


FIG. MV11 MMBI/PERIOD MILES IN 1000 MILE CELLS
UNMODIFIED SDC DATA
397 VEHICLES, ALL BASES

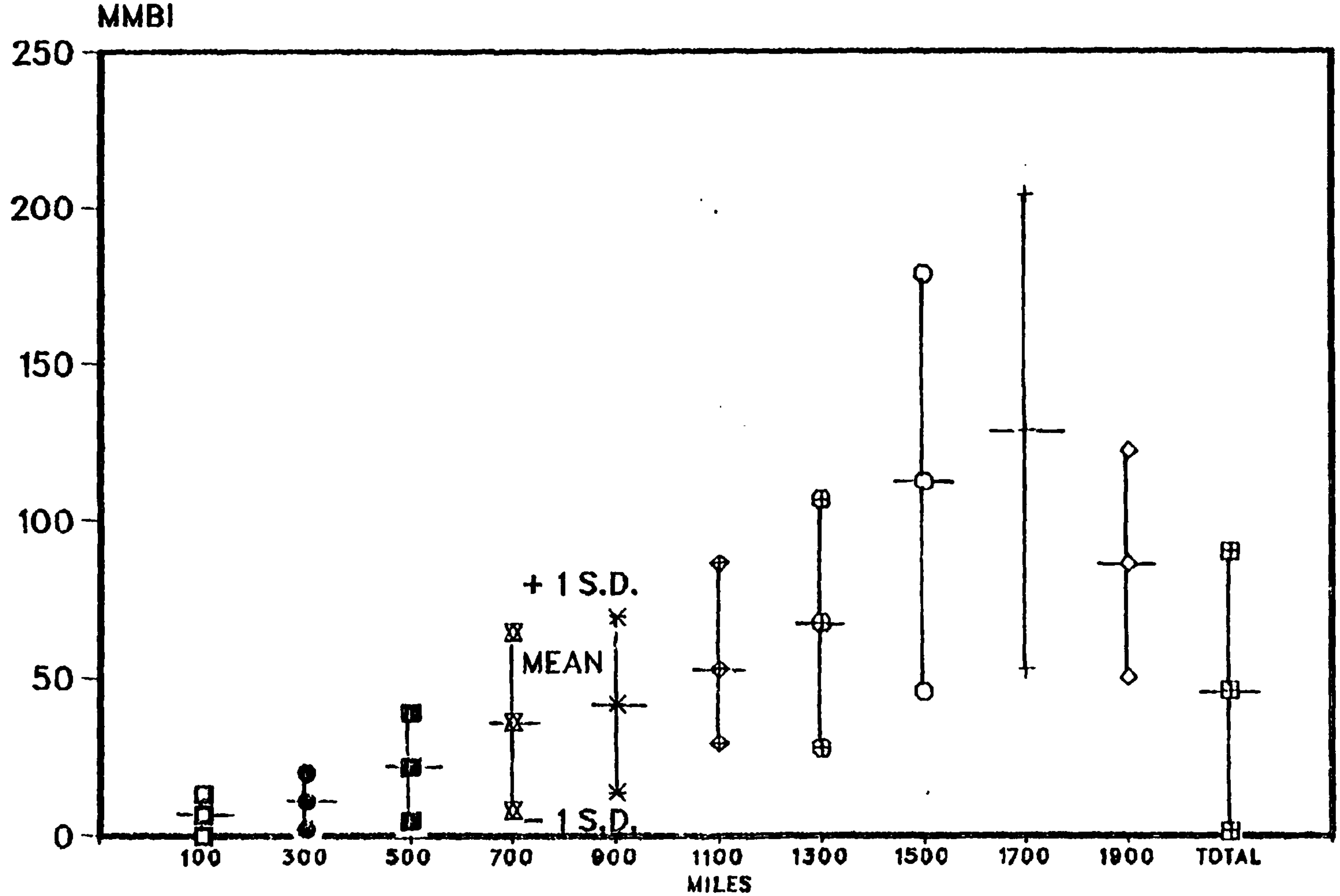


FIG. MV12 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI) VS. PERIOD MILES(397 VEHICLES, ALL BASES) WITH PM EFFECT REMOVED

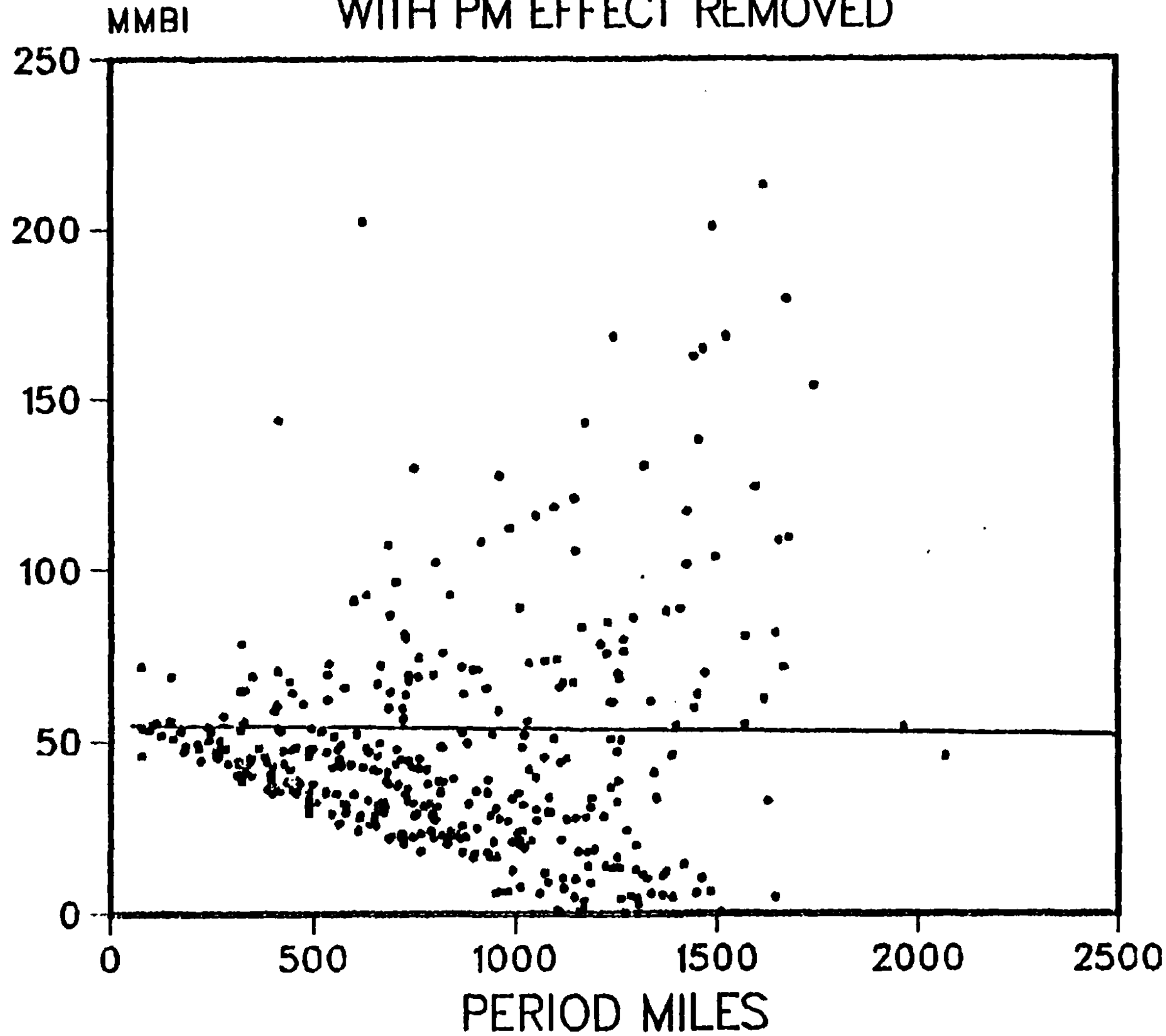


FIG. MV13 MMBI/PERIOD MILES IN 1000 MILE CELLS
397 VEHICLES, ALL BASES
WITH PM EFFECT REMOVED

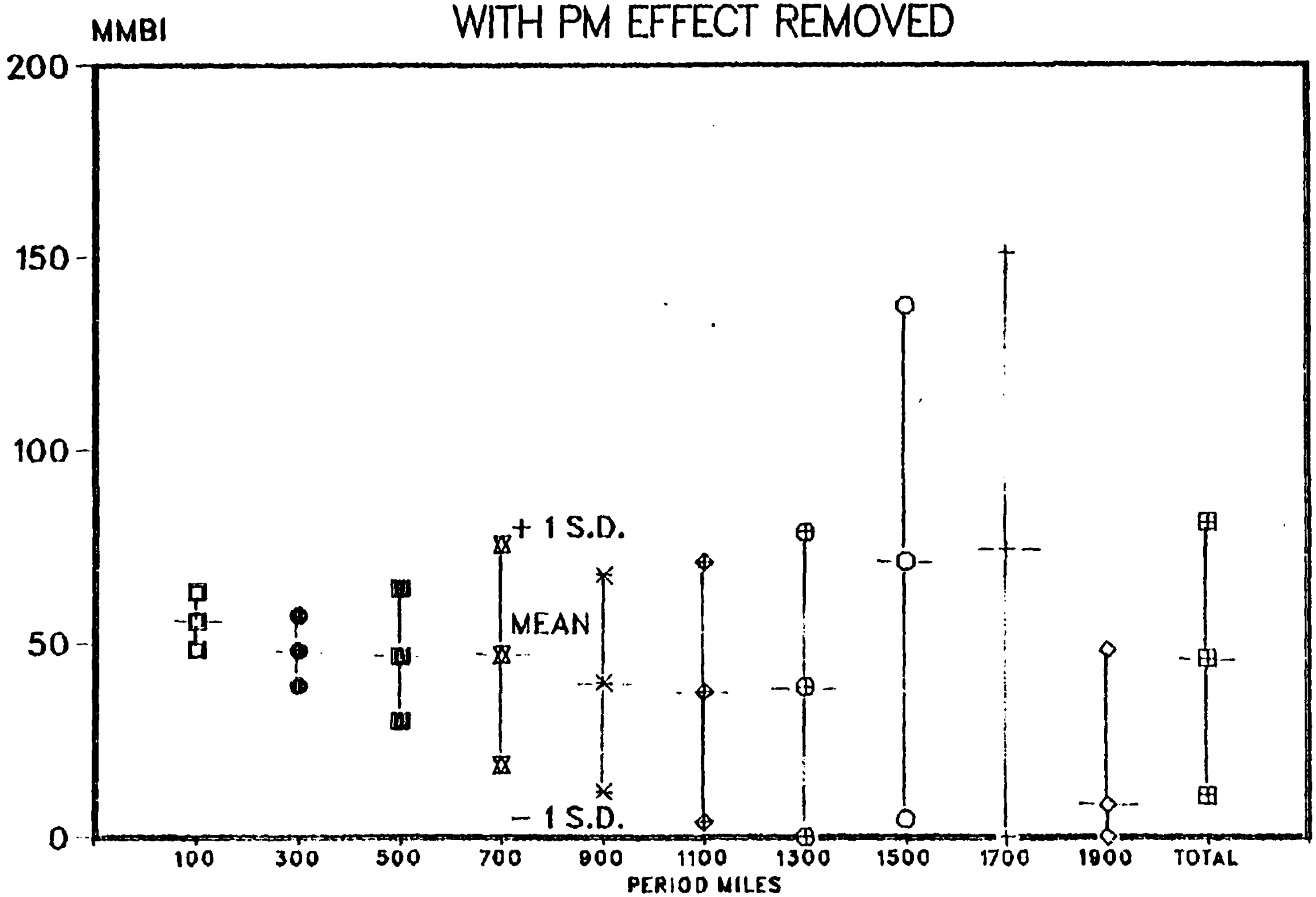


FIG. MV14 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI) VS. VEHICLE AGE(397 VEHICLES, ALL BASES) WITH PM EFFECTS REMOVED

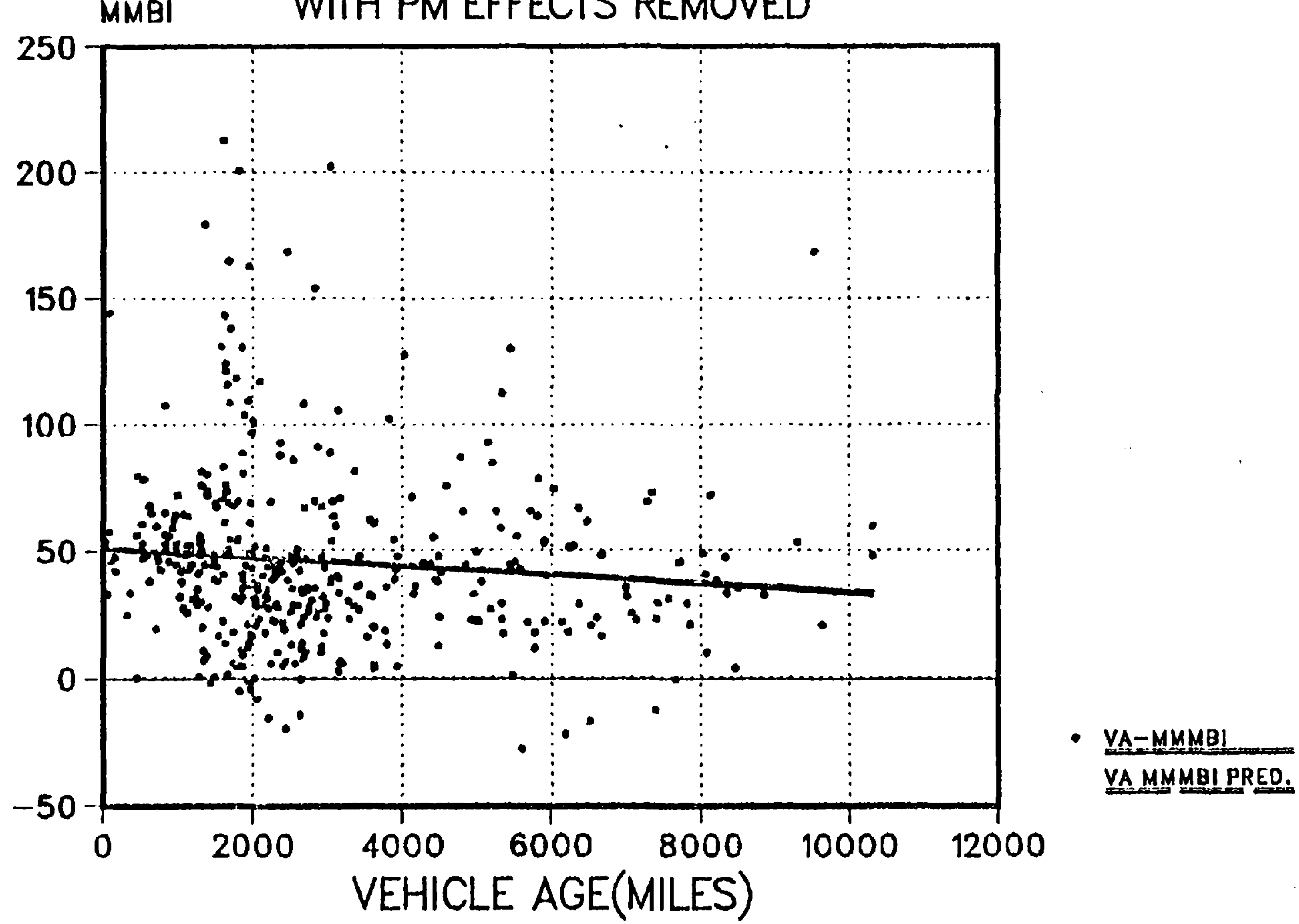


FIG. MV15 VMMMBI/VEHICLE AGE IN 1000 MILE CELLS
VA AND PM EFFECT REMOVED
397 VEHICLES, ALL BASES

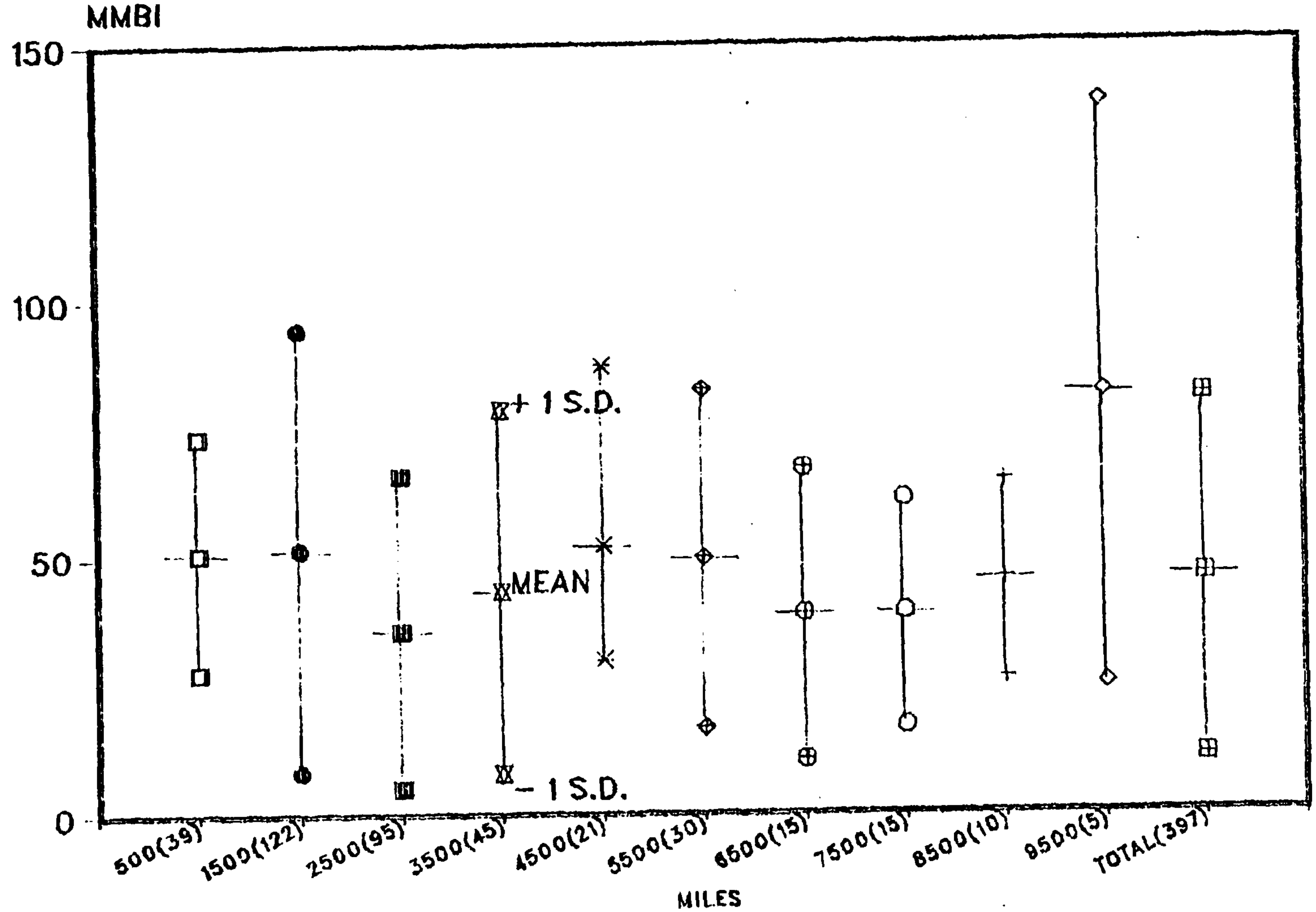


FIG. MV16–A MMBI/VEHICLE TYPE
WITH VA AND PM REMOVED
397 VEHICLES, ALL BASES

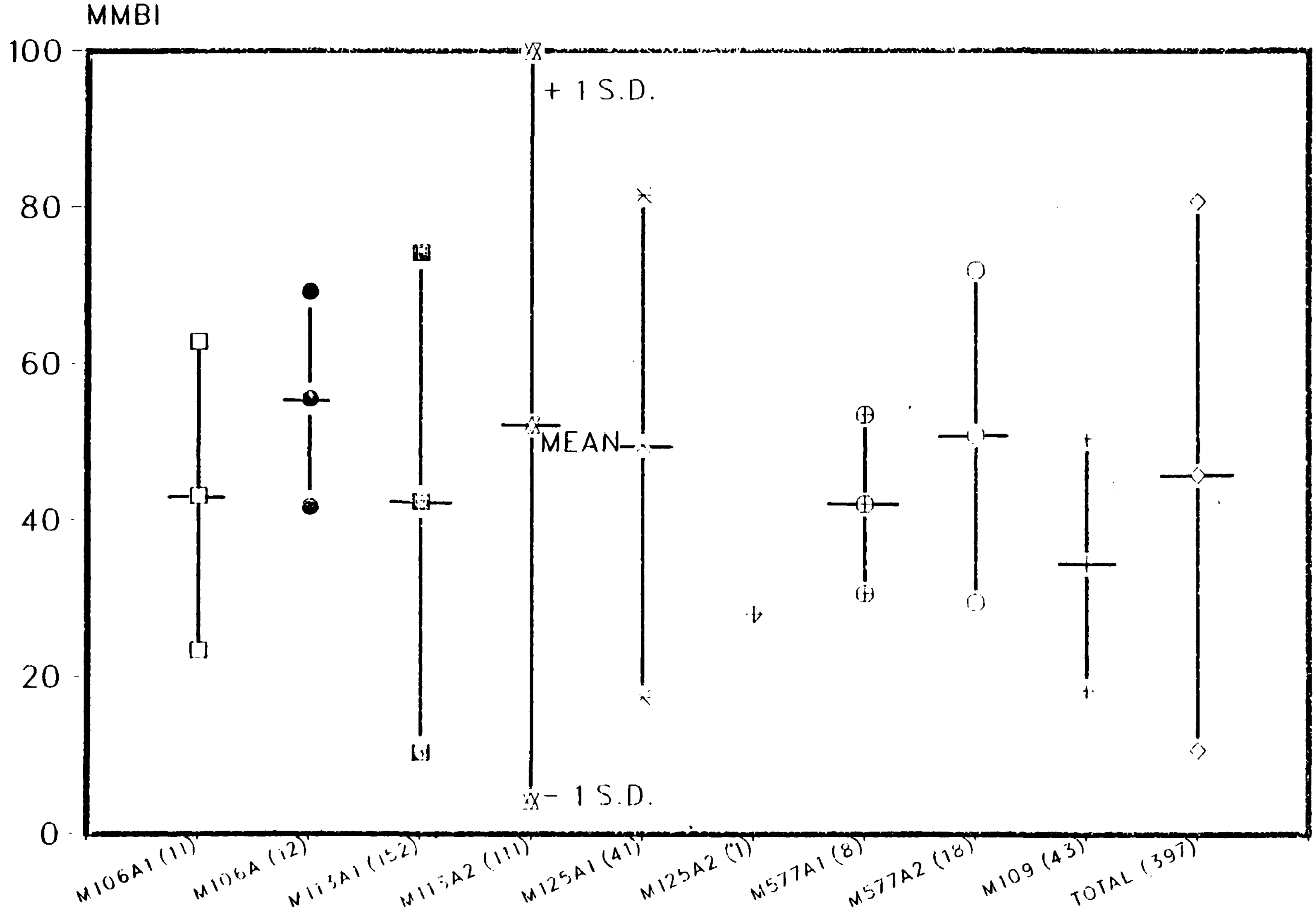


FIG. MV16-B MMBI/VEHICLE TYPE
WITH VEHICLE,VA AND PM REMOVED
397 VEHICLES, ALL BASES

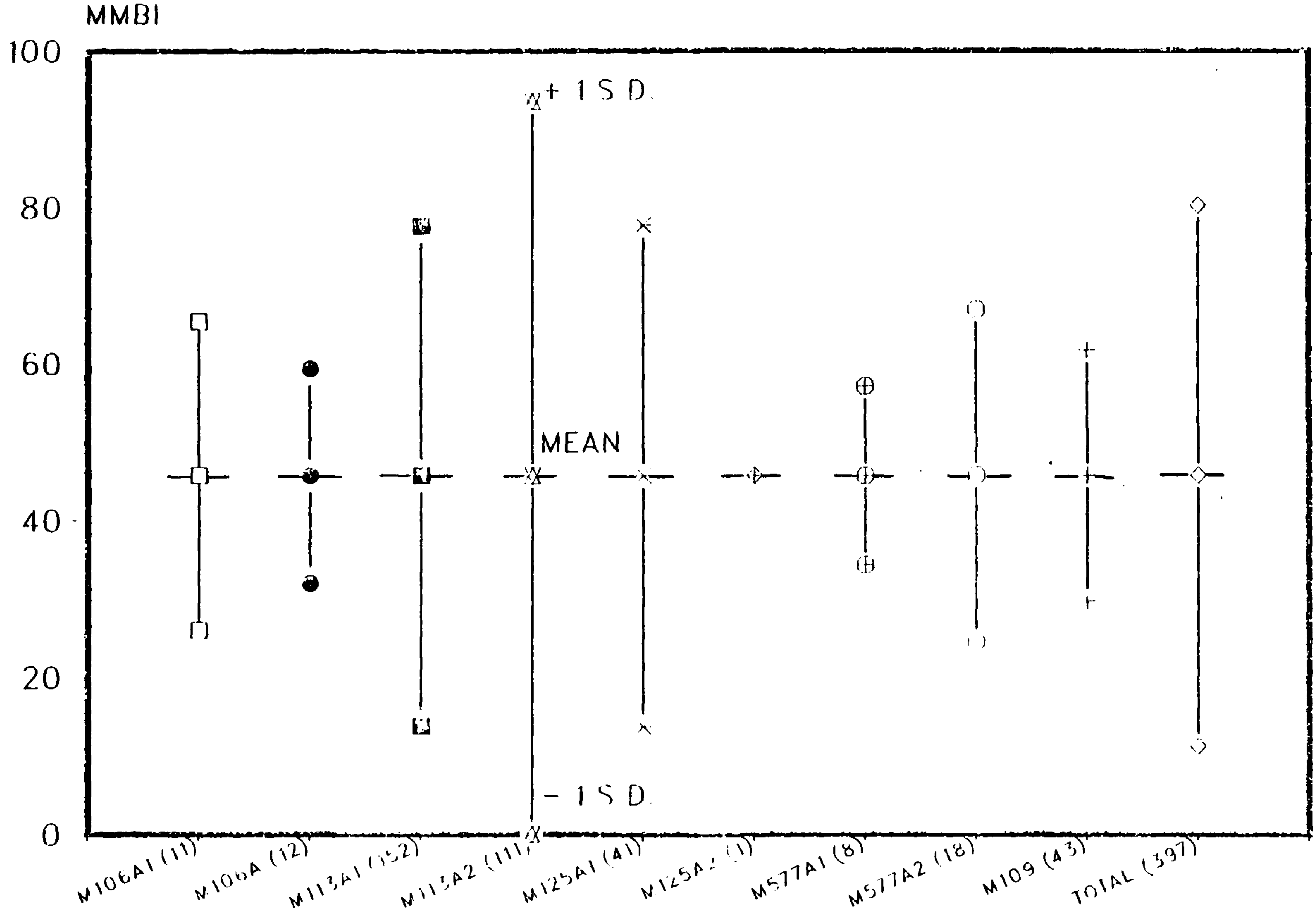


FIG. MV17 MMBI/BASE
VEHICLE,VA,PM EFFECTS REMOVED
397 VEHICLES

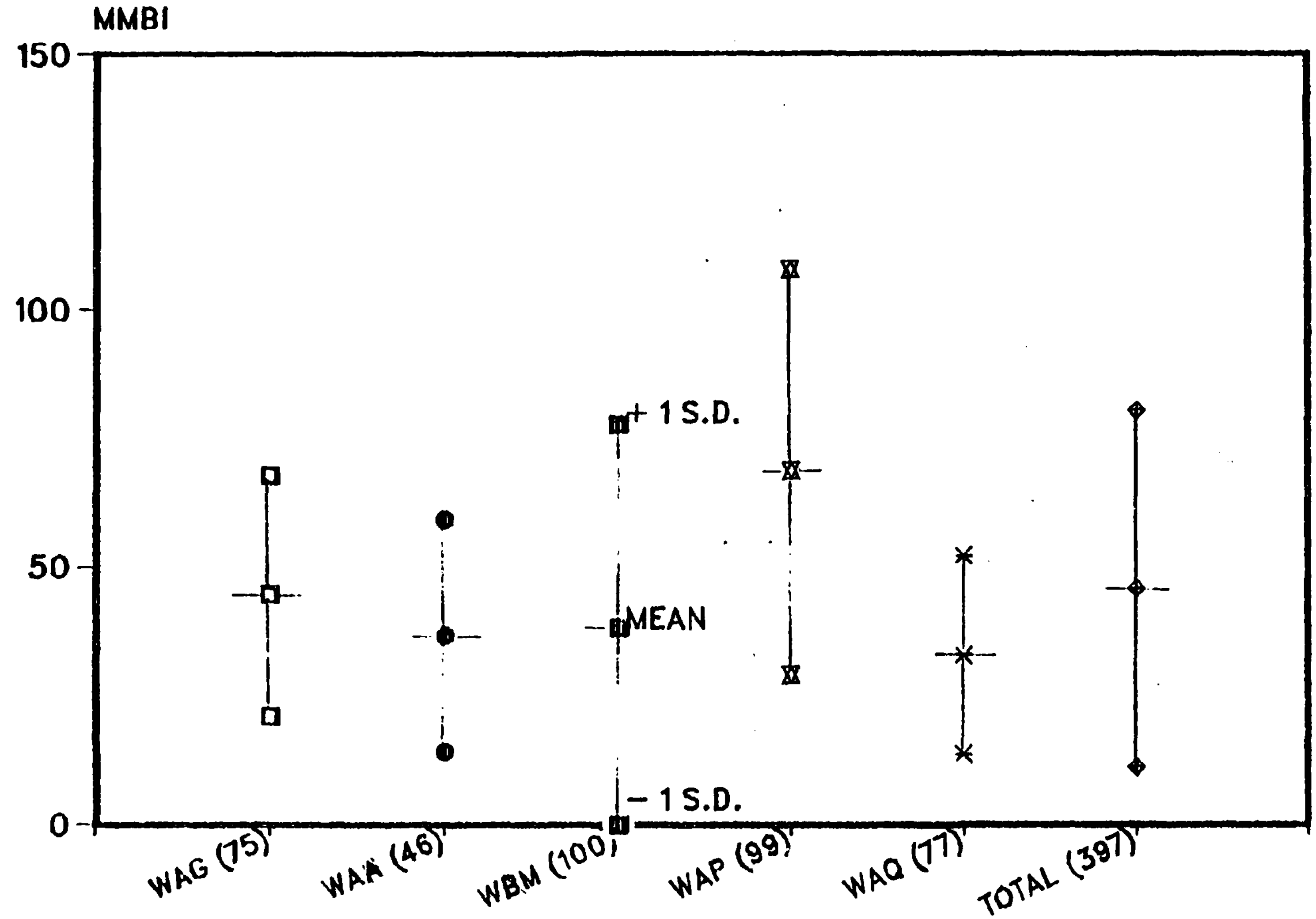


FIG. MV18 MMBI/BASE
BASE, VEHICLE, VA, PM EFFECTS REMOVED
397 VEHICLES

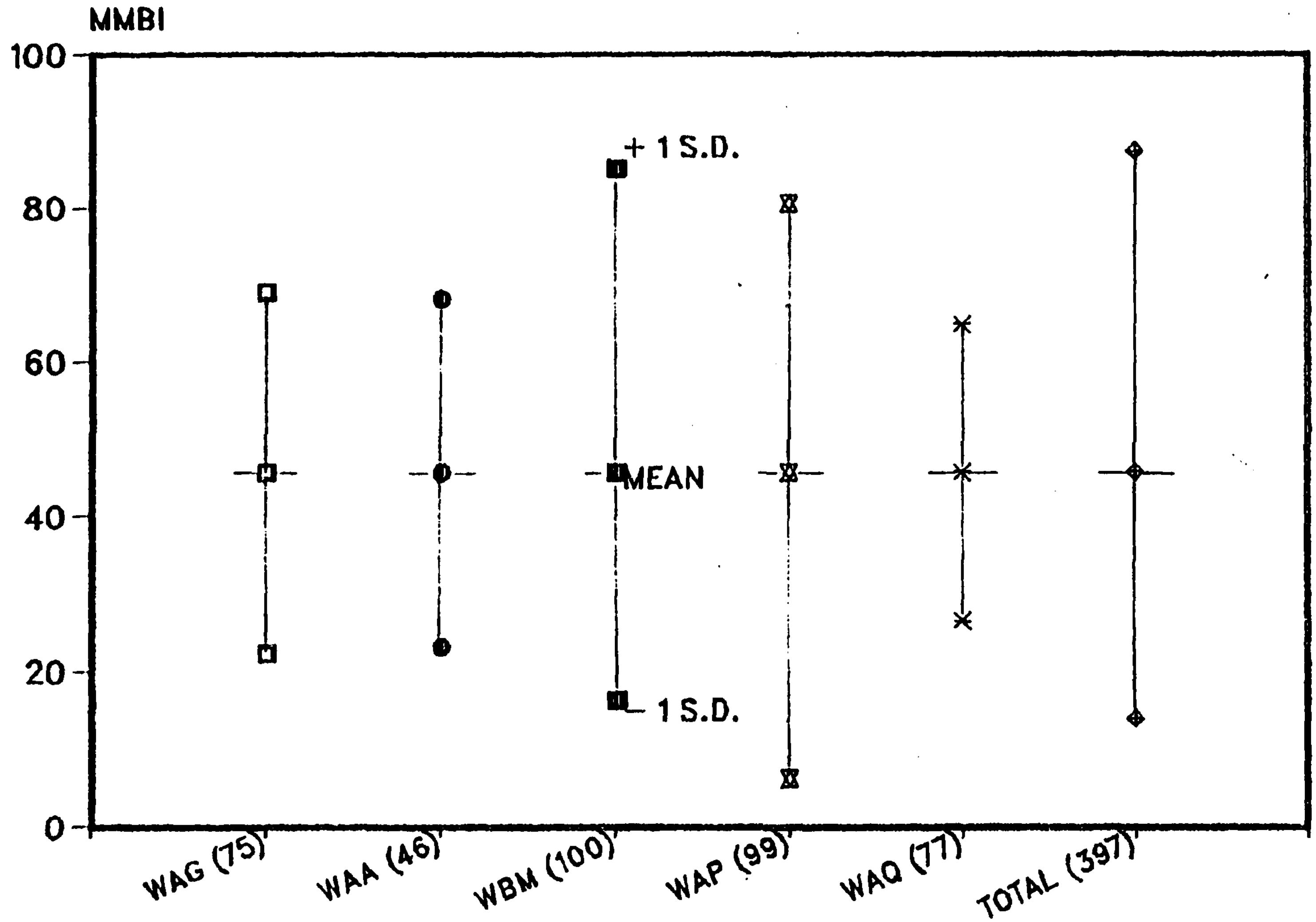


FIG. MV19 MMBI/DEPOT
BASE, VEHICLE, VA, PM EFFECT REMOVED
397 VEHICLES ALL BASES

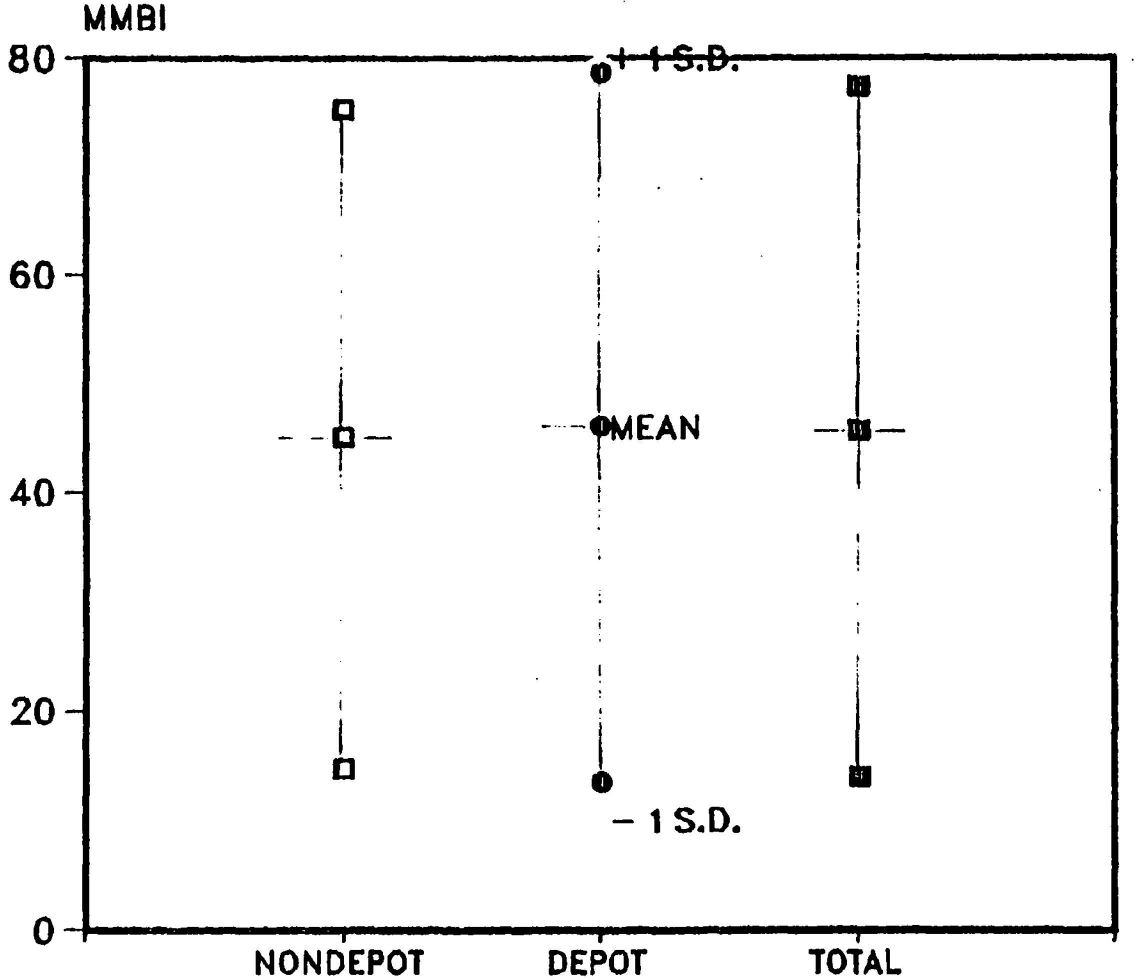
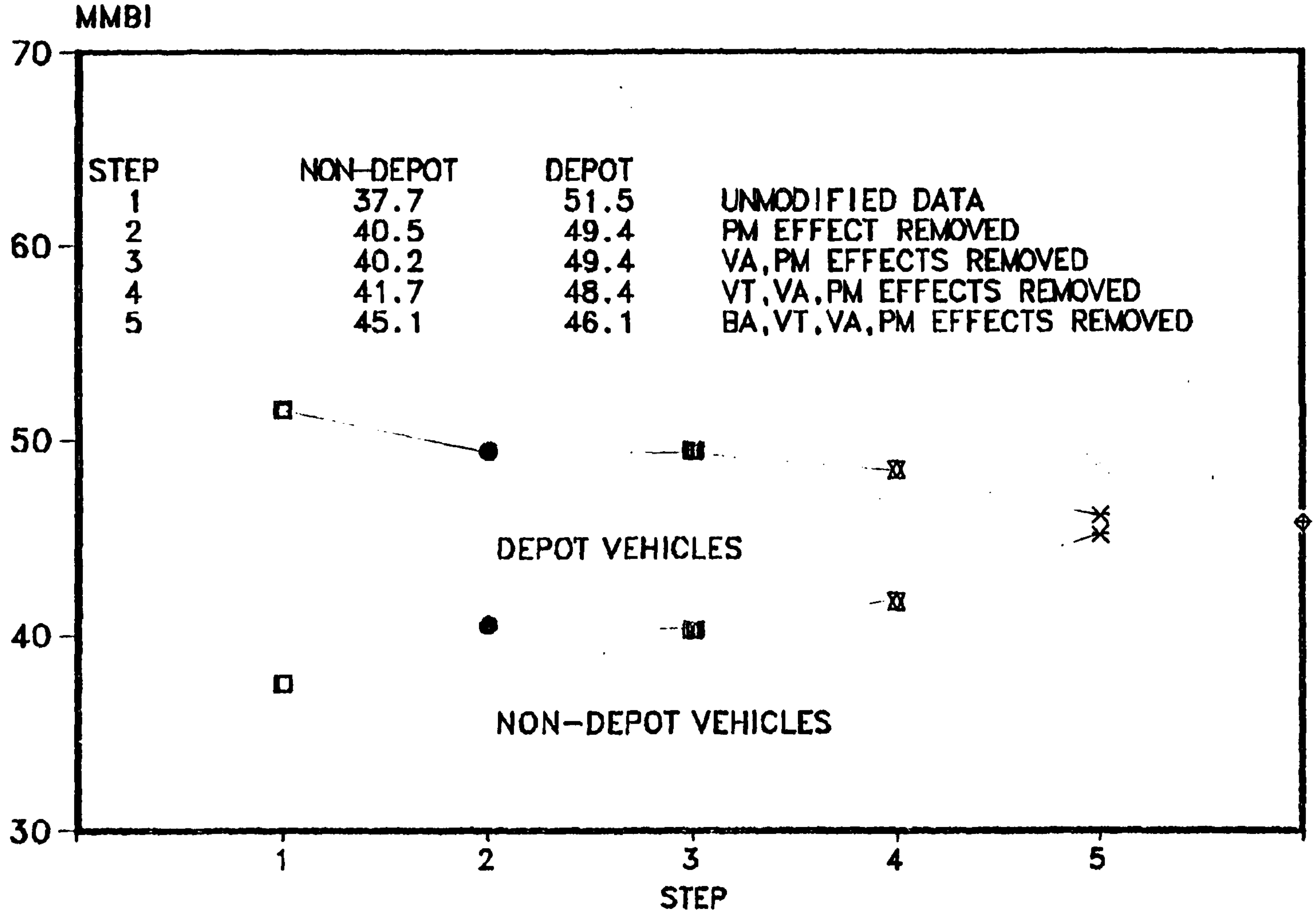


FIG. MV20 CHANGE IN DEPOT EFFECT AS BIASING FACTORS ARE REMOVED



ACTUAL VEHICLE FAILURE ANALYSIS

A vehicle failure is herein defined as a point in time when the vehicle is stopped for a repair. It could be because the vehicle was rendered inoperable due to the failed part or it could be a convenient point in its usage that allowed for an inspection and repair. M113 SDC data does not distinquish between either case. One or several failure incidents could be reported against the vehicle during this single stopping point. This failure measure results in two reliability measures, Mean Miles Between Failure (MMBF) where the total count of when the vehicle is stopped for repair is divided into the total cumulative mileage for each vehicle, and MMBFF where the mileage from start of SDC reporting to first failure and last failure to end of SDC reporting is eliminated from the mileage along with one failure. Mathematical expressions are as follows: Both measures are based upon unscheduled incidents only.

$$MMBF_i = \frac{\text{(TOTAL MILES DRIVEN)}}{\text{(TOTAL VEHICLE FAILURES)}}$$

$$(MMBFF)_i = \frac{\text{(MILEAGE FROM FIRST FAILURE TO LAST FAILURE)}}{\text{(TOTAL VEHICLE FAILURES -1)}}$$

(for i = 1 to 408 for each vehicle)

. The results of an analysis is presented in the following discussion. MMBFF was chosen because it was felt to be a more exact measure of actual vehicle failures or how long on the average could the driver expect the vehicle to operate once started. The analysis follows the Multi-vari analysis performed on the MMBI reliability measure. Hence no graphic results will be presented.

The data fit is again a skewed normal with a mean of 95.1 miles, a standard deviation of 66.6, a skewness of 1.8 and kurtosis of 4.9 (Reference Figure MV1 for comparison).

There were 3 outliers that were not omitted from the data for this analysis. The raw data showed mean of 89.7 MMBFF for non-depot vehicles and 98.8 MMBF for depot. Neither of which is statistically significantly different from the other. This is in agreement with the 3-way ANOVA analysis results.

The unmodified data showed the following bası effect means and variances:

	WAG	WAH	WAM	WAP	WAQ	TOTAL
Mean	90	85	69	104	129	95.1
SD	48	57	50	74	78	66.6
Qty	75	46	100	99	77	397

The unmodified data showed the following vehicle type effect:

	M106		M113		M125		M577			
	A1	A2	A1	A2	A1	A2	A1	A2	M901	Total
Mean	80	74	99	121	91	22	71	65	48	95.1
SD	53	46	66	79	63	--	28	34	17	66.6
Qty	11	12	152	111	41	1	8	18	43	397

The unmodified data showed the following vehicle age linear regression line.

MMBF = 2.6×10^{-3} (vehicle mileage) + 87.35 with again a mean of 95.1, a standard deviation of 66.6 and a goodness of fit measure of .08 (1.00 would be a perfect fit).

This has about the same magnitude as in the MMBI analysis, however it is an increasing effect. The MMBFF data also shows a very strong period miles effect with the following linear regression line.

$$\text{MMBFF} = 8.6 \times 10^{-2} \text{ (period miles)} + 20.0$$

with a mean of 95.1, standard deviation of 66.6 and a goodness of fit measure of .52 (a good fit for this scatter data).

Removing each biasing effect using the same technique used for the MMBI Multi-vari analysis results in the following difference in the depot and non-depot vehicles:

	Non-depot	Depot	Total
Mean	95.7	95.0	95.3
SD	49.0	50.3	49.7
VCA	159	238	387

The conclusion drawn here is there is no significant difference in the expected mean miles to when the vehicle is stopped for repair. This applies to base effect and vehicle type effect. Vehicle age has a slight beneficial effect and there is a strong period miles effect.

FIRST FAILURE ANALYSIS

Since both non-depot and depot vehicles tend to become homogeneous as field failed components are replaced on each alike, a true measure of reliability of depot and non-depot vehicle performance would be to track field failure history on those components receiving some depot process and compare those with the new component performance.

This is not possible within the M113 SDC data. First, because the data does not track either new or depot processed vehicles from a zero miles condition and second, of more importance, is that the processing depot does not record which components received depot processing on an individual vehicle basis, let alone what type of depot process they received.

This lack of record keeping on an individual vehicle basis at the depot precludes any analysis attempting to determine field reliability performance of depot processed vehicles as compared to new components.

DEPOT ACTION EFFECT

The second object of this study is to assess the impact of specific depot actions and procedures on reliability of the M113 FOV in the field. This is of special interest since the depot procedures have changed the DMWRs that required complete overhaul to gradually transition to an Inspect and Repair (I&R) procedure. The vehicles under M113 SDC represent this transition period from 1970 thru 1982. Even though the emphasis in later years is on I&R, the depot tendency is to do as complete an overhaul as possible. An investigation of actual depot practices would likely disclose that there is not much difference in the depot overhaul and established I&R practice up thru 1982. Reliability impact from changes in specific DMWRs cannot be assessed due to lack of record keeping on specific depot vehicles. History of DMWR changes is available along with variation practices to these DMWRs. However, no records as to what was specifically done at each vehicle or even blocks of vehicles were kept by the processing depot. Without knowing the history of at least the major components on the M113 depot vehicles, evaluating the field reliability impact of DMWR changes is impossible to accomplish.

A look at reliability of depot vehicles vs year of depot action can be assessed and is shown in Figure DA1. This is with the unmodified data. This figure shows a reliability growth from 1970 to 1982. However, this data is biased the same wasy as shown in the Multi-vari methodology. It reflects a parallel in vehicle age effect and possibly a period miles effect since younger vehicles have a slight tendency to be driven more. The year of depot effect was again assessed with the unbaised data, that is with vehicle age, period miles, vehicle type and base effects removed. This is shown in Figure DA2. This linear regression fit is essentially flat. The standard deviation for each year was determined and plotted in Figure DA3. From this the conclusion can be easily made that there is no significant difference in the reliability of depot vehicles over the year of their depot action.

This conclusion endorses the current I&R practice of depot processing in that the transition from complete overhaul to I&R such as it is has not degraded the field reliability of depot vehicles. The number of vehicles within each year are shown in Figure DA3. This mean shown with less than 5 vehicles should not be taken as a valid representation.

DATE OF DEPOT ACTION EFFECT
ON RELIABILITY OF DEPOT VEHICLES

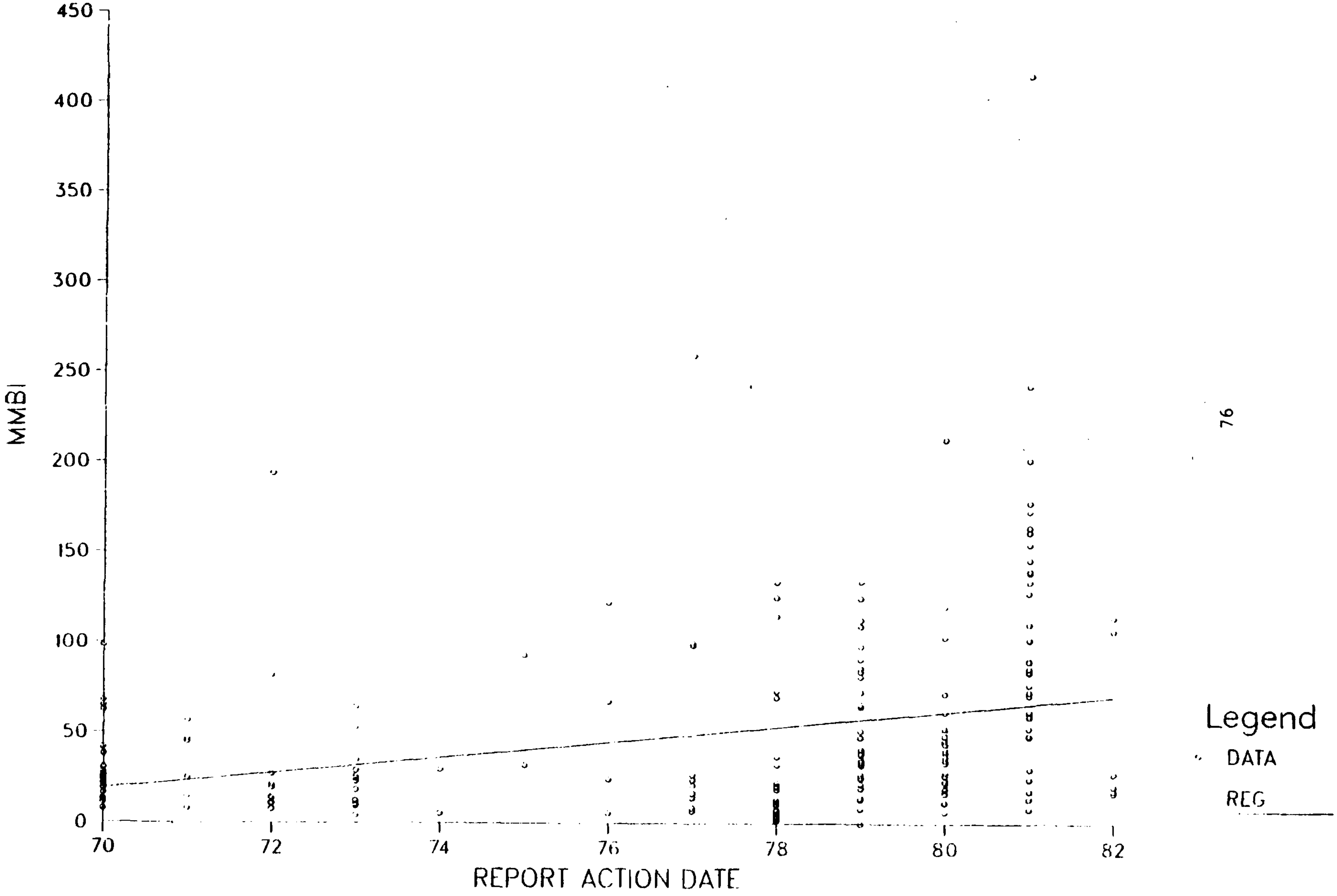


FIG. MV21 MEAN MILES BETWEEN MAINTENANCE INCIDENTS (MMBI) VS. YEAR OF OVERHAUL (236 VEHICLES, ALL BASES) VA,PM,VEH,BA EFFECTS REMOVED

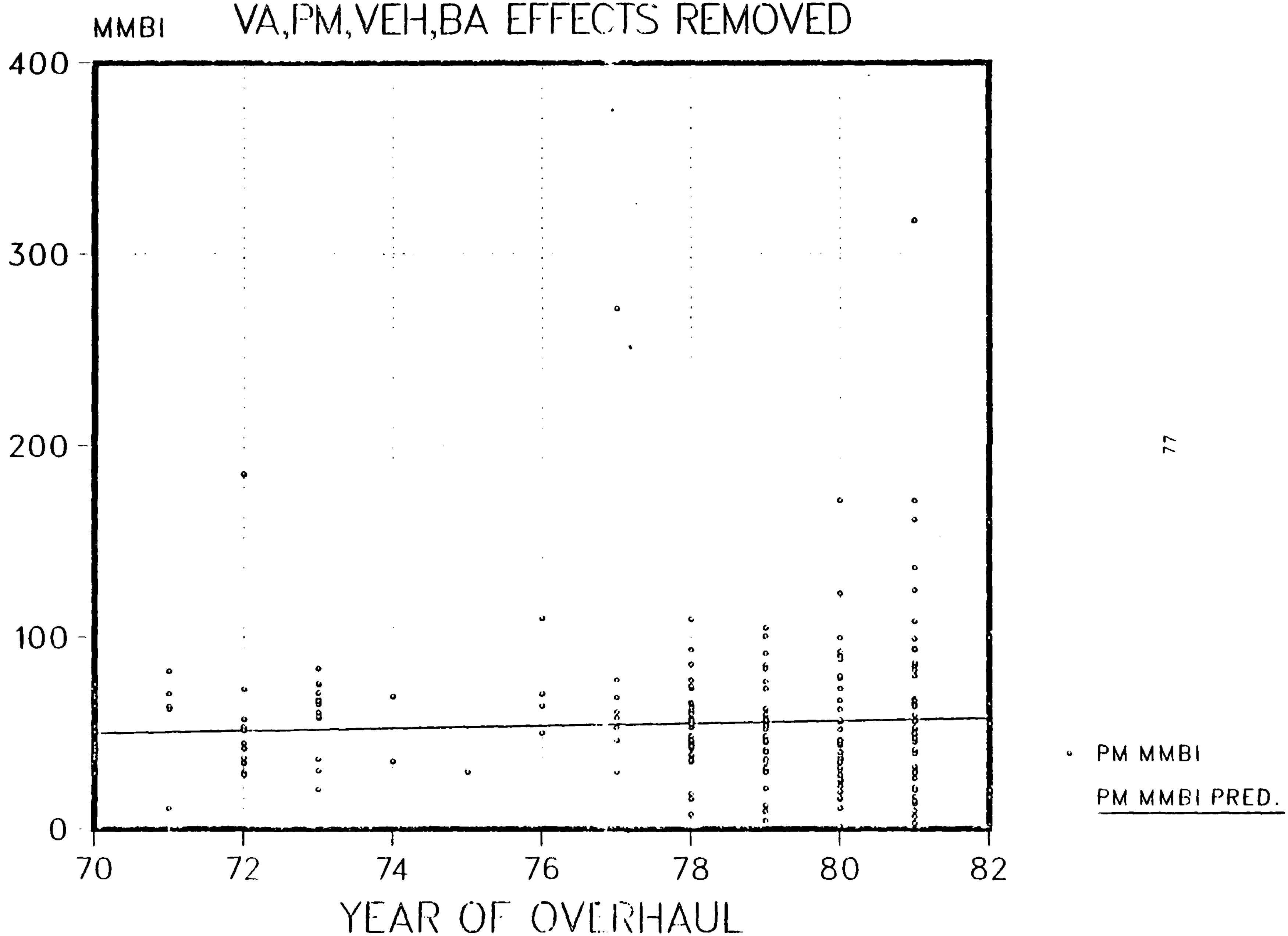
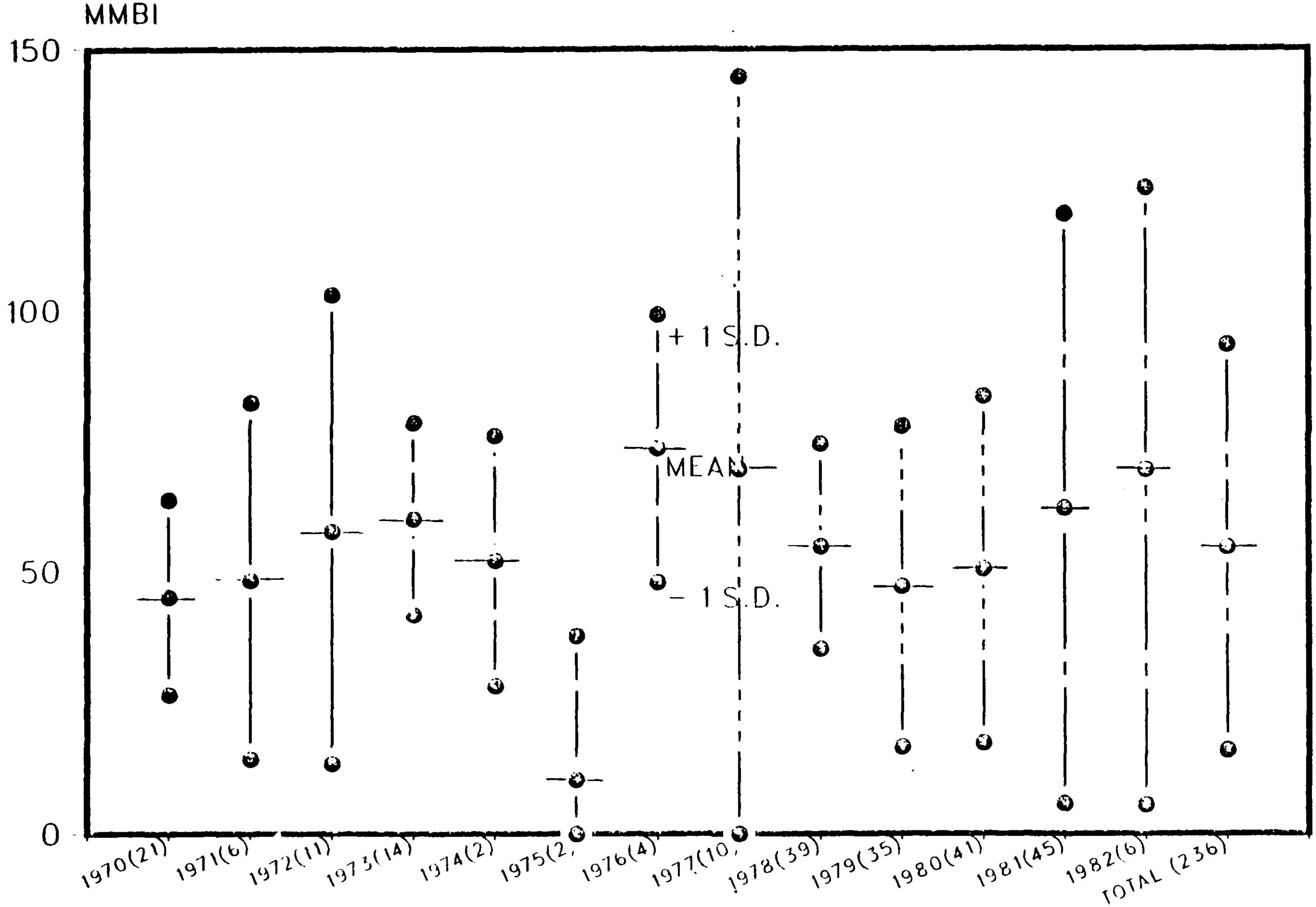


FIG. MV22 MMBI/YEAR OF OVERHAUL
WITH BASE,VEHICLE,VA AND PM EFFECTS REMOVED
236 VEHICLES, ALL BASES



Q-SERVICE EFFECT ON RELIABILITY

The Quarterly service maintenance performed on the M113 SDC vehicles should have an effect on their reliability. This should be especially true since not all vehicles get Q-services on a regular basis. Some vehicles at each of the 5 bases under SDC received no Q-service and some received a total of 6 over the 4 plus quarters reporting period. The normalized ratio of Q-service performed at each base is shown in Figure QS1. Each value is normalized to account for the different number of vehicles at each base. It should be noted that this is Q-service reported and may not represent the actual Q-service performed.

Since the SDC reporting period is for 4 quarters, a zero reading at each level and a max level at 4 would represent a perfect record. Obviously from Figure QS1, each base has a far less than perfect record. Two bases appear to have a slightly better record than the others, these are WAQ (Mannheim) and WAQ (Ft. Stewart), with WAM (Aschaffenberg) not far behind.

The number of Q-services reported on depot and non-depot vehicles was plotted against the strongest reliability measure MMBI in Figure QS2 and QS3. A regression line was fitted to each curve after Q-service points 5 and 6 were lumped into Q-service 4 data point. The result is shown in Figures QS4 and QS5. This shows that the number of Q-services performed has no effect on reliability for non-depot vehicles and a possible slight increasing effect for depot vehicles. This slight increase is not significant.

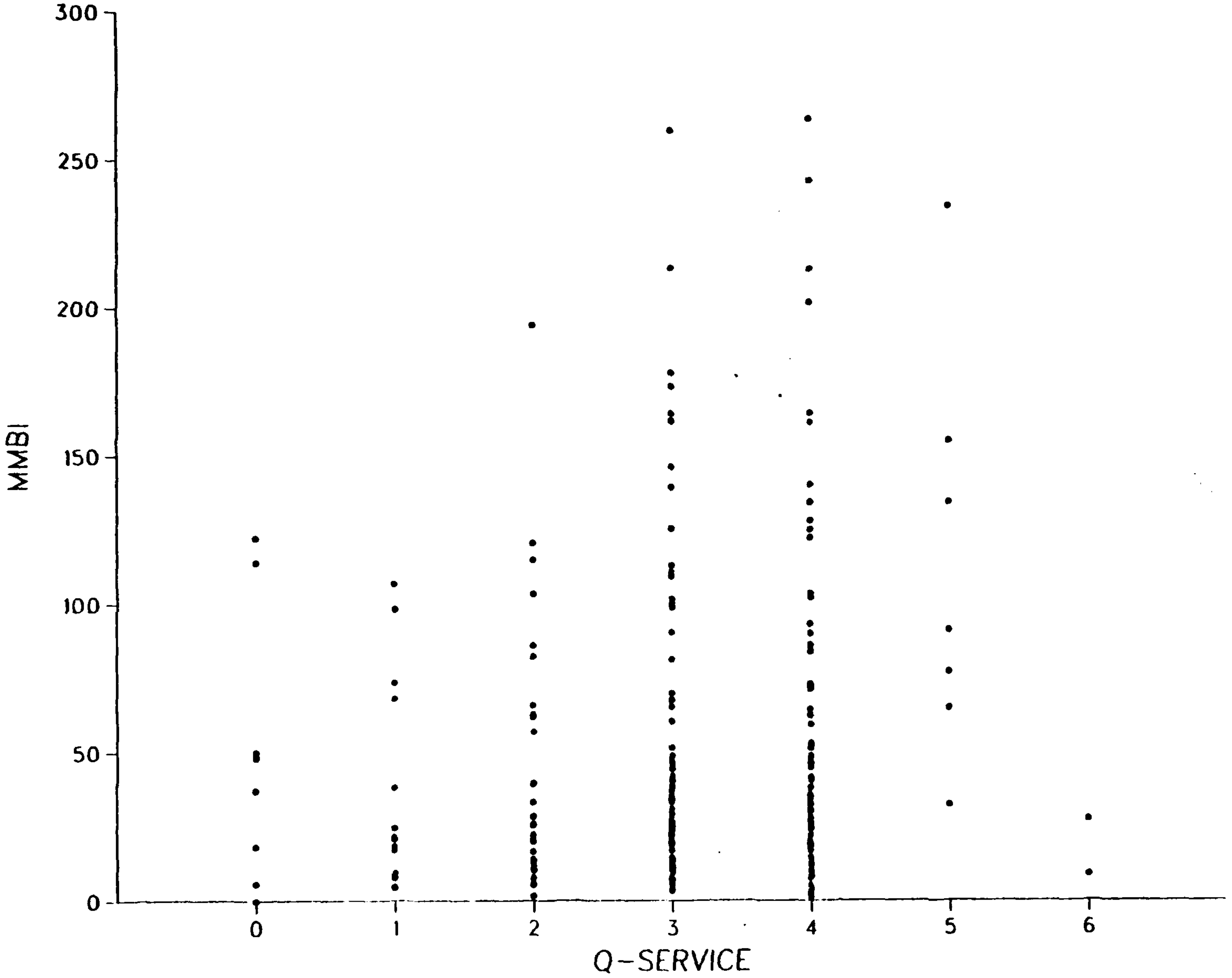
Perhaps it is not the quantity of Q-services performed, but the quality of service performed. The quality of Q-service performed should be measured by the manhours expended during the Q-service action. That is the more manhours expended, the more thorough the Q-service should be. The manhours expended during Q-service ranged from 0 to 200 for both crew and organization. The distribution of each along with clock time is shown in Figure QS6. The explanation of why there is such a large dispersion in the number of hours used to perform a standard procedure Q-service is not known. It could well reflect the quality or thoroughness of the Q-service as assumed above.

Proceeding with this assumption, the total (sum of crew and organization manhours expended on all Q-services performed on each vehicle was plotted against its reliability measure MMBI for both depot and non-depot vehicles. These are shown in Figures QS7 and QS8. The linear regression fit through the depot data shows a strong positive interaction. This shows that the more manhours expended on Q-service for depot vehicles, thus the more thorough it is, the better the reliability performance of the depot vehicle. This relationship is quite strong.

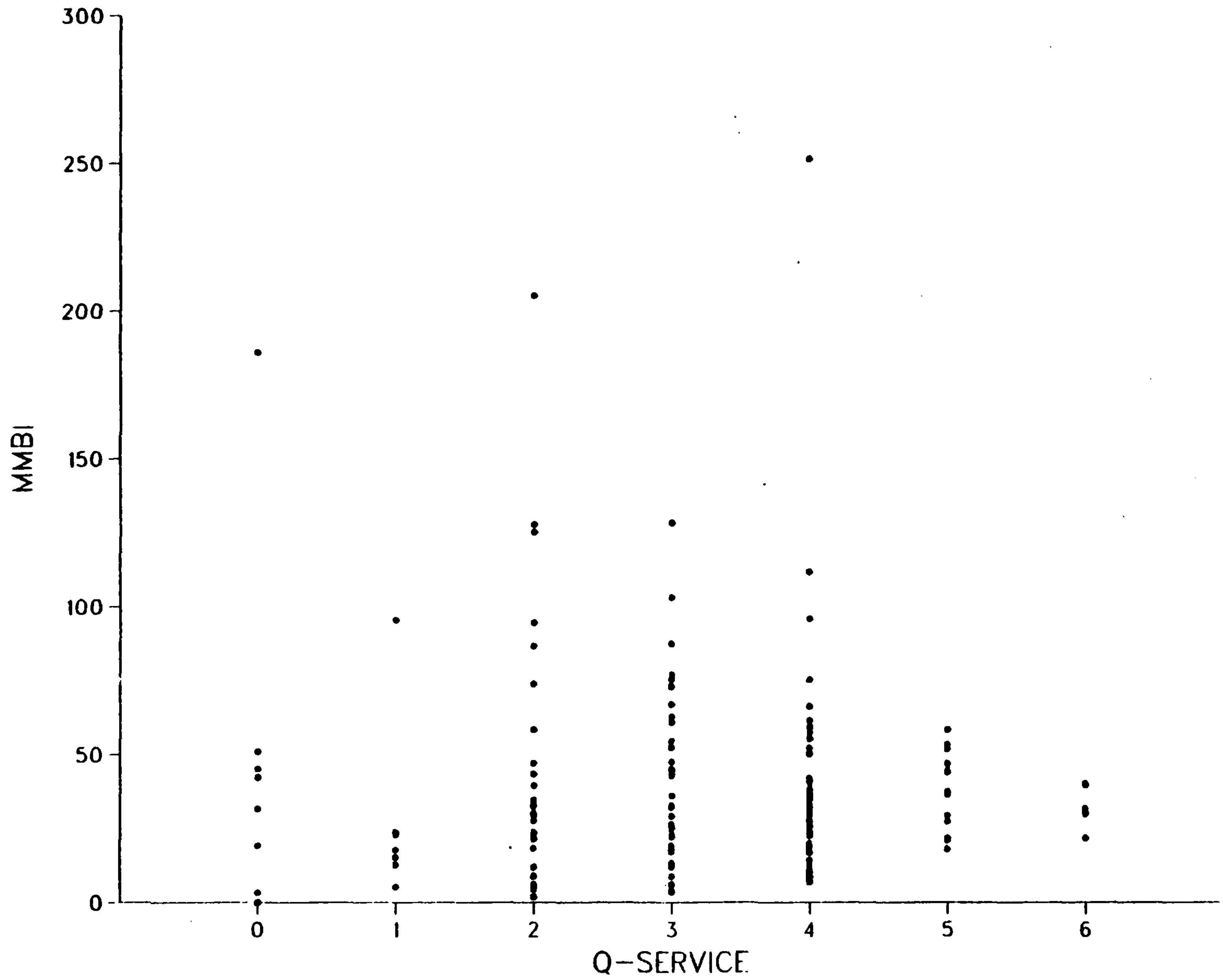
The non-depot vehicles surprisingly show a slight decreasing effect, Figure QS8, that as the MMBI seems the independent of the Q-service, the same trends are shown for the number of Q-services performed (see Figures QS4 and QS6). At this point, no plausible explanation is offered to explain this difference.

An in-depth study of this effect would probably show the effect to be non-linear showing an optimum level of manhours expended. The effect should also show a time lag effect from the fact that preventive maintenance should impact a reliability measure sometime in the future use of the vehicle by preventing or postponing component failure. It is quite possible this lag effect is shown in the non-depot vehicle insensitivity to Q-service.

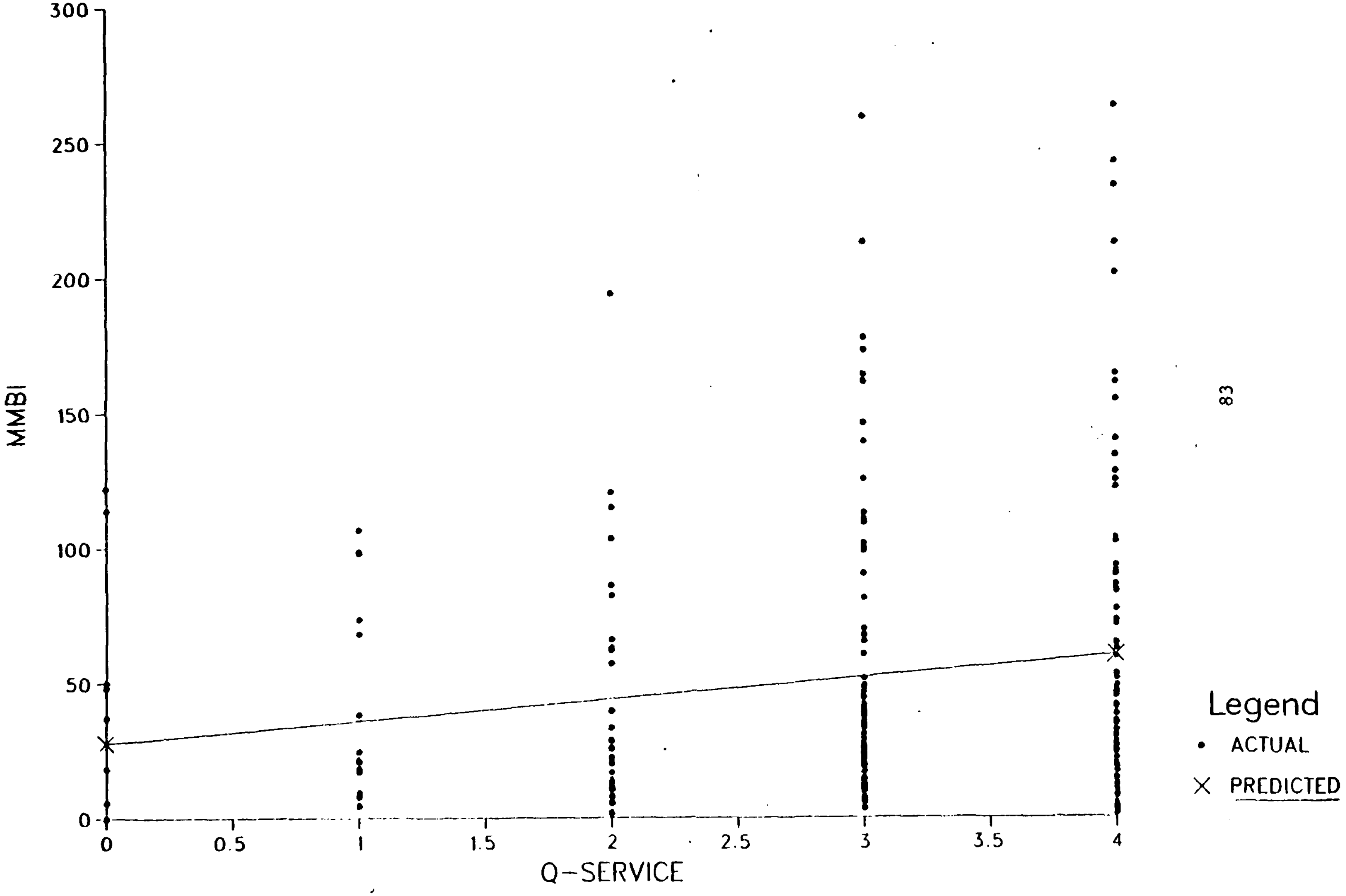
Q-SERVICE PERFORMED ON DEPOT VEHICLES

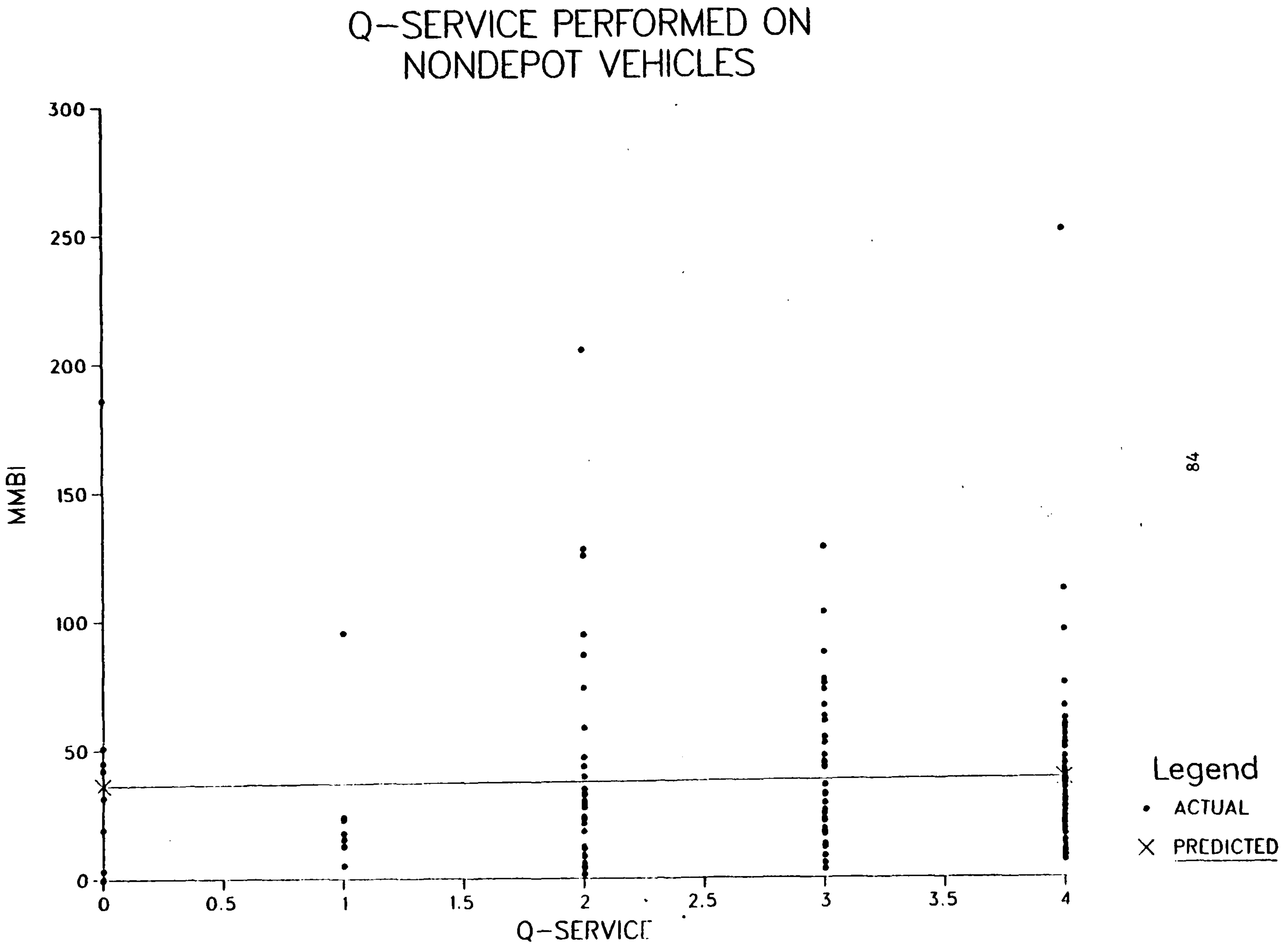


Q–SERVICE PERFORMED ON NONDEPOT VEHICLES

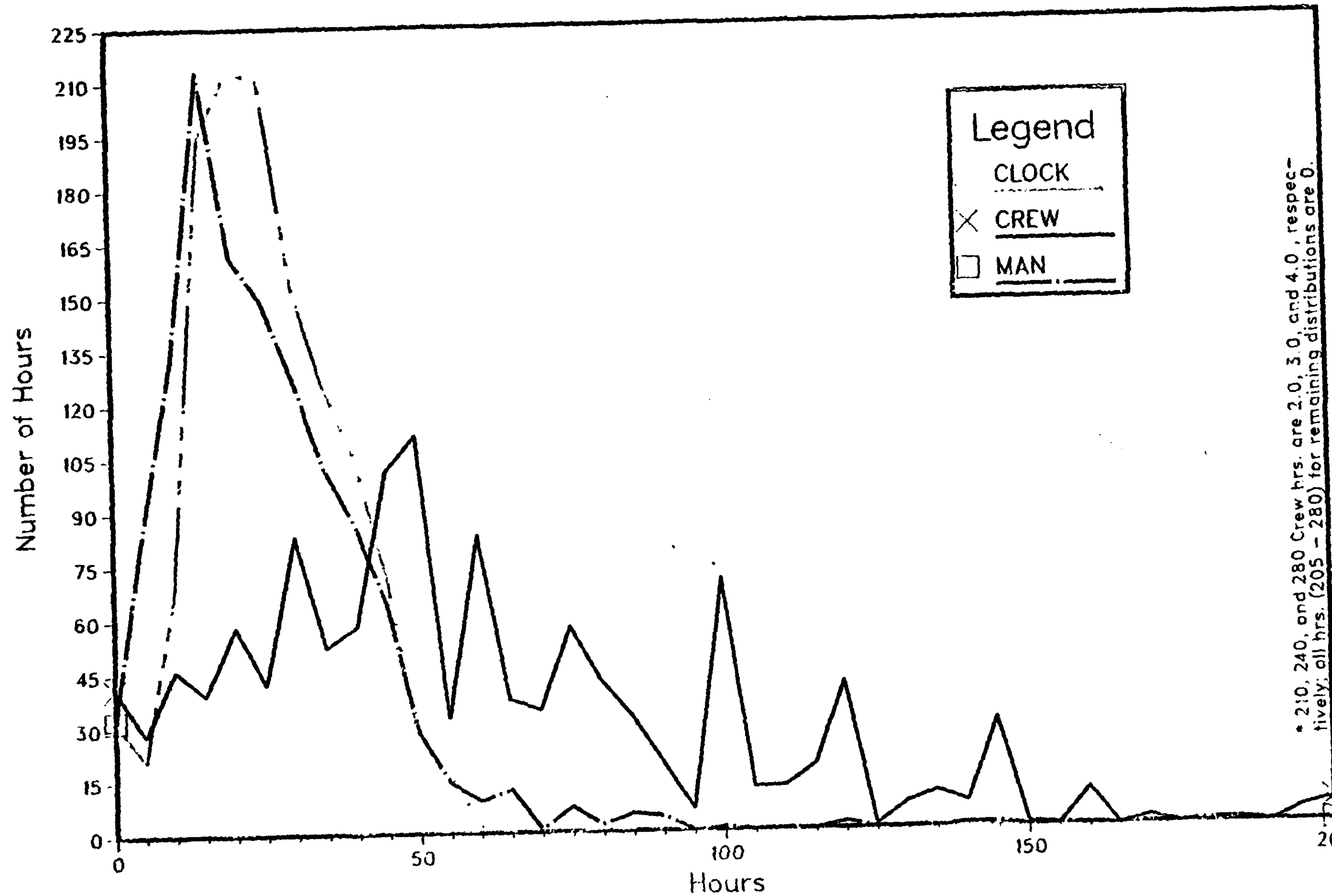


Q-SERVICE PERFORMED ON DEPOT VEHICLES

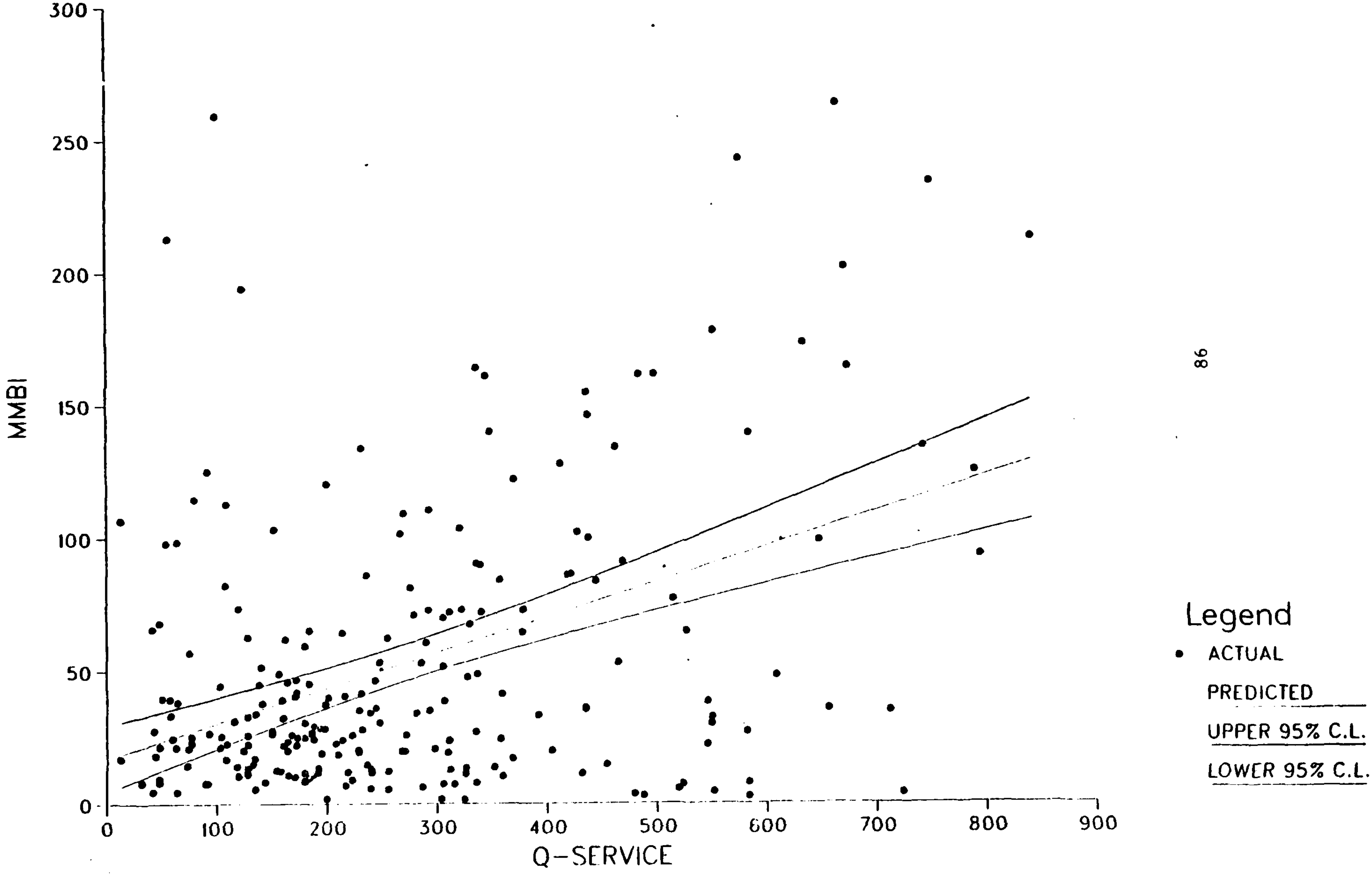



Q–SERVICE PERFORMED ON
NONDEPOT VEHICLES
MMBI
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Q–SERVICE
Legend
ACTUAL
PREDICTED

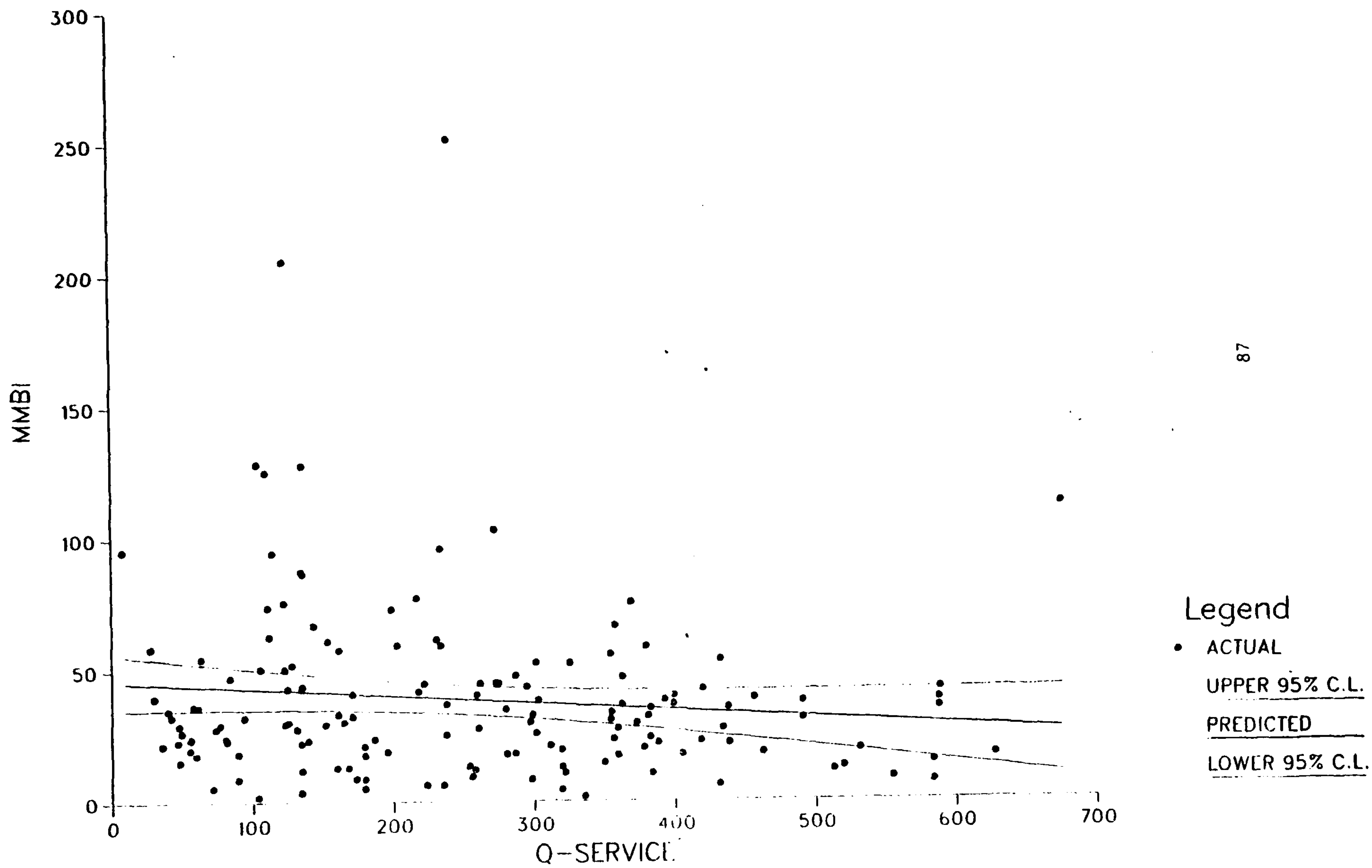
Clock, Crew, and Organizational Man Hours
(in 5 hr increments)



Q–SERVICE TOTAL MAN HOURS
DEPOT VEHICLES



Q–SERVICE TOTAL MAN HOURS NONDEPOT VEHICLES



SUBSYSTEM RELIABILITY

Within the SDC data, there are two codes applied to each recorded incident, a subsystem alpha catagorization (A thru V) and a Federal Group Classification (FGC) code 0100 thru 9500.

The subsystem catagories in each system are very similar, however, there is very poor correlation between them on each incident. The subsystem alpha code required a visual checkoff on the data sheet. The FGC 4-digit code was obtained from the parts manual along with the incidents part number. A sample check on the FGC number recorded against the part number showed an imperfect but good 1 to 1 correlation. Hence the alpha catagorization was judged more erroneous than the FGC numerical code. Thus, the FGC data grouping is used to catagorize and measure subsystem reliability.

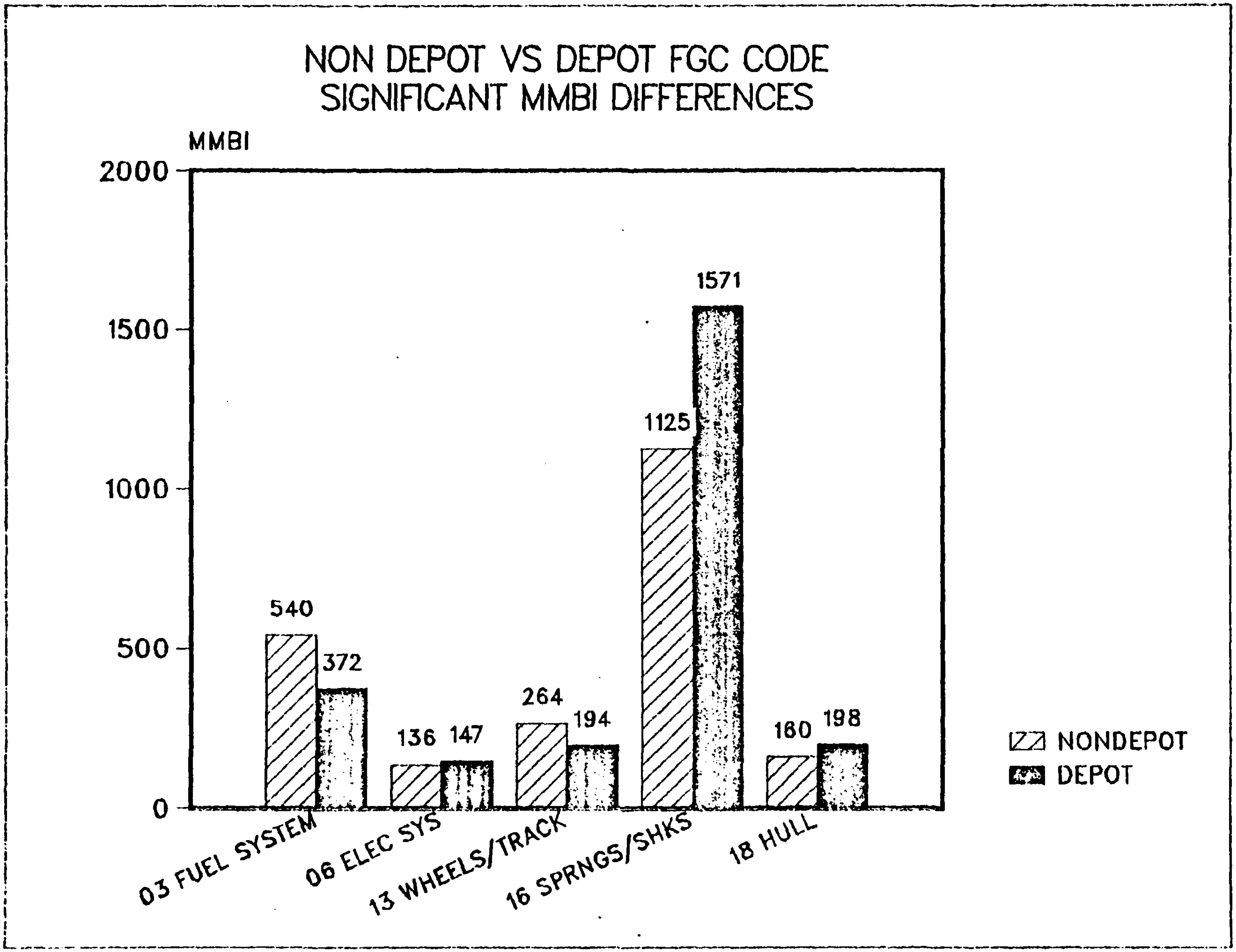
To obtain a reliability measure of FGC subsystems on the depot and non-depot vehicles, all incidents were grouped and counted in each major FGC category as shown in Table SR1. A significance test was applied as recorded in this table. A marginal significance means that the mean difference was significant at the 90% but not the 95% confidence interval. The subsystems that show significant differences in Table SR1 are echoed in Figure SR1. The MMBI data used here is biased in favor of the depot vehicles because no biasing effects were removed. So if the depot subsystem proved better than the non-depot system, it may be due to the bias. However, if the depot vehicles prove less reliable than the non-depot vehicles, then that should be a true significant difference.

FGC category 0300 Fuel Systems and FGC 1300 Wheels and Track are the two subsystems that the depot vehicles showed a significant lower reliability. These two subsystems are prime areas to investigate in Phase II.

FGC	MMBI	FAIL COUNT	MMBI	FAIL COUNT	DESCRIPTION	SIGNIFICANCE
01	723	278	649	194	Eng Assy	Marginal
03	372	540	301	418	Fuel Sys	Yes
04	2646	76	1120	57	Muff & Pipes	No
05	485	415	488	258	Cooling Sys	No
06	147	1367	136	926	Elect Sys	Yes
07	986	204	1024	123	Transmission	No
08	3296	61	2624	48	Final Drive	Marginal
09	2011	100	1099	60	Prop Shaft	No
11	1377	146	1384	91	Rear Axle	No
13	194	1036	264	477	Wheels Track	Yes
14	1478	136	1326	95	Steering/Brakes	No
15	3591	56	2470	51		Yes
16	1571	128	1125	112	Shocks/Springs	Yes
18	198	1015	160	787	Hull	Yes
19						
20						
22	2366	85	2571	49	Hull Acc	No
24	1204	167	1285	98	Hyd/Fluids	No
29	33512	6	62978	2	Kits	No
33	2793	72	1211	104	Armament	Yes
34	2793	72	906	139	Misc	Yes

TABLE SR1

FGC SUBSYSTEM BREAKOUT


NON DEPOT VS DEPOT FGC CODE
SIGNIFICANT MMBI DIFFERENCES
MMBI
2000
1500
1000
500
0
540
372
136
147
264
194
1125
1571
160
198
03 FUEL SYSTEM
06 ELEC SYS
13 WHEELS/TRACK
16 SPRNGS/SHKS
18 HULL
NONDEPOT
DEPOT

COST DRIVERS

Cost drivers are individual components that have a high part cost or a high labor cost or both associated with the maintenance incidents reported under the M113 SDC data base. Both B and C type records are included. This includes both independent and dependent parts, from both scheduled and unscheduled maintenance actions, excluding those actions dealing with vehicle fluids, (oil, fuel, grease, antifreeze). High labor cost can come from a high quantity of parts replaced or a high manhour per part requirement.

Labor and parts costs are summed into a total cost which is not intended to be an exact measure, but only to provide a relative ranking of support cost for the M113 family of vehicles. The part cost is determined from the AMDF listing which does not always reflect current 84 dollars. Labor costs are determined from the sum of all crew, DS, GS and depot maintenance manhour changes times an average cost per maintenance of $14.27. Total cost is not on a yearly basis, or vehicle basis, but reflect costs expended over the total 406 day SDC reporting period for all 408 SDC vehicles.

A total of 1771 different parts were serviced on the M113 family of vehicles. These parts were either replaced with a reconditioned (rebuilt, overhauled, inspected, repaired, remanufactured, cannabalized, etc) replacement part or a new (not previously used manufactured) part. The history of the replacement part is unknown as well as the history of the part replaced. The cost of the replacement part is from the AMDF listing which does not necessarily reflect either new or reconditioned part cost. Hence, no differentiation of new or reconditioned parts are reflected in the part cost (hence, total cost) in cost driver listing. If the part was not replaced with another part but rather repaired (adjusted, serviced, reset, etc) at site, than the AMDF parts cost was not assessed, however, the at-site labor costs for this repair action are accounted for in labor costs. The off-site reconditioning labor and parts cost are not directly accounted for. They are indirectly assessed by assigning the AMDF parts cost.

An explanation of the values shown in the table in Appendix C, Cost Drivers, is as follows:

Col 1	Part NSN
Col 2	Part number may be truncated if in excess of 15 spaces.
Col 3	Truncated nomenclature from the AMDF file
Col 4	Total quantity replaced. This replacement part did not necessarily fail. It could have been replaced because it was a dependent incident or due to driver error or accident.
Col 5	Total quantity adjusted
Col 6	Total of all crew manhours expended replacing or repairing this part.

Col 7 Sum of all Orgnizational maintenance manhours expended aginst this part.

Col 8 Sum of all DS maintenance manhours expended against this part.

Col 9 Sum of all GS maintenance manhours expended against this part.

Col 10 Sum of all depot maintenance manhours expended against this part.

Col 11 Unit part cost taken from the 84 AMDF listing. If the part could not be found in the AMDF, it was listed as zero cost. The same cost is used to reflect both new or reconditioned parts.

Col 12 Total parts cost which is equal to quantity replaced (Col 4) times Col 11.

Col 13 Total labor costs which is equal to the sum of all labor manhours (Col 6, 7, 8, 9, and 10) times an average maintenance labor manhour cost of $14.27

Col 14 Total cost which is equal to the sum of total parts cost (Col 13) and total sales costs (Col 12).

Cost drivers are identified and ranked so as to aid future investigations whose purpose would be to reduce field maintenance costs (one of the objects of Phase II of this study). The highest cost drivers are periscopes and telescopes and power train corronents from engine thru track pads. There are 168 parts that show a total cost expenditure of more than $1000. The remaining 1603 parts listed total costs from $999.00 to zero cost. Surprisingly, some screws, nuts and washers are included in the above category. This is due to the fact that a disproportionate labor cost was associated with these parts. It is felt that labor cost in replacing a nut, for example, should be included in what part the nut secures and not assigned to the nut.

Supplementing the cost driver list in Appendix C is listing of the 100 most frequently used unscheduled parts (incident reports) in the M113 SDC reporting period. This listing again intended to aid Phase II investigations. It is interesting that the most frequent reported unscheduled incident is automotive grease.

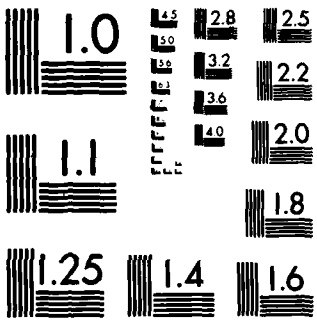
AD-A149 127 M113 NEW VERSUS OVERHAUL(U) ARMY TANK-AUTOMOTIVE COMMAND WARREN MI D J HACKENBRUCH NOV 84 TACOM-83-34 2/2

UNCLASSIFIED F/G 19/3 NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

DETAILED CONCLUSIONS

1. Field usage shows little or a slight tendency to use lower mileage vehicles over older, higher mileage vehicles. This is true for both depot and non-depot vehicles.

2. At those bases that have both non-depot and depot vehicles, there is no preferential vehicle use tendency.

3. There is no tendency to use A2 designated vehicles over A1 designated vehicles at those bases that have both types, especially for the M113.

4. Some of the vehicles under SDC are non-operational or operational and not used throughout the four quarter reporting period.

5. There is statistical evidence that some bases reported vehicle mileage accumulation without reporting failure incidents at the start of the SDC collection period and again at the end of the SDC collection period.

6. There is evidence of missing failure incidences. However, this is on a per vehicle basis and not particular to any one base location.

7. The upgraded A2 versions of the M113 FOV perform better than their counterpart A1 version, however, this cannot be positively concluded with statistical confidence.

8. The vehicle-age effect on mean miles between failure incident shows a tendency to take the classical statistical bath tub curve. However, the large variance in the data prevents statistical verification

9. M113 SDC data by its very nature tends to have large variances. This does not preclude estimation of a true mean providing that a large number of vehicles (samples) is present.

10. The M113 SDC data indicated that the M113 family of vehicles does not have a definite wear-out pattern at the assumed 6000 mile overhaul mileage. In fact, the failure rate shows no large increasing trend even up to 10,000 miles.

11. The failure history vs. vehicle age indicates that the present practice of inspecting each vehicle on an as-needed basis and using the depot practice of Inspect and Repair rather than overhaul at 6000 miles, is a better practice. This merits further investigation to establish its validity.

12. All bases have the same influence on vehicle reliability performance except for one which is significantly better. The cause is not known, but it is not due to vehicle type, vehicle age or period miles biasing effects. It is possibly due to the apparent lack of reporting failure incidents in the beginning and end of the M113 SDC reporting period, and to the better Q-service attributed to that base.

13. There is no significant difference in the reliability performance in non-depot and depot vehicles. This conclusion is assuming biasing effects of vehicle base, age, type and miles driven are removed.

14. On the average, a M113 type of vehicle can expect to have a MMBI of 45 miles between failure incidents. This is assuming that it is driven about 1000 miles per year and is approximately 5000 miles in age. Any deviation from this mean will have a stong effect on its expected mean.

15. Labor manhour costs reported in the SDC M113 data base appear to be high. On the other hand, not all labor cost expended in replacing the component are reflected for that component. Some of its labor costs are assigned to its brackets, nuts, washers, and screws which were lost, damaged or otherwise replaced to secure the component. The validity of this conclusion should be investigated in Phase II.

16. Nuts, bolts and washers are identified as cost drivers because of a suspected misleading labor practice of spreading the replacemnt manhours over all parts replaced including these securing parts. The validity of this conclusion should be investigated in Phase II.

17. The highest cost drivers are periscopes and telescopes and power train components from engine thru track pads.

18. The subsystem alpha categorization does not correlate well with vehicle part number within each incident report. The 4-digit FGC code correlates much better.

19. Fuel systems and wheels and track subsystems were significantly less reliable on depot vehicles as compared to non-depot vehicles.

20. There are dependent failure incidents (parts replaced to get at the independent failed part) in the B-type records which should only have independent failures. And there are independent failure incidents reported in the C-type records which should only have dependent failures.

21. Approximately 17.5% of the SDC M113 B-records improperly contained dependent failure incidents. Less than 5% of the SDC M113 C-records contained independent failure records.

22. The SDC M113 data base contained no C2 reocrds. This is in violation of contractual requirements.

23. The SDC M113 data base appears to improve in its reporting procedures as the data reporting period progressed from start to finish.

24. There were errors in the M113 data base in reporting mismatched nomenclature, NSN and Part Number. The frequency of these errors does not degrade the usefulness of the data base.

25. The M113 SDC data base is unscored. The Maintenance Action Code contained within is not consistent in its ranking of failure incidents as mission, safety or other types of failure.

26. The M113 SDC data base has a random start and a random finish when odometer mileage is used as the measure of RAM performance. This factor introduces a bias in the data except when the underlying distribution is truly exponential.

27. There is a very low correlation between vehicle odometer miles and vehicle engine meter reading. Within each vehicle, both readings increase proportionally, but a wide variation is seen between vehicles.

28. The reporting sequence of failure incidents suggests that there are significant variations in the way SDC data was collected at some of the 5 bases. This conclusion should be verified in Phase II.

29. The M113 SDC data cannot be blocked into an analysis of variance (ANOVA) with valid results due to voids in the data and strong biasing due to unbalanced and/or dependent effects.

30. The lack of record keeping an individual vehicle at the processing depot precludes any analysis attempt to determine field reliability performance of depot vehicle components as compared to new (non-depot processed) vehicle components.

31. There is no significant difference in the field reliability of depot vehicles regardless of the year of their depot action. This conclusion is significant in that it strongly endorses the current I&R practice of depot processing over the past practice of complete overhaul.

32. The effect of the Number of Quarterly Services performed on the M113 FOV under the SDC reporting period has little or no effect on reliability performance for both depot and non-depot vehicle.

33. There is large dispersion of both crew and organization manhours used in performing Q-services. This is unexpected since the Q-service procedure is standard.

34. The manhours expended on Q-service, thus the more thorough it is, the better the field reliability performance of depot vehicle. This is a strong relationship. Surprisingly, this is not true for non-depot vehicles.

35. The M113 FOV can expect on the average to run 95 miles before requiring repair of an unscheduled failure. (MMBFF reliability measure). This is assuming the vehicles are driven about 1000 miles per year, and is approximately 5000 miles in age. Any deviation in these mean values will have a strong influence on this expected mean.

36. There is no significant difference in MMBFF reliability measure for depot and non-depot vehicles. This applies to vehicle type and base effect. Vehicle age has a slight increasing effect that is not statistically significant and a strong increasing period miles effect that is statistically significant.

RECOMMENDATIONS

1. The preventive maintenance practices on the M113 should be studied to determine optimum type and quality. A measure of the quality as well as the quantity of preventive maintenance should be subjected to a non-linear statistical analysis with a time lag effect.

2. The SDC process of selecting all vehicles at a base location with a large number of vehicles should be evaluated. An optimal number of vehicles should be able to be selected to provide good statistically significant results. This may be as low as 10 vehicles in each effect block of interest. Keeping data on more than this number of vehicles has little or no payoff.

3. The current depot practice of not keeping historical records on individual components on specific vehicles processed through the depot should be reviewed. Potential payoff of being able to evaluate depot practice on field reliability performance is a worthwhile payoff.

4. Detailed guidance should be given and enforced as to the accepted method of assigning manhour charges to all parts replaced. A disproportionate manhour charge was assigned to simple parts such as replaced washers and screws. This charge, if realistic, should be assigned to its secured part.

APPENDIX A

VEHICLE PURGING

Vehicle Purging

Contained within the 408 vehicles recorded in the SDC data base are several vehicles with very high MMBI (Mean Miles Between Incidents) or zero MMBF. A separate investigation within the data records of each suspect vehicle was conducted to see if the recorded data (or lack of) can be judged valid.

Vehicle M113A2, C 4441, 5450 miles. Depot, WAM

Date	Remarks
81334	Start miles 1126 at entry into SDC
81349	Final drive failure at 1200 miles (No other failures recorded)
82090	Quarterly report showing 1200 miles, 158 engine hours.
82181	Final Quarterly report showing 6576 miles, 727 Engine hours.

Action taken: Remove this vehicle from data base. Reason: 437 miles and 569 accumulated in 90 days. This is considered unrealistic data entry error ruled out because of corresponding increase in engine hour recording.

Vehicle 113A1, MSJ 17717, 2005 miles, non-depot, WAM.

Date	Remarks
81334	Start miles 5520 at entry to SDC
82090	First Quarter report at 6040 miles. No failures reported in 520 miles. This is suspect.
82091	First of 32 failures reported at 6040 miles
82344	Last of 32 failures reported at 7525 miles
82365	End miles 7525

Action taken: Even though the data shows no failures in 520 initial miles (suspect failure incidents were not recorded at start of test). This vehicle was not deleted. This is a common fault in the data and is not peculiar to this vehicle.

Vehicle M113A2, SJ 11223, 1917 miles, depot, WAP

Date	Remarks
81334	Start miles 346
82113	First of 15 failures reported at 1606 miles. 1260 miles accumulated in 144 days with no failure incidents recorded.
82342	Last of 15 fialures reported at 2263 miles
82365	End miles 2263

Action taken: This vehicle was not deleted. (See "Action taken" note on vehicle MSJ17717 above.

Vehicle M113A1, C1124, 1835 miles, depot, WAG

Date	Remarks
82005	Start miles 6482
82048	First of 27 failures at 6558
82210	713 miles reported in 13 days with no failures
82336	Last of 27 failures reported at 8317 miles
82365	End miles at 8317.

Action taken: Even though data shows 713 miles accumulated in 13 days, this action was not deleted.

Vehicle M113A1, MSJ 13974, 0 miles, depot, WAG

Date	Remarks
82242	Start miles 34
82365	End miles at 34. No failures reported

Action taken: Vehicle deleted because it was not used in 123 days of reporting.

Vehicle M113A1, F 2128, 0 miles, depot, WAQ

Date	Remarks
81338	Start miles at 970
81343	Drive assembly failure at 970 miles. Only failure reported.
82181	End miles 970

Action taken: Vehicle deleted from data base for non-use for 208 days waiting drive assemblv repair. Judged as non-representative of normal field usage.

Vehicle M113A1, MSJ 14136, 0 miles, depot, WAG

Date	Remarks
82286	Start miles 2045
82300	M17 Periscope incident at 2045 miles
82337	Battery replacement at 2045 miles
82365	End miles 2045

Action taken: Vehicle deleted for non-use for 79 days.

Vehicle M113A1, MSJ 21862, 353 miles, non-depot, WAM

Date	Remarks
81334	Start miles 3024
82092	End miles 3377. 353 miles reported in 121 days with no failure incidents reported.

Action taken: Vehicle deleted. Suspect lack of reporting.

Vehicle M113A1, MSJ 21877, 288 miles, non-depot, WAM

Date	Remarks
81334	Start miles 3345
82090	End miles 3633. 288 miles reported in 121 days with no failure incidents reported.

Action taken: Vehicle deleted. Sister vehicle MSJ 21862 above.

Vehicle M113A1, SJ 14152, 15 miles, non-depot, WAH

Date	Remarks
82285	Start miles 3112
82365	End miles 3127. No failures reported in 80 days and 15 miles of running

Action taken: Vehicle deleted. Judged non-representative of normal field use.

Vehicle M577A2, PAA1727, 350 miles, non-depot, WAM

Date	Remarks
81334	Start miles 787
82090	End miles 1137. No failures reported in 121 days and 350 miles of running.

Action taken: Vehicle deleted. Suspect lack of data reporting.

Vehicle M113A1, SJ 13083, depot, WAM

Date	Remarks
81334	Start miles 1416
82043	Greased at 1792 miles
82192	Greased at 2133 miles
82276	Fuel pump at 2257 miles
82321	Fuel pump at 2358 miles
82365	End miles at 2453

Action taken: Vehicle eliminated. Vehicle went 1037 miles in 396 days and had two fuel pumps replaced. It is identified as an outlier in statistical tests. RESID = 4.2

Vehicle M113A2, MSJ 13733, depot, WAP

Date	Remarks
81334	Start miles 1253
82247	Greased at 1960 miles
83393	Greased at 2086 miles
82298	Greased at 2183 miles
82237	Greased at 2882 miles
82365	End miles 2912

Action taken: Vehicle eliminated. Vehicle went 1659 miles in 369 days and had no hardware failures. It is identified as an outlier in statistical tests. RESID = 7.3

Vehicle M577A2, PAA 01738, non-depot, WAQ

Date	Remarks
81327	Start miles 1554
82012	Retainer replaced at 1554 miles
82103	Pin replaced at 1673 miles
82263	Nut replaced at 2139 miles
82365	End miles 2308

Action taken: Vehicle eliminated. Vehicle went 754 miles in 403 days and had no hardware failures. It is identified as an outlier in statistical test. RESID = 4.0

Summary of Actions Taken:

1 vehicle deleted due to suspected erroneous high miles
3 vehicles deleted because they were non-runners
4 vehicles deleted because they had no failure incidents reported against them.
3 vehicles deleted because they were statistical outliers.

APPENDIX B

INCIDENT DEPENDENCY INVESTIGATION

INCIDENT DEPENDENCY INVESTIGATION

The "B Record for M113" ABT (Sample output shown as Exhibit A1) compiled from the M113, 450 character SDC data tape, B1 and B2 records, contains several groupings of incidents (An incident should be an independent failure/repair) that occurred on the same reporting date. Exhibit A2 is a tabulation the number of records that have the same report date and vehicle serial number. This A2 exhibit shows that only 43% of the incidents reported are single incidents, that is reported on separate days. The remaining 57% of the incidents have two or more possibly related parts reported as replaced on the same reporting date.

Exhibit A2 shows that three blocks of incidents, one block of 33 and two blocks of 11, were chosen to investigate. The two 11 blocks are shown in Exhibit A1. The 33 block is shown in Exhibit A3.

	VEHICLES SN	REPORT DATE	VEHICLE	NEW/OVERHAUL	NO OF INCIDENTS
Block 1	89	82263	M106A1	New	11
2	85	81343	M106A1	New	11
3	165	82095	M577A1	New	33

Searching the M113 450 character SDC data tape for all records containing the incident numbers for each of the two 11 and the one 33 blocks shows that no C1 or C2 records were reported. Exhibit A4 shows that there were 12,020 C1 records reported, but none for above incident numbers. The C1 and C2 records are for reporting related replacement parts and fluids. Exhibit A4 also shows that there are no C2 records. That omission is a violation of contractual requirements.

Further search for the M113 SDC tape shows that there were C1 records reported for the three Julian dates of interest typical examples of these are shown in Exhibit A5. They are mostly for fluids with very few parts.

Each part was identified to a figure number (assembly drawing) from 34P manuals for Series M113 Vehicles. These tabulations are shown in Exhibits B, C, and D. Some parts have multiple applications as they are common parts. The assumption was made that if any figure number of a common part matched another part in the block then that application was the actual part replaced.

Parts that appear to be related (34P figure number was repeated) were copied from the 34P TM and are shown in Exhibits E and F.

	VEHICLES SN	SUPPORTING EXHIBITS
Block 1	89	D + None
2	85	B + E1 thru E5
3	165	C + F1 thru F5

Review of these exhibits E and F show that they're multiple related incidents in vehicle SN 85 and 165. None were found for vehicle SN 89. Vehicle 89 has a later Julian date than the other two blocks thus indicating a possible learning curve in the reporting procedure. This poses a problem in the data in that it loses consistency. This will impose a further bias to any analysis.

Exhibits E show that 9 of the 11 incidents from Block 2 could be related to one to three failures. Exhibits F show that similar relationship exist.

Exhibits E show that 17 clock hours and 34 labor manhours were expended in repair of these 11 incidents. This appears to be excessive.

B RECORDS FOR M113, 450 CHARACTER TAPE

B RECORDS FOR M113, 450 CHARACTER TAPE M106A1

SERIAL#		INDT	INCDNT#	PART NAME	PART NSN	[illegible]
CHB	89	81332	S40001P	ENGINE, O.S.	2815-00-124-[illegible]	[illegible]
CHB	89	82049	S40002P	TRANSMISSION O.S.	2520-00-066-[illegible]	[illegible]
CHB	89	82049	S40003P	ENGINE O.S.	2815-00-124-5370	[illegible]
CHB	89	82071	S40004P	ENGINE OS.	2815-00-124-5370	[illegible]
CHB	89	82071	S40005P	TRANSMISSION O.S.	2520-00-066-[illegible]	[illegible]
CHB	89	[illegible]	S40012	CUSHION, RUDDER, SPR	2520-[illegible]-077-[illegible]	[illegible]
CHB	89	[illegible]	S40015	CLAMP, LOOP	5340-00-782-7[illegible]	[illegible]
CHB	89	82133	S40021	EYESHIELD, OPTICAL	[illegible]-00-[illegible]	[illegible]
CHB	89	[illegible]	S40022	QUARTERLY SERVICE		
CHB	89	82166	S40023P	ENGINE O.S.	2815-00-[illegible]	[illegible]
CHB	89	82166	S40024P	TRANSMISSION O.S.	2520-00-0[illegible]	[illegible]
CHB	89	82193	S40025P	ENGINE O.S.	2815-00-0[illegible]-[illegible]244	[illegible]
CHB	89	82193	S40026P	TRANSMISSION O.S.	2520-00-[illegible]	[illegible]
CHB	89	82217	[illegible]	HOSE ASSEMBLY, [illegible]	[illegible]	[illegible]
CHB	89	82217	S40028	IGNITION UNIT, MANIF	[illegible]	[illegible]
CHB	89	82217	S40029	BELTS, V, MATCHED SE	3030-00-[illegible]	[illegible]
CHB	89	82217	S40030	COCK, DRAIN	4820-00-[illegible]	[illegible]
CHB	89	82217	S40031	SWITCH, SENSITIVE	5930-00-041-[illegible]	7743730
CHB	89	82217	S40032	PAD, CUSHIONING	2590-00-738-[illegible]	10710[illegible]
CHB	89	82224	S40033P	ENGINE O.S.	[illegible]	[illegible]
CHB	89	82224	S40034P	TRANSMISSION O.S.	[illegible]	[illegible]
CHB	89	82230	[illegible]	QUARTERLY SERVICE		
CHB	89	[illegible]	[illegible]	ENGINE O.S.	[illegible]	[illegible]
CHB	89	82251	S40037P	TRANSMISSION O.S.	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	TERMINAL, LUG	59[illegible]-00-[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	COVER, ELECTRICAL CO	[illegible]	[illegible]
CHB	89	[illegible]	S40041	BUMPER, RUBBER	[illegible]	[illegible]
CHB	89	[illegible]	S40042	PULLEY, GROOVE	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	SWITCH, SENSITIVE	[illegible]	[illegible]
CHB	89	[illegible]	S40045	NUT, COUPLING, ELECT	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	PLATE, REGULATOR MOU	[illegible]	[illegible]
CHB	89	[illegible]	S40047	BATTERY BOX	[illegible]	[illegible]
CHB	89	82263	S40048	WASHER, FLAT	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	BELTS, V, MATCHED SE	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	SHOCK ABSORBER, DIRE	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	SHOCK ABSORBER, DIRE	[illegible]	[illegible]
CHB	89	[illegible]	[illegible]	ENGINE O.S.	2815-00-[illegible]	[illegible]
CHB	[illegible]	[illegible]	[illegible]	TRANSMISSION O.S.	[illegible]	[illegible]
CHB	[illegible]	[illegible]	[illegible]			
CHB	085	[illegible]	[illegible]	TRANSMISSION, O.S.	[illegible]	[illegible]
CHB	085	[illegible]	[illegible]	ENGINE, O.S.	[illegible]	[illegible]
CHB	085	81341	R4[illegible]	Q-SERVICE		
CHB	085	[illegible]	[illegible]	SEAL PLAIN ENCASED	[illegible]	[illegible]
CHB	085	[illegible]	[illegible]	HOSE	2590-00-[illegible]	[illegible]
CHB	085	81343	R40021	FILTER, FLUID	[illegible]-00-[illegible]	[illegible]
CHB	085	81343	R40025	CLAMP, LOOP	5340-00-[illegible]-[illegible]	1150[illegible]
CHB	085	81343	R40026	CLAMP, LOOP	5340-[illegible]	[illegible]
CHB	085	81343	R40027	COUPLING HOSE	4730-00-800-[illegible]	[illegible]
CHB	085	[illegible]	[illegible]	RECEPTACLE,LEAD ASSY	[illegible]	[illegible]
CHB	085	81343	R40029	SWITCH PRESSURE	5930-00-771-[illegible]	[illegible]
CHB	085	81343	R40030	CONTROL ASSEMBLY	2590-00-[illegible]-[illegible]	[illegible]
CHB	085	81343	R40031	CLAMP, LOOP	5340-00-[illegible]	[illegible]
CHB	085	81343	R40032	BRACKET, ANGLE	5340-00-133-9732	10932821
CHB	085	81343	R40054	TUBE, BENT, ALUMINUM	4710-00-999-2353	10943121
CHB	085	81344	R40002	SWITCH SENSITIVE	2510-00-195-9922	10160542

EXHIBIT A1

# OF BLOCKS WITH 1 RECORD(S):	5486	
# OF BLOCKS WITH 2 RECORD(S):	869	
# OF BLOCKS WITH 3 RECORD(S):	354	
# OF BLOCKS WITH 4 RECORD(S):	201	
# OF BLOCKS WITH 5 RECORD(S):	89	
# OF BLOCKS WITH 6 RECORD(S):	70	
# OF BLOCKS WITH 7 RECORD(S):	49	
# OF BLOCKS WITH 8 RECORD(S):	43	
# OF BLOCKS WITH 9 RECORD(S):	33	
# OF BLOCKS WITH 10 RECORD(S):	27	
# OF BLOCKS WITH 11 RECORD(S):	28	(Two blocks of 11 incidents, one early date and one late date, investigated.
# OF BLOCKS WITH 12 RECORD(S):	14	
# OF BLOCKS WITH 13 RECORD(S):	13	
# OF BLOCKS WITH 14 RECORD(S):	9	
# OF BLOCKS WITH 15 RECORD(S):	6	
# OF BLOCKS WITH 16 RECORD(S):	4	
# OF BLOCKS WITH 17 RECORD(S):	4	
# OF BLOCKS WITH 18 RECORD(S):	2	
# OF BLOCKS WITH 19 RECORD(S):	3	
# OF BLOCKS WITH 20 REOCRD(S):	3	
# OF BLOCKS WITH 21 RECORD(S):	2	
# OF BLOCKS WITH 22 RECORD(S):	1	
# OF BLOCKS WITH 23 RECORD(S):	1	
# OF BLOCKS WITH 24 RECORD(S):	2	
# OF BLOCKS WITH 25 RECORD(S):	1	
# OF BLOCKS WITH 26 RECORD(S):	0	
# OF BLOCKS WITH 27 RECORD(S):	2	
# OF BLOCKS WITH 28 RECORD(S):	1	
# OF BLOCKS WITH 29 RECORD(S):	0	
# OF BLOCKS WITH 30 RECORD(S):	0	
# OF BLOCKS WITH 31 RECORD(S):	0	
# OF BLOCKS WITH 32 RECORD(S):	0	
# OF BLOCKS WITH 33 RECORD(S):	1	(Block of 33 incidents investigated)
# OF BLOCKS WITH 34 RECORD(S):	0	
# OF BLOCKS WITH 35 RECORD(S):	0	
# OF BLOCKS WITH 36 RECORD(S):	1	
# OF BLOCKS WITH 37 RECORD(S):	0	
# OF BLOCKS WITH 38 RECORD(S):	1	
# OF BLOCKS WITH 39 RECORD(S):	0	
# OF BLOCKS WITH 40 RECORD(S):	0	
TOTAL # OF RECORDS:	12705	

EXHIBIT A2

OF RECORDS IN BLOCK: 33

CHZ	165	82095	R20037	WIRING HARNESS	[illegible]-00-930-2332	11588191
CHZ	165	82095	R20038	RUBBER STRIP	[illegible]-00-143-7051	10942565
CHZ	165	82095	R20039	RUBBER STRIP	5320-00-143-7051	10942565
CHZ	165	82095	R20040	GASKET	5330-00-199-5884	MS35769-31
CHZ	165	82095	R20041	BRACKET, ASSEMBLY	2540-00-411-5794	11633210
CHZ	165	82095	R20042	STRAP TIEDOWN	5975-00-473-5595	8743398
CHZ	165	82095	R20043	GASKET	5330-00-543-7160	7962267
CHZ	165	82095	R20044	SWITCH THERMOSTATIC	5930-00-680-9481	[illegible]
CHZ	165	82095	R20046	HEADLIGHT	6220-00-679-9046	MS51318-1
CHZ	165	82095	R20047	LIGHT, MARKER	6220-00-670-7692	[illegible]
CHZ	165	82095	R20048	LENS	6220-00-557-8229	7961266
CHZ	165	82095	R20049	BUMPER RUBBER	5340-00-779-4573	10886357
CHZ	165	82095	R20050	IGNITION UNIT	2920-00-770-1641	7061198
CHZ	165	82095	R20051	LENS, LIGHT	6220-00-741-2769	8327366
CHZ	165	82095	R20052	PARTS KIT	2930-00-711-9362	5702866
CHZ	165	82095	R20053	RECEPTACLE AIR BOX	2990-00-890-0697	5134925
CHZ	165	82095	R20054	CLIP, RETAINING	5340-00-857-1424	8763397
CHZ	165	82095	R20055	CLAMP LOOP	5340-00-922-6301	MS21333-79
CHZ	165	82095	R20056	CRADLE	2590-00-961-8332	8763393
CHZ	165	82095	R20057	CRADLE WIRING HARNES	2590-00-962-8333	8763291
CHZ	165	82095	R20058	SCREW MACHINE	5305-00-984-6210	MS35206-263
CHZ	165	82095	R20059	CYLINDER HYDRAULIC	1590-00-446-2487	7542461
CHZ	165	82095	R20060	ADAPTER, BUSHING	[illegible]-800-1648	10874812
CHZ	165	82095	R20061	WIRING HARNESS	[illegible]	[illegible]
CHZ	165	82095	R20062	BREATHER ASSEMBLY	[illegible]-019-[illegible]	[illegible]
CHZ	165	82095	R20063	T. SEAT RECEPTACLE	[illegible]-057-1587	[illegible]21
CHZ	165	82095	R20064	BUMPER, RUBBER	[illegible]-913-3359	[illegible]171
CHZ	165	82095	R20065	CUSHION	[illegible]	[illegible]778
CHZ	165	82095	R20066	RUBBER STRIP	[illegible]-143-7051	[illegible]
CHZ	165	82095	R20067	SEAL RUBBER	[illegible]-947-2260	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EXHIBIT A3

```
00001:# OF RECORDS WITH CODE A1:   2188
00002:# OF RECORDS WITH CODE A2:      0
00003:# OF RECORDS WITH CODE B1:  17278
00004:# OF RECORDS WITH CODE B2:  17278
00005:# OF REOCRDS WITH CODE B3:  17278
00006:# OF RECORDS WITH CODE C1:  12020
00007:# OF RECORDS WITH CODE C2:      0
00008:# OF RECORDS WITH CODE D:    2038
00009:# OF RECORDS WITH CODE E1:      0
00010:# OF RECORDS WITH CODE E2:      0
00011:# OF RECORDS WITH CODE F:       0
```


EXHIBIT A4

CHB 08306CB1 81343R40020 M1C6A1

OIL ENGI9150-00-186-6681 MILL2104 18

A

MSJ 1272806CC1 581343M10011S 81343
OIL: 9150-00-189-6727 MIL[illegible]2104 16

A

MSJ 1272806CC1 681343M10011S 81343
OIL: 9150-00-186-6681 MIL[illegible]2104 20

A

MSJ 1272806CC1 [illegible]81343M10011S 81343
OIL: FIN9150-00-186-6681 MIL[illegible]2104 9

A

MSJ 1272806CC1 [illegible]13[illegible]M10011S 81343
OIL: TRA9150-00-186-6681 MILL2104 2

A

MSJ 1272806CC1 [illegible]81343M10011S 81343
RICATIO[illegible] 4730-00-0[illegible] [illegible]6 [illegible]203-1 4

A

MSJ 1272806CC1 [illegible]81343M10011S 81343
HEADLIGHT6220-00-[illegible] [illegible]7987 1

A

MSJ 180[illegible]806CC1 [illegible]M10013 M11362
140 0 0

MSJ 180[illegible]806[illegible] [illegible]1343M10013 81349
QUARTERLY SERVICE
*300 280 300

MSJ 180[illegible]806CCB [illegible]1343M10013 118 [illegible] 280 118 E3 200 118
E4 20

MSJ 18[illegible]806CC1 181343M10013S 81349
OIL: 915[illegible]-00-189-6727 MILL2104 16

A

MSJ 1[illegible]806CC1 2[illegible]1343M10013S 81349
OIL: OE [illegible]150-00-186-6681 MILL2104 20

A

MSJ 1804806CC1 381343M10013S 81349
OIL: FIN9150-00-186-6681 MILL2104 9

A

MSJ 18[illegible]806CC1 481343M10013S 81349
OIL: TRA9150-00-186-6681 MILL2104 3

A

MSJ 1804806CC1 581343M10013S 81349
ENT. FLUI[illegible]40-00-080-6283 5573014 1

A

MSJ 1804806CC1 681343M10013S 81349
ENT FLUI[illegible]40-00-715-1730 5573032 1

A

MSJ 180[illegible]806CC1 781343M10013S 81349
HT FUID [illegible]910-00-428-[illegible]155 5574508 1

A

MSJ 1804806CC1 881343M10013S 81349
OIL ENGI9150-00-186-6681 MILL2104 18

A

MSJ 180[illegible]806CC1 [illegible]81343M10013S 81349
BER [illegible]2500-00-67[illegible]-[illegible]657 8763180 1

A

EXHIBIT A5

M106A1 SN 085 NEW
DATE 81343

INCID	NAME	NSN	PN	FIG	ITEM	CLCK	T-HRS
R40020	HOSE	2590-999-2384	10942651	6	16	1.5	3.0
R40021	FILTER	2910-884-1207	5575009*			1.5	3.0
		*SHOULD BE	5575824				
R40025	CLAMP*	5340-782-1804	11589145	60	09	.5	1.0
	*BRACK	SHOULD BE					
R40026	CLAMP	5340-598-8062	MS21919G4	7	02	.5	1.0
				17	19		
R40027	HOSE*	4730-800-2828	10865913	6	17	2.5	2.5
	*COUPL	SHOULD BE		124	01		
				235	01		
				238	05		
				239	02		
				241	14		
R40028	RECEP	2590-930-2054	10950251	33	27	2.0	4.0
R40029	SWITCH	5930-771-8119	10874979	6	02	1.5	3.0
R40030	CONTRL	2590-679-9168	10861660*	17	11	3.0	6.0
		SHOULD BE	10861660-1				
R40031	CLAMP	5340-664-2369	MS21919DG26	60	8	1.5	3.0
R40032	BRACK	5340-133-9732	10932821	17	2	1.0	4.0
R40054	TUBE	4710-999-2358	10943121	23	32	.5	1.0
			TOTAL			17.0	34.0

TABLE 1 VEHICLE M106A1, VEHICLE NO 089, REPORT DATE 81343

EXHIBIT B

M577A1 NEW SN 165

INCID NO	NAME	NSN	PN	FIG	ITEM
R20037	HARNESS WIRE	2590-930-2332	11589191	76	01
R20038	RUB STRIP	9320-143-7051	10942565	162	34
R20039	RUB STRIP	9320-143-7051	10942565	162	34
R20040	GASKET	5330-199-5884	MS35769-31	239	05
R20041	BRACKET	2940-411-5794	11633210	240	06
R20041	BRACKET	2940-411-5794	11633210	3	06
R20042	STRAP TIEDWN	5975-473-5595	8763398	62	04
				66	25
				68	32
				69	16
R20043	GASKET	5330-543-7160	7962267	44	03
R20045	SWITCH THERMO	5930-688-9881	7771274-2	50	02
R20046	HEADLIGHT	6220-678-9046	MS51318-1	49	01
R20047	LIGHT MARKER	6220-670-7692	MS51303-2	47	01
R20048	LENS	6220-557-8229	7962266	44	04
R20049	BUMPER RUB	5340-779-4573	10886357	54	28
				55	08
R20050	IGN UNIT	2990-770-1641	*7062198**	*NO LISTING*	
R20051	LENS, LIGHT	6220-741-2769	8327366	49	17
R20052	KIT PARTS	2930-711-9362	5702866	25	KIT
R20053	AIR BOX	2990-890-0697	5134825*	NO LISTING	
R20054	CLIP RET	5340-857-1424	8763397	69	21
	INCLUDED IN 7 OTHER FIGURES				
R20055	CLAMP LOOP	5340-922-6301	MS21333-79	4	11
R20056	CRADLE	2590-962-8332	8763393	59	1
				62	1/5
				66	24
				68	31
				69	17
R20057	CRADLE	2590-162-8333	8763391	69	22
	INCLUDED IN 8 OTHER FIGURES				18
					17
					10
					22
					26
					02
					04
					26
R20058	SCREW MACH	5305-984-6210	MS35206263		
	INCLUDED IN 26 OTHER FIGURES				

EXHIBIT C PAGE 1

INCID NO	NAME	NSN	PN	FIG	ITEM
R20059	CYL HYD	2590-446-2487	7532461	233	01
R20060	BUSHING ADAPT	4730-800-4648	10874812	236	04
				240	05
R20061	HARNESS WIRE	2590-930-2332	11589191	76	01
R20062	BREATHER ASSY	4720-019-1324	8376371	232	06
				236	03
				240	04
				245	02
R20063	INSERT REC	2815-057-1582	5135721		
R20064	BUMPER RUB	5340-913-3359	10886471	134	19
				188	20
R20065	CUSHION	5330-401-5232	10886778	162	35
R20066	RUBBER STRIP	9320-143-7051	10942565	162	34
R20067	SEAL RUBBER	5330-937-2230	10886779	162	35
R20068	WASHER FLAT	5310-877-5972	10910174-3	3	11
				4	06
				98	02
				101	01
				103	13
				235	15
				244	32
R20069	CLIP RET	5340-857-1424	8763397	62	02
				66	05
				67	05
				68	05
				69	21
				74	05
				93	02
				299	02
R20070	STRAP WEBBING	5340-543-3477	8690468	176	08
				181	10
				182	13
				185	04
				186	11
				190	11
				192	01

EXHIBIT 2 PAGE 2

M106A1 NEW
VEHICLE NO. 089, DATE 82263

INCID	NAME	NSN	PN	FIG	ITEM	CLCK	T-HRS
S40039	COVER	5935-773-1428	7731428	76	11	1.0	1.0
S40041	BUMPER	5340-209-9281	8341563	142	08	.5	.5
				143	06		
				151	13		
				154	09		
				160	05		
S40042	PULLEY	3020-679-9189	8756915	231	08	1.0	2.0
				232	12		
S40044	SWITCH	5930-841-1506	7748750	97	15	1.0	1.0
S40045	NUT	5975-771-6634	7716634	63	27	1.5	3.0
				64	06		
				78	14		
				78.1	03		
				79	07		
S40046	PLATE	2920-109-4309	11633594	28	03	1.0	2.0
S40047	BOX	2590-134-0822	10886040	56	02	1.0	3.0
S40048	WASHER	5310-809-8536	MS27183-24	1	07	4.0	8.0
				105	05		
S40049	BELT	3030-833-1336	MS51066P54	27	08	1.5	1.5
		SHOULD BE	5106652-2				
S40050	SHOCK	2540-714-6156	10875328	127	01	3.0	6.0
S40051	SHOCK	2540-714-6156	10875328	127	01	2.0	4.0

Exhibit D
Vehicle M106A1, Vehicle No. 089, Report Date 82263

EXHIBIT D

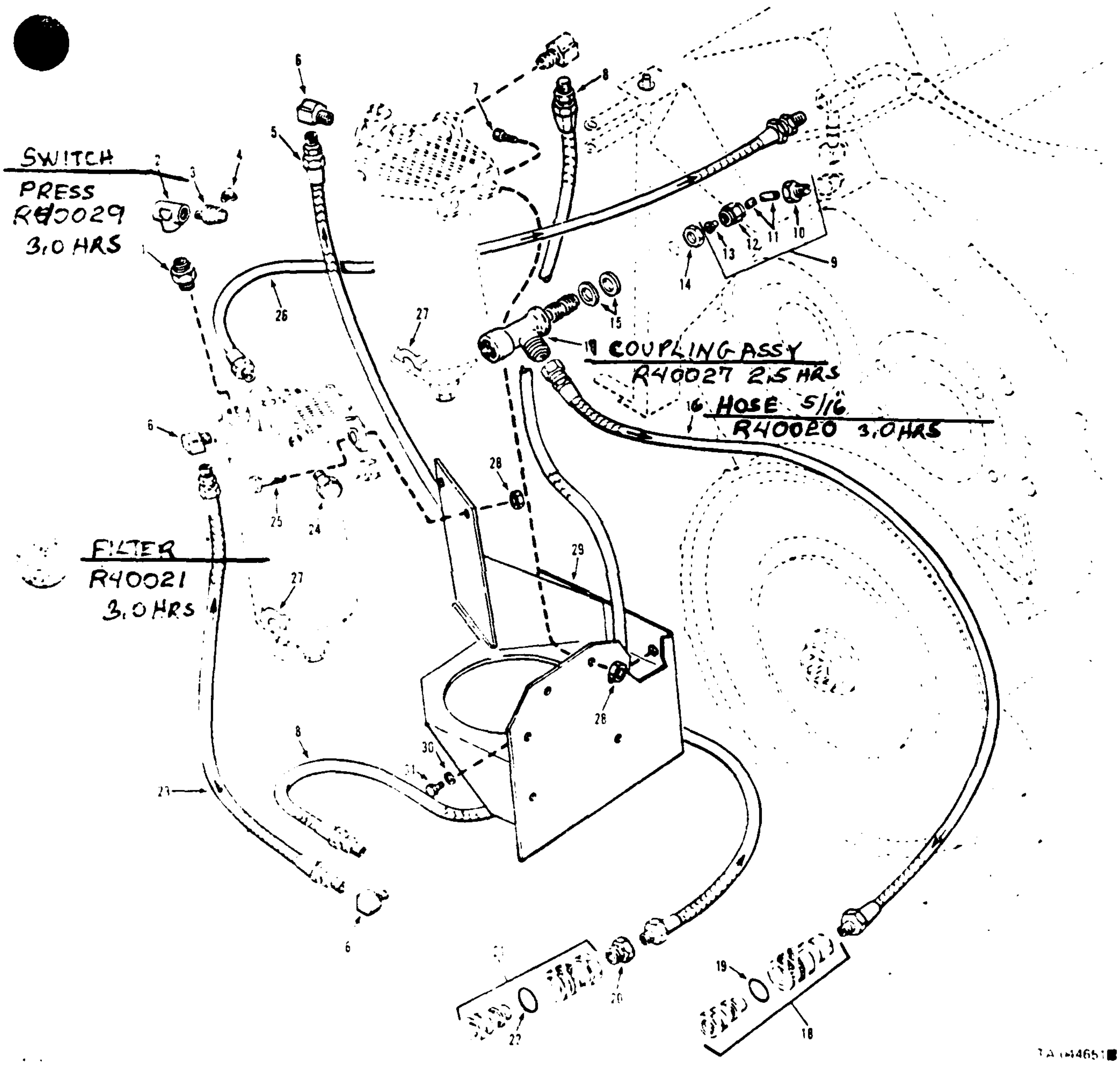

SWITCH
PRESS
R40029
3.0 HRS
COUPLING ASSY
R40027 2.5 HRS
HOSE 5/16
R40020 3.0 HRS
FILTER
R40021
3.0 HRS
TA 084651

EXHIBIT E1

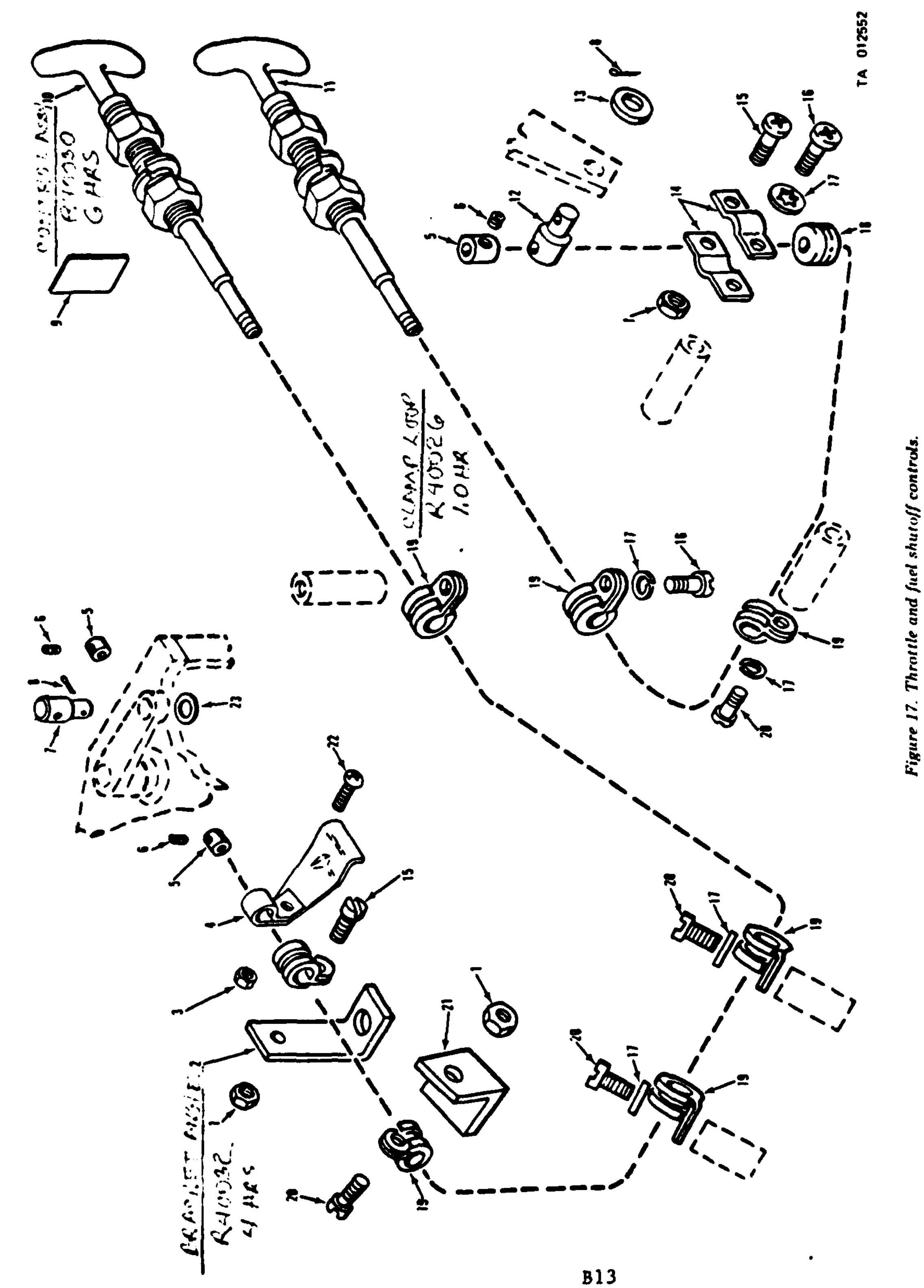


Figure 17. Throttle and fuel shutoff controls.

B13

EXHIBIT E2

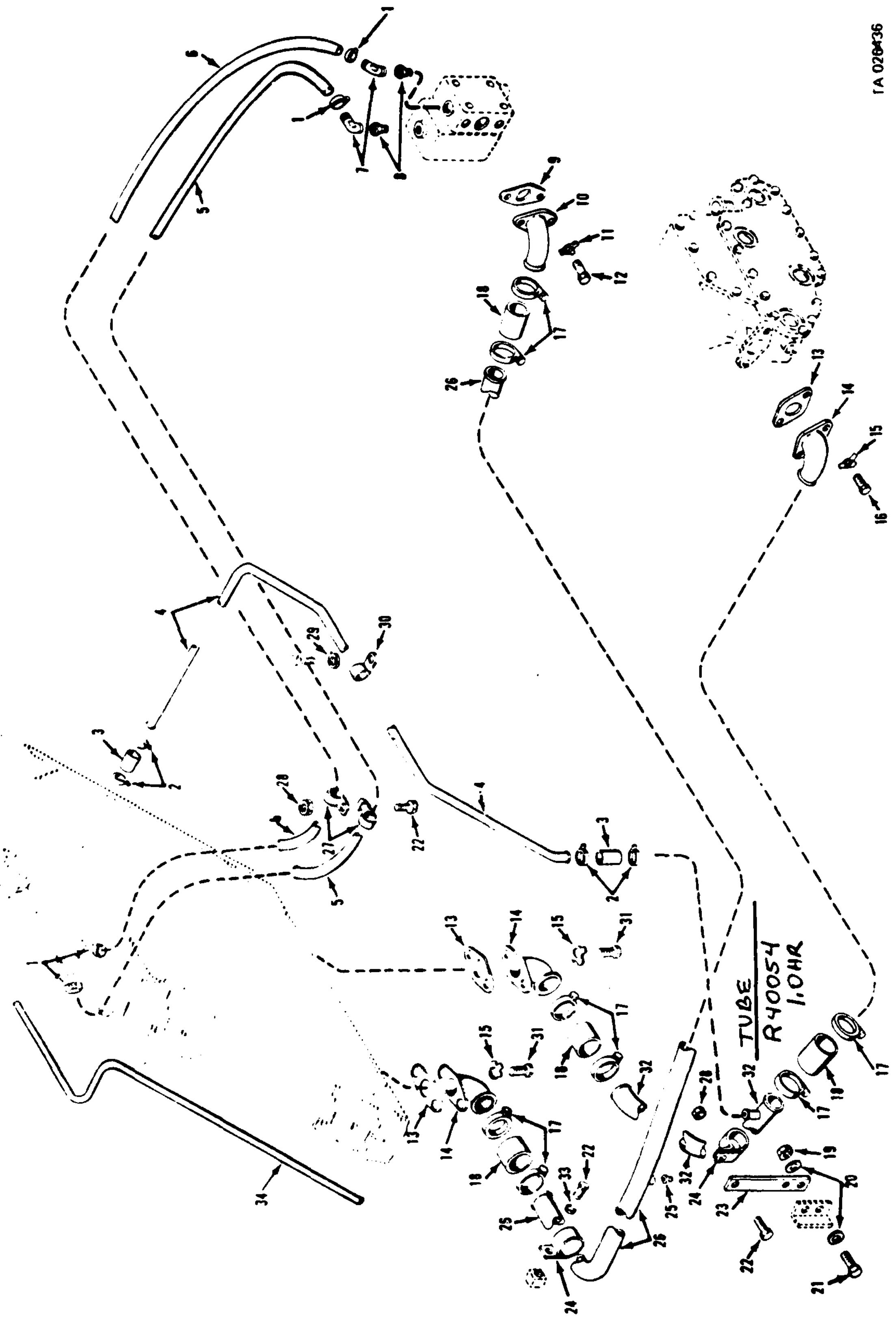


Figure 33. Radiator hoses, tubes and fittings

EXHIBIT E3

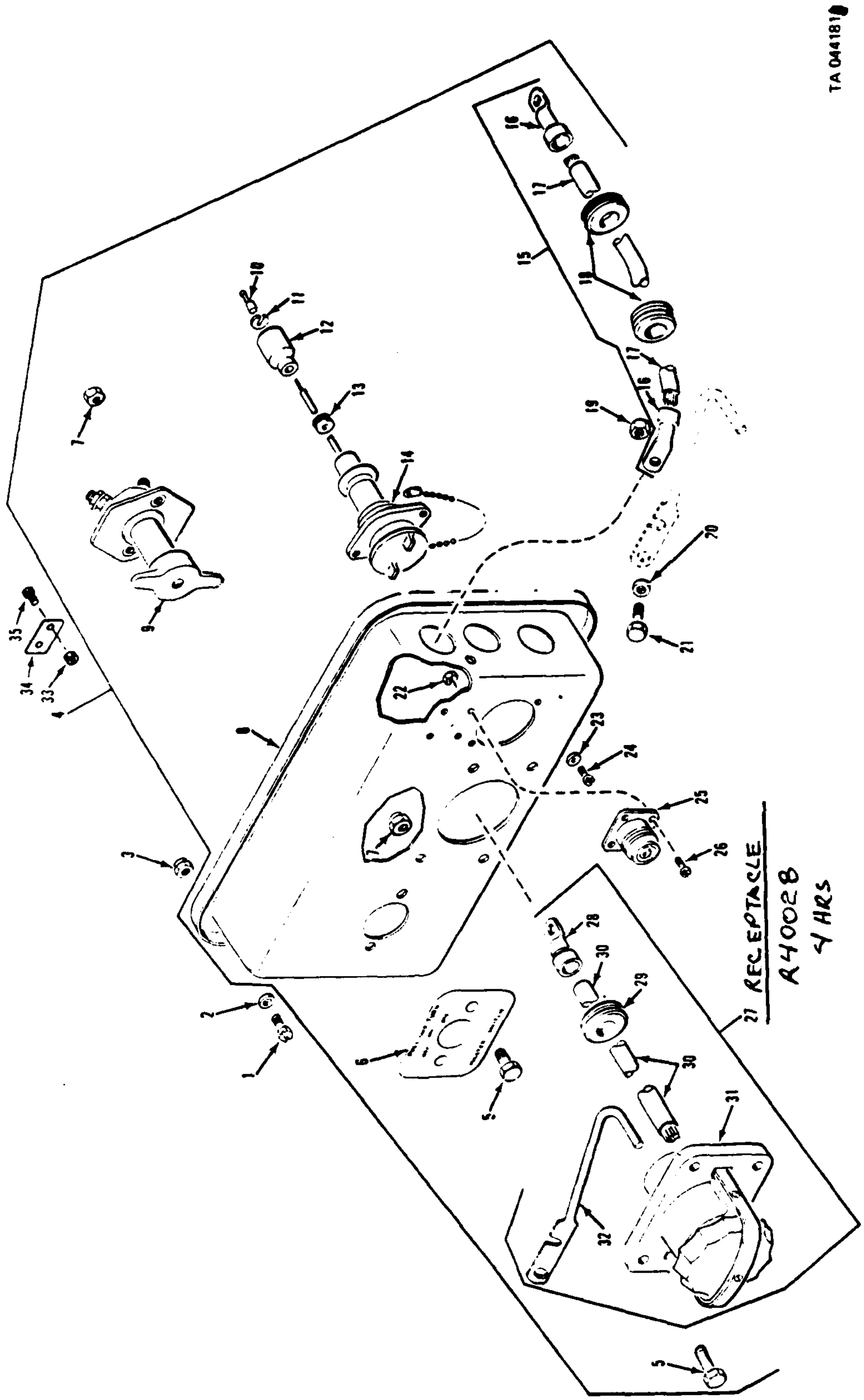
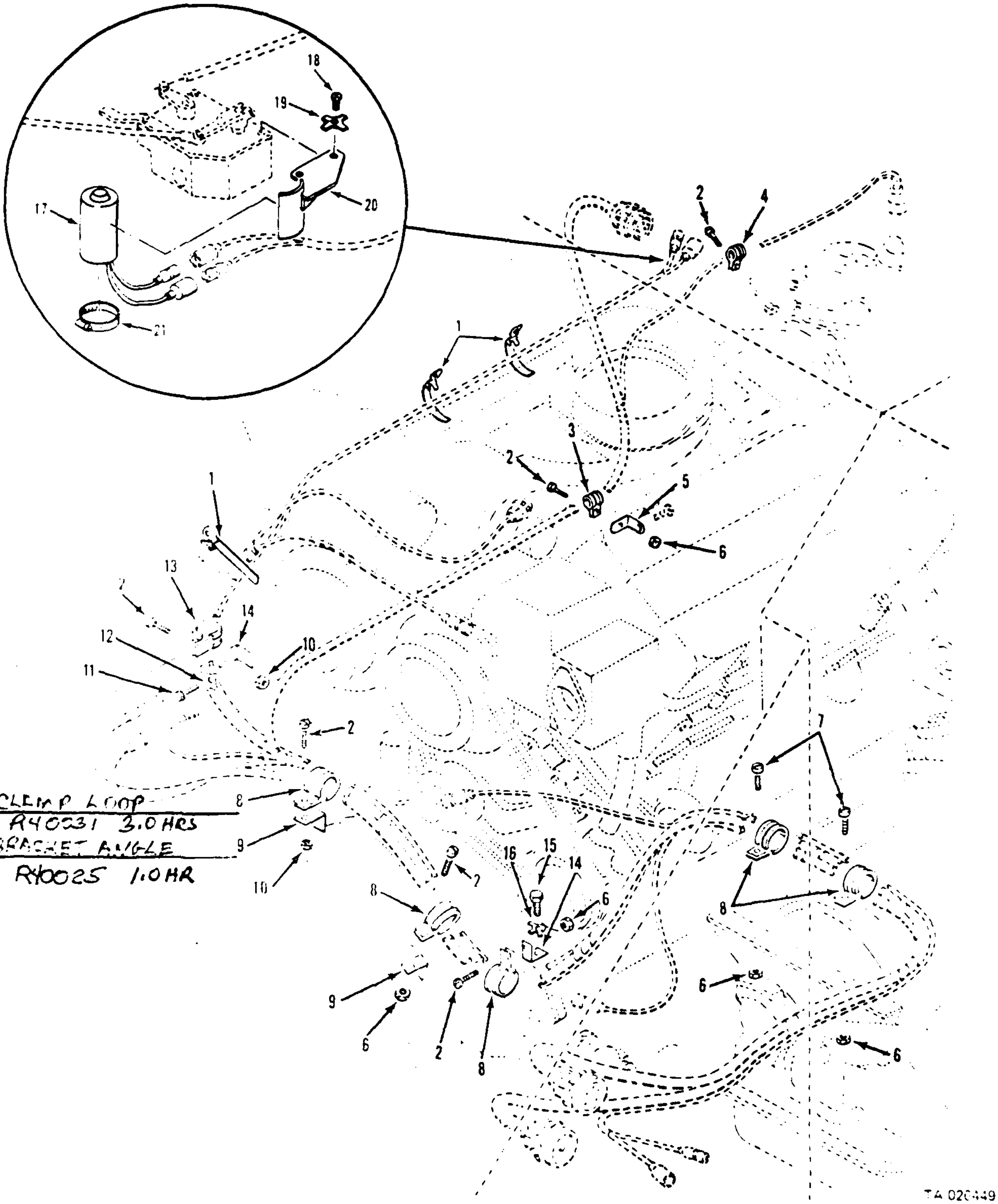


Figure 33—Master switch panel (M113A1, M106A1, M125A1, M132A1, M741, XM806E1).

EXHIBIT E4



CLEMP LOOP
R40231 3.0 HRS
BRACKET ANGLE
R40025 1.0 HR

Figure 60. Power plant wiring harness attaching parts.

EXHIBIT E5

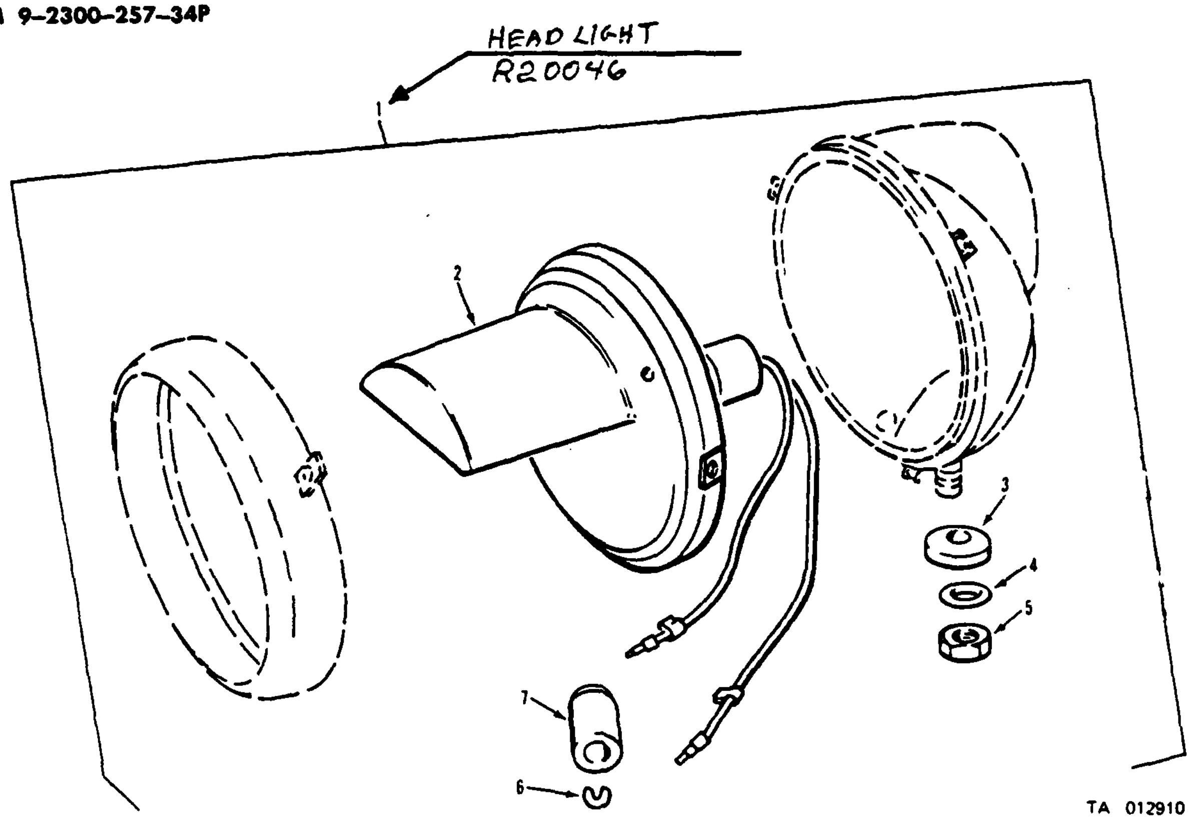


Figure 43.—Blackout headlight.

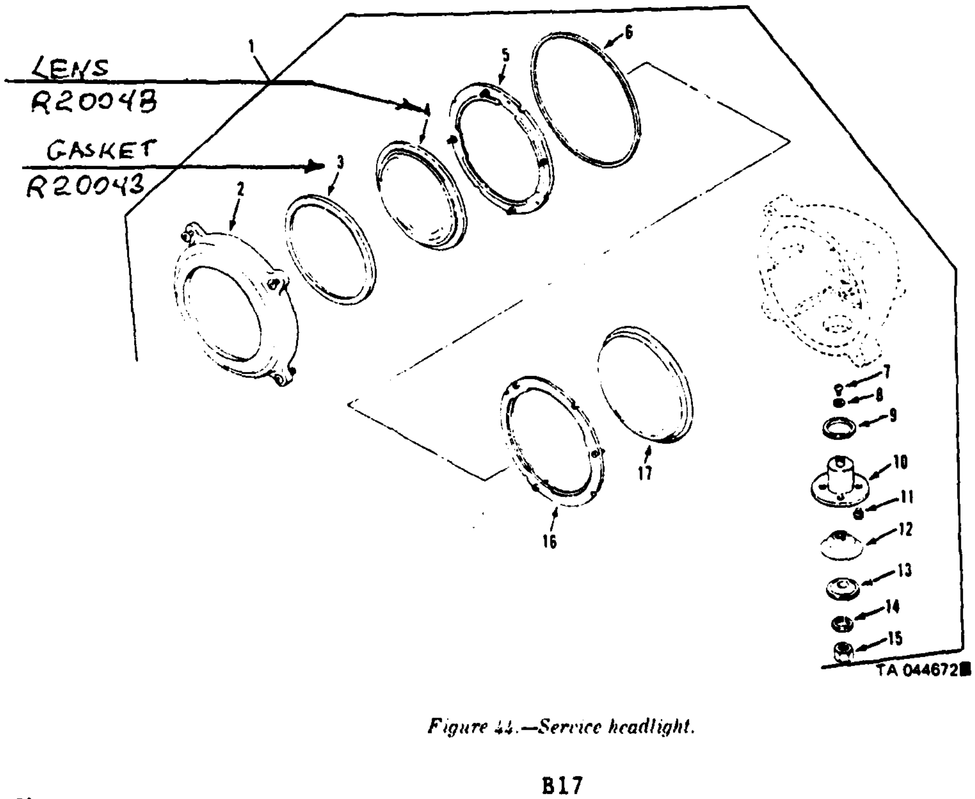


Figure 44.—Service headlight.

B17

EXHIBIT F1

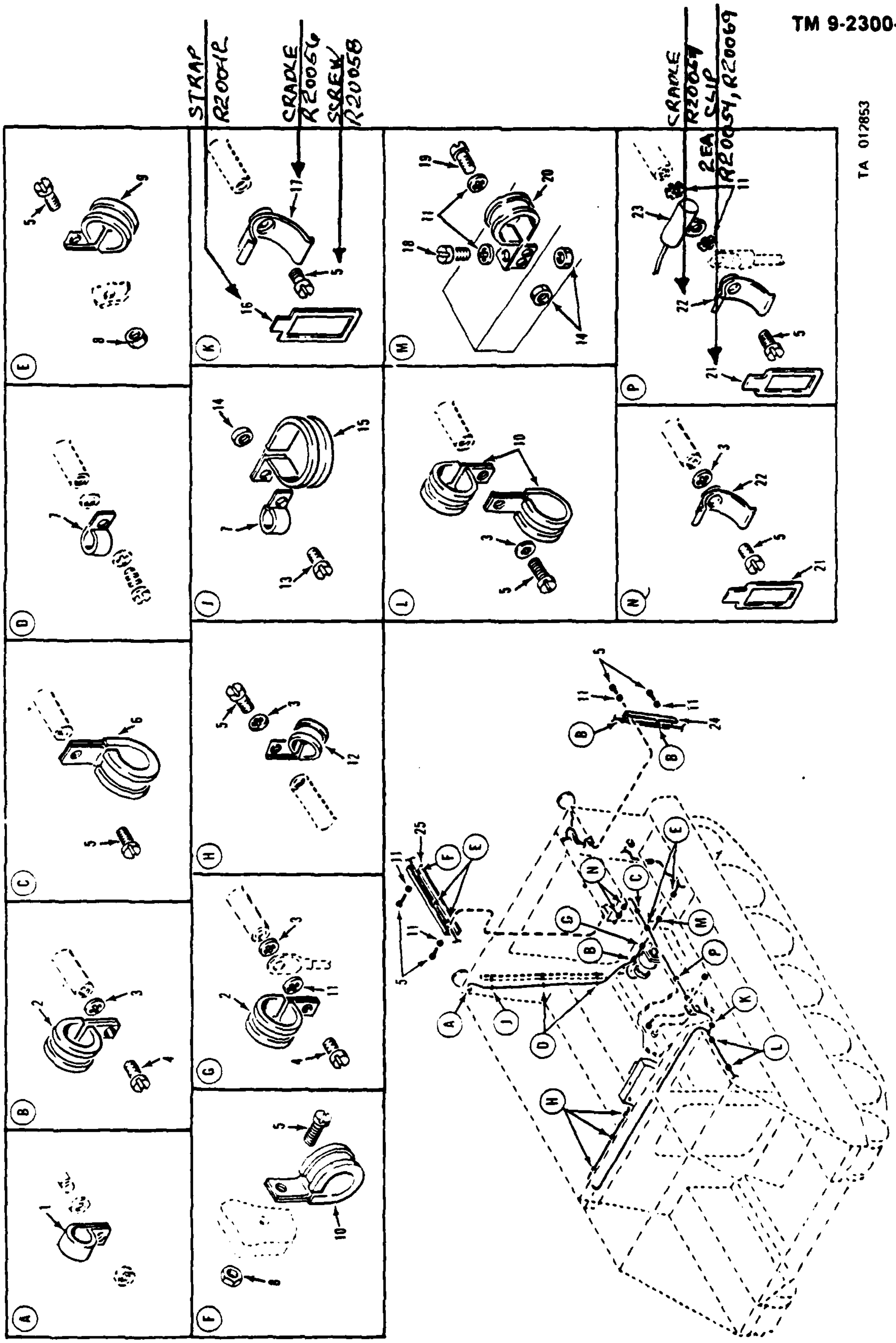


Figure 69. Main rear wiring harness attaching parts (M106A1, M125A1).

EXHIBIT F2

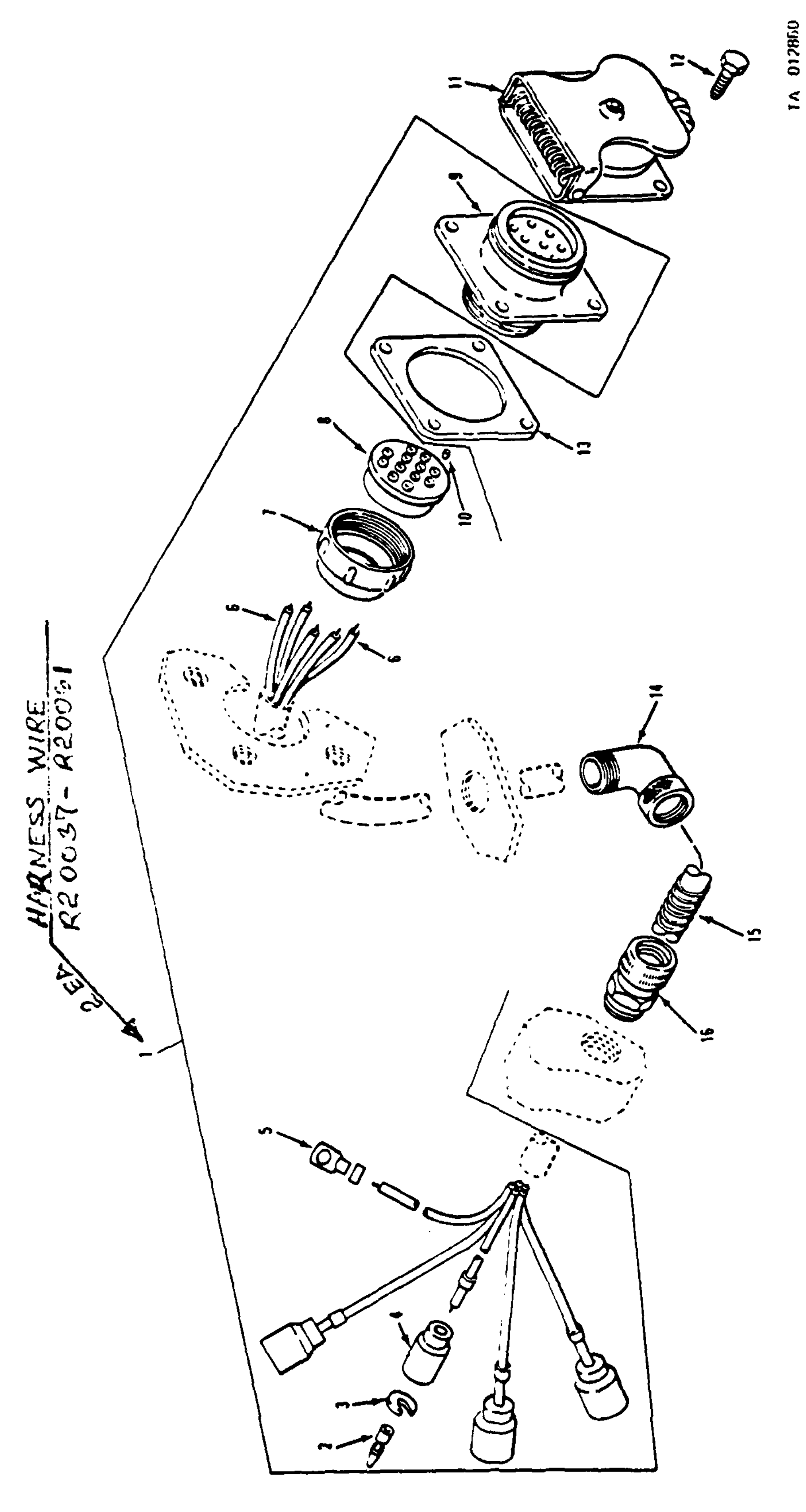


Figure 76. Trailer light wiring harness.

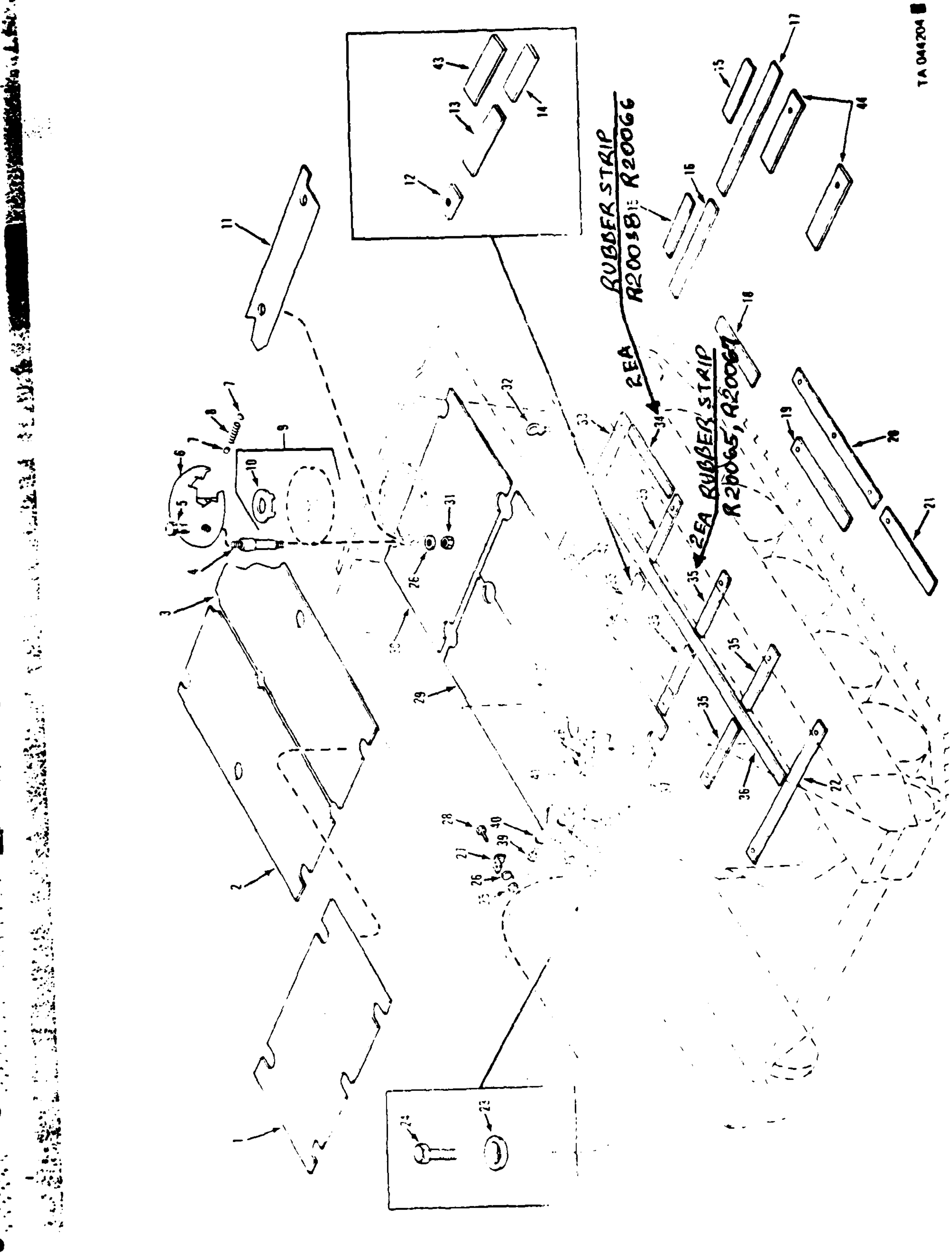


Figure 162. Floor plates and cushions.

EXHIBIT F4

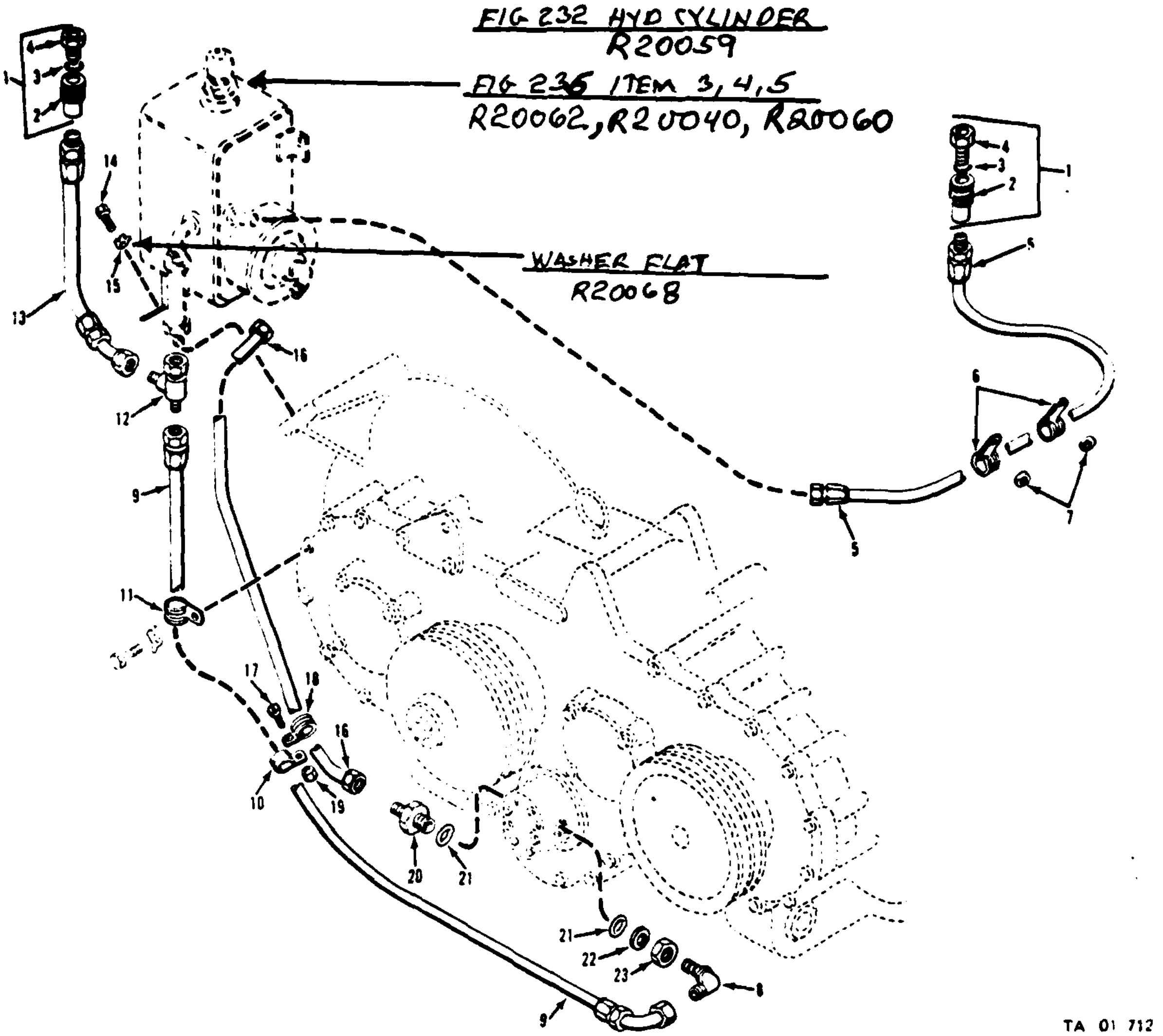


Figure 235. Ramp hydraulic lines and fittings (except M741).

EXHIBIT F5

APPENDIX C

COST DRIVERS

NSN	PART NO.	NOMENCLATURE	QTY REP	QTY ADT	CREW HRS	ORG HRS	DS HRS	GS HRS	DEPOT HRS	UNIT PART COST $	TOTAL PARTS COST $	LABOR COST $	TOTAL COST $
1240-01-050-7256	12266500	PERISCOPE,TANK	29	14	0.0	97.9	0.0	0.0	0.0	56578.00	1640762.00	1397.03	1642159.00
2815-00-124-5390	8738127	ENGINE WITH CONTAIN	101	2	993.0	975.9	667.0	48.0	0.0	8168.00	824968.00	38299.24	863267.13
2815-00-054-0244	5125379	ENGINE, DIESEL	53	0	541.2	778.8	460.3	0.0	0.0	10425.00	552525.00	25404.87	577929.87
2520-00-066-4240	8355951	TRANSMISSION,HYDRAU	101	1	698.4	729.0	663.5	0.0	0.0	3409.00	344309.00	29837.13	374146.13
2530-00-678-2908	11677988-6	TRACK SHOE,VEHICULA	4695	2108	2296	112.9	5.0	0.0	0.0	41.88	196626.56	34452.02	231078.56
2520-00-572-8605	10932770	GEARCASE, TRANSFER	43	0	313.0	289.1	252.5	0.0	0.0	2337.00	100491.00	12195.14	112686.14
2520-00-714-6135	10875026	DIFFERENTIAL AND DR	25	4	211.1	159.5	43.0	0.0	0.0	4147.00	103675.00	5902.07	109577.06
2520-00-895-9164	10890372	DRIVE ASSEM, OUTPUT	68	1	265.4	194.7	14.6	0.0	0.0	1268.40	86251.20	6773.97	93025.17
2920-00-782-1955	10947517	GENERATOR,ENGINE AC	116	5	143.3	206.4	7.5	2.0	0.0	658.00	76328.00	5125.78	81453.77
1430-01-053-7202	12265774	CONTROL,PANEL ASSEM	7	2	8.0	1.0	58.0	0.0	0.0	7969.00	55783.00	956.09	56739.09
2530-00-334-5877	11678270	WHEEL, SOLID RUBBER	556	37	738.3	60.7	0.0	0.0	0.0	69.48	38630.88	11401.72	50032.60
2520-01-061-5570	12253625	GEARCASE, TRANSFER	17	1	52.0	209.5	92.5	0.0	0.0	2337.00	39729.00	5051.58	44780.50
6140-00-057-2554	MS35000-3	BATTERY,STORAGE	488	48	534.4	425.5	0.0	0.0	0.0	58.22	28411.36	13697.75	42109.11
2530-00-088-9531	11677982	PAD, TRACKSHOE, VEH	6376	1968	1322	50.7	0.0	0.0	0.0	3.30	21040.80	19596.96	40637.76
4140-00-711-8354	10866240	FAN,VANEAXIAL	27	3	61.5	89.4	0.0	0.0	0.0	1342.00	36234.00	2153.34	38387.34
1240-01-064-7204	12266851	TELESCOPE,PANORAMIC	3	6	0.0	12.3	0.0	0.0	0.0	9312.00	27936.00	175.52	28111.52
3020-00-141-1154	11678255	SPROCKET WHEEL	346	35	525.6	68.3	0.0	0.0	0.0	54.56	18877.76	8474.95	27352.71
2930-01-060-2493	12253584-1	FAN VANEAXIAL	14	1	69.5	60.0	0.0	0.0	0.0	1398.00	19572.00	1847.96	21419.96
2540-01-071-0651	11669489	HEATER,VEHICULAR,CO	13	1	24.5	6.5	0.0	0.0	0.0	1378.00	17914.00	442.37	18356.37
2920-00-900-7993	10947439	REGULATOR,ENGINE GE	133	52	171.8	289.4	0.0	1.0	0.0	81.71	10867.43	6595.58	17463.00
2930-00-168-4896	11662993	RADIATOR,ENGINE COO	24	3	115.7	79.1	0.0	0.0	0.0	556.00	13344.00	2779.80	16123.79
2540-00-714-6156	10875328	SHOCK ABSORBER,DIRE	175	1	177.2	168.0	0.0	0.0	0.0	62.49	10935.75	4926.00	15861.75
2590-01-054-0279	12265838	CABEL ASSEM, SPEC	10	3	0.4	23.6	101.5	0.0	0.0	1279.00	12790.00	1790.88	14580.88
2520-00-679-9657	8763180	CUSHION,RUBBER,SPRO	484	17	643.1	116.2	0.0	0.0	0.0	6.75	3267.00	10835.21	14102.21
2520-00-678-8382	10942567	WHEEL,SPROCKET	68	4	128.7	23.3	0.0	0.0	0.0	166.00	11288.00	2169.04	13457.04
2920-00-514-0464	11663416	STARTER, ENGINE, EL	38	3	119.9	140.3	0.0	0.0	0.0	251.00	9538.00	3713.05	13251.05
6650-00-704-3549	7043549	PERISCOPE M17	150	20	54.7	12.9	1.7	0.0	0.0	74.11	11116.50	988.91	12105.41
2920-01-011-2814	11668641	STARTER, ENGINE, EL	31	1	86.2	143.0	0.5	0.0	0.0	251.00	7781.00	3277.82	11058.82
2530-00-403-6776	11660968	ADJUSTER, TRACK, VE	51	216	306.8	86.8	0.0	0.0	0.0	70.44	3592.44	5616.66	9209.10
2540-01-028-8573	11669371	SHOCK ABSORBER,DIRE	69	0	38.5	23.8	0.0	0.0	0.0	108.00	7452.00	889.02	8341.02
2530-00-679-8001	8756623	SHROUD, TRACK	66	3	78.5	10.2	0.0	0.0	0.0	98.64	6510.24	1265.75	7775.99
2510-00-476-6565	11647365-1	VANE,TRIM VEHICULAR	74	1	227.5	27.7	0.0	0.0	0.0	41.91	3101.34	3641.70	6743.04
5330-00-679-9879	8756298	SEAL, PLAIN ENCASED	129	5	199.8	133.9	0.0	0.0	0.0	12.05	1554.45	4761.90	6316.35
5305-00-269-3241	MS90727-65	SCREW,CAP,HEXAGON H	516	88	166.8	197.7	51.5	0.0	0.0	0.06	30.96	5936.31	5967.27
2940-00-168-2338	11598003	AIR CLEANER,INTAKE	34	7	35.7	1.8	0.0	0.0	0.0	157.00	5338.00	535.12	5873.12
2530-01-053-4811	12265502-1	BRAKE,ELECTRIC	14	23	0.3	19.5	14.5	0.0	0.0	350.00	4900.00	489.46	5389.46
2540-01-075-7792	12265903	LATCH ASSEMBLY,CARG	7	1	0.0	4.0	0.0	0.0	0.0	760.00	5320.00	57.08	5377.08
2520-00-714-6157	10875330	SPIDER,UNIVERSAL JO	63	12	75.3	162.4	16.0	0.0	0.0	21.83	1375.29	3620.30	4995.59
2590-00-679-9643	8763300	PUMP,ROTARY	20	19	26.8	44.8	0.0	0.0	0.0	193.00	3860.00	1021.73	4881.73
2930-00-168-4899	11662994	RADIATOR, ENG COOL	7	0	38.0	23.0	0.0	0.0	0.0	558.00	3906.00	870.47	4776.47
5330-01-035-9832	12253286	SEAL,PLAIN ENCASED	106	0	122.2	111.7	0.0	0.0	0.0	13.41	1421.46	3337.75	4759.21
2530-00-856-2299	10907799	WHEEL,METAL TIRE	46	0	50.7	11.9	0.0	0.0	0.0	83.88	3858.48	893.30	4751.78
2590-01-054-0328	12265839	CABLE ASSEMBLY,SPEC	6	4	0.0	6.5	64.0	0.0	0.0	607.80	3646.80	1006.03	4652.83
2990-00-903-0908	5135876	SHAFT,BLOWER DRIVE	34	0	102.0	164.5	24.5	0.0	0.0	12.87	437.58	4152.57	4590.15
2520-00-679-9240	10861450	SPIDER, U-JOINT	72	12	122.1	135.6	59.0	0.0	0.0	0.00	0.00	4519.31	4519.31
1015-00-436-4874	10918100	BIPOD ASSEMBLY	2	4	2.5	0.1	12.0	0.0	0.0	2098.00	4196.00	208.34	4404.34
2590-01-075-7795	12277437	HAND CONTROL SUBASS	1	2	0.0	1.0	9.0	0.0	0.0	4210.00	4210.00	142.70	4352.70
5930-00-771-8119	10874979	SWITCH,PRESSURE	138	39	61.7	142.1	0.5	0.0	0.0	10.22	1410.36	2915.35	4325.71
2530-00-996-0719	10918162-2	ARM ASSEMBLY,PIVOT,	13	0	44.9	30.7	0.0	0.0	0.0	245.00	3185.00	1078.81	4263.81
2540-00-597-9981	1166126	HEATER KIT, VEH COM	2	0	51.0	51.0	0.0	0.0	0.0	1293.00	2586.00	1455.54	4041.54
5305-00-042-6417	MS90725-113	SCREW,CAP,HEXAGON H	1270	50	75.0	24.4	15.5	161.0	0.0	0.07	88.90	3937.09	4025.99
2530-00-711-8381	10866132	ARM ASSEM, TRACK ID	13	6	113.3	68.6	0.0	0.0	0.0	102.00	1326.00	2595.71	3921.71
2520-01-115-1809	5703824	PARTS KIT,POWER TRA	11	0	16.0	15.0	1.0	0.0	0.0	309.00	3399.00	456.64	3855.64
2815-00-789-1006	5198203	CYLINDER HEAD,DIESE	7	2	28.0	29.0	25.0	0.0	0.0	356.00	2492.00	1170.14	3662.14
3030-01-065-6264	11669505-1	BELTS,V,MATCHED SET	98	17	52.0	84.2	9.0	0.0	0.0	15.73	1541.54	2072.00	3613.54
2815-00-251-8581	5135735	COVER AND SEAL ASSY	2	0	0.0	3.0	0.0	0.0	0.0	1740.00	3480.00	42.81	3522.81
5330-00-570-4060	10942893	SEAL,PLAIN ENCASED	350	22	119.7	101.3	0.0	0.0	0.0	0.7	245.00	3153.66	3398.66
3130-01-062-0868	11669361	HOUSING,BEARING UNI	40	0	114.0	11.0	0.0	0.0	0.0	36.2	1449.60	1783.75	3233.35

NSN	PART NO.	NOMENCLATURE	QTY REP	QTY ADT	CREW HRS	ORG HRS	DS HRS	GS HRS	DEPOT HRS	UNIT COST $	TOTAL PART COST $	LABOR COST $	TOTAL COST $
4210-00-910-9663	10946814	CYLINDER,COMPRESSED	16	6	13.4	95.4	0.0	0.0	0.0	99.10	1585.60	1552.58	3138.17
5310-00-982-6809	MS21044N10	NUT,SELF-LOCKING,HE	3260	116	129.1	31.6	0.0	0.0	0.0	0.25	815.00	2293.19	3108.19
2990-00-572-8649	10932802	PIPE,EXHAUST	24	23	58.0	67.5	0.0	0.0	0.0	52.62	1262.88	1790.88	3053.76
2520-00-767-3153	5702859	PARTS KIT,FLUID PRE	185	0	31.6	70.6	0.0	0.0	0.0	8.40	1554.00	1458.39	3012.39
2910-00-073-3011	5228783	INJECTOR ASSEMBLY,F	18	3	28.0	29.0	17.0	0.0	0.0	100.66	1811.88	1055.98	2867.86
5330-00-570-4057	10942892	SEAL,PLAIN ENCASED	278	10	94.3	81.9	0.0	0.0	0.0	0.86	239.08	2514.37	2753.45
2520-00-088-9866	11660974	BRAKE,SINGLE DISK	22	3	24.1	38.3	0.0	0.0	0.0	84.03	1848.66	890.45	2739.11
4720-00-089-2201	10932293-2	HOSE ASSEMBLY,NONME	29	3	105.8	60.8	0.0	0.0	0.0	11.74	340.46	2377.38	2717.84
1430-01-057-2629	12266374	REMOTE CONTROL SYST	1	1	0.0	1.5	11.0	0.0	0.0	2482.00	2482.00	178.37	2660.37
2530-00-004-0761	11677984	TRACK SHOE,VEHICULA	42	1	56.5	1.8	0.0	0.0	0.0	42.21	1772.82	831.94	2604.76
2990-00-944-2053	5139094	PARTS KIT,DIESEL EN	2	2	34.8	42.8	44.0	0.0	0.0	432.92	865.84	1735.23	2601.07
2590-00-679-9159	10861448	PUMP ASSY	25	2	19.9	46.5	0.0	0.0	0.0	65.78	1644.50	947.53	2592.03
2930-00-767-7881	8529880	RADIATOR,OIL COOLER	6	1	60.0	68.2	0.0	0.0	0.0	118.00	708.00	1829.41	2537.41
3030-00-833-1336	MS51066P54-2	BELTS,V,MATCHED SET	111	28	46.8	96.8	0.0	0.0	0.0	3.73	414.03	2049.17	2463.20
2520-00-572-8724	10932788	SHAFT,SHOULDERED	7	0	36.0	80.0	43.5	0.0	0.0	24.34	170.38	2276.06	2446.44
4210-00-270-4512	7714780	EXTINGUISHER,FIRE,C	33	0	7.3	65.7	0.0	0.0	0.0	41.60	1372.80	1041.71	2414.51
2510-00-999-2298	1063786	FENDER	3	9	28.6	111.7	1.0	0.0	0.0	118.00	354.00	2016.35	2370.35
6240-00-368-4972	453128	LAMP,INCANDESCENT	174	4	49.3	54.9	0.0	0.0	0.0	5.04	876.96	1486.93	2363.89
2930-01-061-4294	11669369	RADIATOR,ENGINE COO	4	2	12.5	21.3	2.0	0.0	0.0	446.00	1784.00	510.87	2294.87
6830-00-782-2641	BBN411	NITROGEN	$125	2900	0.0	159.1	0.0	0.0	0.0	0.00	0.00	2270.35	2270.35
2815-00-758-9042	5106297	BLOWER ASSEMBLY,ENG	2	0	11.0	7.0	46.0	0.0	0.0	676.10	1352.20	913.28	2265.48
3030-00-684-1485	MS51066P74-2	BELTS,V,MATCHED SET	93	22	41.6	82.9	0.0	0.0	0.0	4.96	461.28	1776.61	2237.89
2530-00-996-0718	10918162-1	ARM ASSEMBLY,PIVOT,	8	0	20.1	20.0	0.0	0.0	0.0	206.00	1648.00	572.23	2220.23
9150-00-252-6383	MIL-H-5606	HYDRAULIC FLUID,PET	614	31	55.0	40.3	0.0	0.0	0.0	1.35	828.90	1359.93	2188.83
6220-00-984-5180	11589477-2	HEADLIGHT	61	1	23.3	28.4	0.0	0.0	0.0	23.75	1448.75	737.76	2186.51
2350-01-045-1123	676000	COMBAT VEHICLE,ANTI	0	21	0.0	72.0	0.0	14.0	67.0	320251.00	0.00	2183.31	2183.31
3110-00-100-4471	712532	BEARING,ROLLER,TAPE	49	0	69.4	61.0	0.0	0.0	0.0	5.92	290.08	1860.81	2150.89
4720-00-781-9866	10932440-2	HOSE ASSEMBLY,NONME	23	3	40.5	81.4	0.0	0.0	0.0	17.29	397.67	1739.51	2137.18
9150-00-186-6681	MILL2104	LUBRICATING OIL,ENG	1004	0	45.3	40.3	1.0	0.0	0.0	0.89	893.56	1235.78	2129.34
5330-01-060-2531	11669372	SEAL,PLAIN ENCASED	49	1	48.5	54.2	0.0	0.0	0.0	13.41	657.09	1465.53	2122.62
4330-00-860-7343	5703089	NIIN NOT FOUND	169	3	43.3	103.4	0.0	0.0	0.0	0.00	0.00	2093.41	2093.41
2530-00-773-2138	10875366	SUPPORT,BEARING,ROA	68	6	79.5	44.4	0.0	0.0	0.0	3.17	215.56	1768.05	1983.61
5305-00-269-3236	MS90727-60	SCREW,CAP,HEXAGON H	318	10	46.5	59.9	31.0	0.0	0.0	0.04	12.72	1960.70	1973.42
2940-00-168-2337	11598399	FILTER ELEMENT,INTA	52	4	23.0	2.5	0.0	0.0	0.0	29.42	1529.84	363.88	1893.72
5930-00-699-9085	MS39058-1	SWITCH,SENSITIVE	9	6	10.0	12.5	105.0	0.0	0.0	8.09	72.81	1819.42	1892.23
1440-01-074-5900	12265512	BOX,SLIP RING,ASSEM	1	0	0.0	0.5	6.0	0.0	0.0	1782.00	1782.00	92.75	1874.75
5310-00-000-0079	10910174-33	WASHER,FLAT	1289	52	53.3	66.5	0.0	0.0	0.0	0.10	128.90	1709.54	1838.44
2530-00-679-7966	8763360	TORSION BAR,SUSPENS	10	4	48.5	26.5	0.0	0.0	0.0	76.25	762.50	1070.25	1832.75
4010-00-712-8374	10874714	WIRE ROPE ASSEMBLY,	55	4	56.7	47.0	0.0	0.0	0.0	6.27	344.85	1479.80	1824.65
2590-00-679-9168	10861660	CTRL ASSEM,PUSH-PUL	67	7	38.7	69.8	0.0	0.0	0.0	4.10	274.70	1548.29	1822.99
5330-00-789-4867	5133619	GASKET	32	0	49.5	76.6	0.0	0.0	0.0	0.16	5.12	1799.45	1804.57

	NSN	PART NO.	NOMENCLATURE		QTY USED
NSNPN:	9150-00-190-0905	MIL-G-10924	GREASE,AUTOMOTIVE A	CT:	731
NSNPN:	2530-00-078-2908	11677988-6	TRACK SHOE,VEHICULA	CT:	281
NSNPN:	6140-00-057-2554	MS35000-3	BATTERY,STORAGE	CT:	243
NSNPN:	2530-00-334-5877	11678270	WHEEL, SOLID RUBBER	CT:	176
NSNPN:	2530-00-403-6776	11660968	ADJUSTER, TRACK, VE	CT:	157
NSNPN:	2920-00-900-7993	10947439	REGULATOR,ENGINE GE	CT:	150
NSNPN:	5930-00-771-8119	10874979	SWITCH,PRESSURE	CT:	140
NSNPN:	6240-00-368-4972	453128	LAMP,INCANDESCENT	CT:	112
NSNPN:	2530-00-088-9531	11677982	PAD, TRACKSHOE, VEH	CT:	109
NSNPN:	3030-00-833-1336	MS51066P54-2	BELTS,V,MATCHED SET	CT:	92
NSNPN:	6850-00-181-7940	MILA46153	NIIN NOT FOUND	CT:	92
NSNPN:	2520-00-679-9657	8763180	CUSHION,RUBBER,SPRO	CT:	89
NSNPN:	2920-00-782-1955	10947517	GENERATOR,ENGINE AC	CT:	81
NSNPN:	2540-00-714-6156	10875328	SHOCK ABSORBER,DIRE	CT:	77
NSNPN:	3030-00-684-1485	MS51066P74-2	BELTS,V,MATCHED SET	CT:	76
NSNPN:	2815-00-124-5390	8738127	ENGINE WITH CONTAIN	CT:	76
NSNPN:	5305-00-042-6417	MS90725-113	SCREW,CAP,HEXAGON H	CT:	76
NSNPN:	5340-00-209-9281	8341563	BUMPER,RUBBER	CT:	75
NSNPN:	9150-00-186-6681	MILL2104	LUBRICATING OIL,ENG	CT:	75
NSNPN:	2510-00-476-6565	11647365-1	VANE,TRIM VEHICULAR	CT:	72
NSNPN:	2590-00-679-9168	10861660	CTRL ASSEM,PUSH-PUL	CT:	68
NSNPN:	4730-00-050-4208	MS15003-1	FITTING,LUBRICATION	CT:	67
NSNPN:	2940-00-168-2337	11598399	FILTER ELEMENT,INTA	CT:	66
NSNPN:	2520-00-066-4240	8355951	TRANSMISSION,HYDRAU	CT:	65
NSNPN:	3020-00-141-1154	11678255	SPROCKET WHEEL	CT:	61
NSNPN:	3030-01-065-6264	11669505-1	BELTS,V,MATCHED SET	CT:	59
NSNPN:	5330-00-714-6138	10875056	GASKET	CT:	56
NSNPN:	6650-00-704-3549	7043549	PERISCOPE M17	CT:	56
NSNPN:	5305-00-269-3241	MS90727-65	SCREW,CAP,HEXAGON H	CT:	52
NSNPN:	2590-00-867-8841	10861660-1	CTRL ASSEM,PUSH-PUL	CT:	51
NSNPN:	4010-00-712-8374	10874714	WIRE ROPE ASSEMBLY,	CT:	51
NSNPN:	6240-00-266-9940	MS25231-1829	LAMP,INCANDESCENT	CT:	51
NSNPN:	5340-01-016-7671	MS17987-829	PIN,QUICK RELEASE	CT:	49
NSNPN:	5310-00-982-6809	MS21044N10	NUT,SELF-LOCKING,HE	CT:	49
NSNPN:	5930-00-841-1506	7748750	SWITCH,SENSITIVE	CT:	48
NSNPN:	5330-00-679-9879	8756298	SEAL, PLAIN ENCASED	CT:	48
NSNPN:	2590-00-299-0739	10943083	VALVE,POPPET,HULL D	CT:	48
NSNPN:	6220-00-984-5180	11589477-2	HEADLIGHT	CT:	47
NSNPN:	6680-00-933-3600	MS24544-2	INDICATOR,LIQUID QU	CT:	47
NSNPN:	5305-00-726-2543	MS90727-160	SCREW,CAP,HEXAGON H	CT:	46
NSNPN:	4820-00-849-1220	MS35782-5	COCK,DRAIN	CT:	44
NSNPN:	2990-00-572-8649	10932802	PIPE,EXHAUST	CT:	44
NSNPN:	5330-00-570-4060	10942893	SEAL,PLAIN ENCASED	CT:	43
NSNPN:	3030-01-065-6265	11669505-2	BELTS,V,MATCHED SET	CT:	41
NSNPN:	5305-00-761-4227	MS90726-111	SCREW,CAP,HEXAGON H	CT:	41
NSNPN:	2590-00-683-0598	MS51074-1	HORN,ELECTRICAL	CT:	40
NSNPN:	5340-00-598-0556	MS21919G40	CLAMP,LOOP	CT:	40
NSNPN:	3030-00-421-1553	5139228	NIIN NOT FOUND	CT:	39
NSNPN:	2530-00-679-8001	8756623	SHROUD, TRACK	CT:	38
NSNPN:	5330-00-570-4057	10942892	SEAL,PLAIN ENCASED	CT:	38
NSNPN:	2910-00-999-9452	10947970	VALVE	CT:	36
NSNPN:	2940-00-745-7730	5575032	FILTER ELEMENT,FLUI	CT:	36
NSNPN:	2815-00-054-0244	5125379	ENGINE, DIESEL	CT:	36
NSNPN:	5930-00-930-5016	MS27200-1	SWITCH,PULL	CT:	35
NSNPN:	6220-00-678-9046	MS51318-1	HEADLIGHT	CT:	35
NSNPN:	2590-00-930-2054	10950251	RECEPTACLE AND LEAD	CT:	34
NSNPN:	5340-00-835-9815	8720150	SEAL,ANTIPILFERAGE	CT:	34
NSNPN:	2540-00-831-6946	10866352	CUSHION,SEAT,VEHICU	CT:	34

NSNPN:	[illegible]50-00-190-0905	MIL-G-10924	GREASE,AUTOMOTIVE ,	[illegible]:	731

	NSN	PART NO.	NOMENCLATURE	QTY USED	
NSNPN:	2590-00-679-9643	8763300	PUMP,ROTARY	CT:	34
NSNPN:	2520-00-679-9244	8756542	LINING	CT:	34
NSNPN:	4730-00-930-2341	11589346	PLUG,PIPE	CT:	33
NSNPN:	2920-00-514-0464	11663416	STARTER, ENGINE, EL	CT:	33
NSNPN:	2990-00-903-0908	5135876	SHAFT,BLOWER DRIVE	CT:	32
NSNPN:	5930-00-688-9881	7771274-2	SWITCH,THERMOSTATIC	CT:	32
NSNPN:	5310-00-059-3531	10942891	WASHER,SHOULDERED A	CT:	32
NSNPN:	5330-00-679-9213	10861512	GASKET	CT:	31
NSNPN:	2590-00-930-2332	11589191	WIRING HARNESS,BRAN	CT:	30
NSNPN:	4210-00-769-9779	10875341	FXD FIRE EXT, CYLIN	CT:	30
NSNPN:	6220-00-670-7692	MS51303-2	LIGHT,MARKER,CLEARA	CT:	30
NSNPN:	5940-00-549-6581	MS75004-1	TERMINAL,LUG	CT:	30
NSNPN:	6220-00-337-7463	MS51073-1	LIGHT,DOME	CT:	30
NSNPN:	2920-01-011-2814	11668641	STARTER, ENGINE, EL	CT:	29
NSNPN:	2510-00-933-6954	10917897	CLAMP,SHROUD,TRACK	CT:	29
NSNPN:	6220-00-984-5181	MS53023-1	HEADLIGHT	CT:	28
NSNPN:	2520-00-678-8382	10942567	WHEEL,SPROCKET	CT:	28
NSNPN:	6240-00-019-0877	MS15570-1251	LAMP,INCANDESCENT	CT:	28
NSNPN:	5330-01-035-9832	12253286	SEAL,PLAIN ENCASED	CT:	27
NSNPN:	5310-00-000-0079	10910174-33	WASHER,FLAT	CT:	27
NSNPN:	5975-00-930-2348	11588831	ELBOW,ELECTRICAL CO	CT:	26
NSNPN:	4730-00-908-3193	MS35842-12	CLAMP,HOSE	CT:	26
NSNPN:	6220-00-819-7028	8747987	LAMP UNIT,VEHICULAR	CT:	26
NSNPN:	5340-00-702-2848	MS21333-128	CLAMP,LOOP	CT:	26
NSNPN:	4730-00-800-2828	10865913	COUPLING ASSEMBLY,Q	CT:	25
NSNPN:	2520-00-895-9164	10890372	DRIVE ASSEM, OUTPUT	CT:	24
NSNPN:	2920-00-735-9542	11602713	RELAY,ELECTROMAGNET	CT:	24
NSNPN:	6220-00-337-6471	MS51330-1	STOP LIGHT-TAILLIGH	CT:	24
NSNPN:	5330-00-290-7860	5571024	GASKET	CT:	24
NSNPN:	2930-00-168-4896	11662993	RADIATOR,ENGINE COO	CT:	24
NSNPN:	5930-00-944-1660	MS90530-1	SWITCH,PRESSURE	CT:	23
NSNPN:	6680-00-825-2076	MS35916-2	TACHOMETER,MECHANIC	CT:	23
NSNPN:	5310-00-809-5998	MS27183-18	WASHER,FLAT	CT:	23
NSNPN:	5305-00-719-5235	MS90727-114	SCREW,CAP,HEXAGON H	CT:	23
NSNPN:	5340-00-598-0415	MS21919DG18	CLAMP,LOOP	CT:	23
NSNPN:	4720-00-089-2201	10932293-2	HOSE ASSEMBLY,NONME	CT:	23
NSNPN:	2530-01-053-4811	12265502-1	BRAKE,ELECTRIC	CT:	22
NSNPN:	1240-01-050-7256	12266500	PERISCOPE,TANK	CT:	22
NSNPN:	5306-00-920-0640	10932622	BOLT,TEE HEAD	CT:	22
NSNPN:	4730-00-908-6294	MS35842-16	CLAMP,HOSE	CT:	22
NSNPN:	5305-00-725-4105	MS90726-164		CT:	22

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