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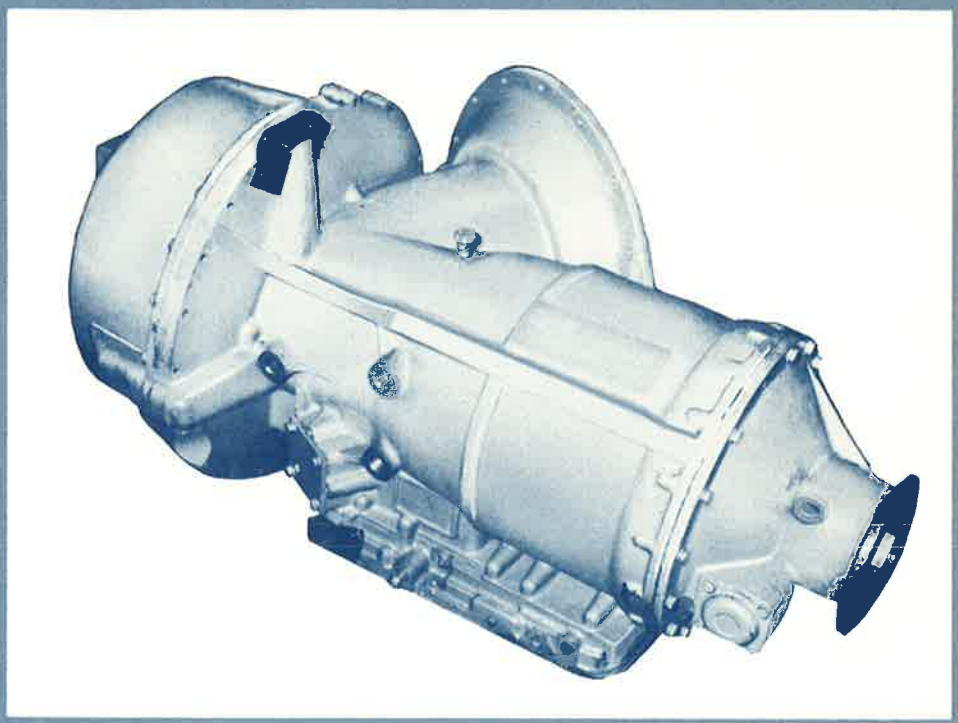
U.S. Department
of Transportation
**Urban Mass
Transportation
Administration**

Updated Reliability Evaluation of V730 Transmission

Prepared by:
Transportation Systems Center
Operations Assistance Division

July 1983



UMTA Technical Assistance Program

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Office of Technical Assistance
Office of Bus and Paratransit Systems
Washington DC 20590

PREFACE

This report culminates a two year review of factors concerning the reliability of the Detroit Diesel Allison V730 automatic transmission for urban transit buses.

Gratitude is expressed to all transit agencies who provided V730 transmission failure data to the Transportation Systems Center. They are too numerous to list here but are given in the report. We recognize the amount of time and effort required on the part of these agencies to collect the requested information. The reliability analysis of the V730 transmission would not have been possible without their cooperation and support.

We also thank the personnel of Detroit Diesel Allison for their assistance and cooperation throughout this project.

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1. SUMMARY

The Detroit Diesel Allison (DDA) V730 automatic, 3-speed, transit bus transmission has had a generally unfavorable performance record since its introduction in 1976. A preliminary study by the Transportation Systems Center of the problems encountered and the effectiveness of corrective measures was described in a 1982 UMTA Technology Sharing report*. Since then, a reasonable amount of operating time has been accumulated on units incorporating a number of corrective design modifications.

The extended data indicates a general and significant improvement in reliability. Data from the Southern California Rapid Transit District, (SCRTD), is particularly indicative. It shows a high proportion of such units yet to have their first failure even after mileages averaging 75000. This is in contrast to the excessively-early onset of first-failures in the lower-serial-numbered transmissions reported in the 1982 report referenced below.

The following material presents the extended data and describes, in more detail, its analysis and the resulting conclusions.

*"Reliability Evaluation of V730 Transmission", Urban Mass Transportation Administration, UMTA-MA-06-0120-82-6, DOT-TSC-UMTA 82-19, available through the National Technical Information Service, Springfield, Virginia 22161.

2. INTRODUCTION

2.1 GENERAL

The Detroit Diesel Allison (DDA) V730 automatic transmission displayed signs of poor reliability soon after its introduction to city transit service in late 1976. Its poor performance was attributable to a number of causes including service and maintenance, as well as design and general quality.

During 1981-82, and following a first phase industry survey, the Department of Transportation, Transportation Systems Center (TSC), supporting the Urban Mass Transportation Administration Office of Bus and Paratransit Systems, conducted a substantial collection and analysis of V730 transmission failure data. This study concluded that earlier versions of the V730 transmission were unreliable, but, with the introduction of certain design changes in 1981, a definite improvement in early-life reliability was being achieved. However, it was necessary to accumulate more mileage on these newer transmissions (above Serial #18481) before the V730's improved performance could be confirmed. A report* documenting these conclusions was published in March, 1982 and distributed to transit agencies and the manufacturer.

2.2 OBJECTIVE/PURPOSE

This study is a follow-up to the 1981 study and represents a thorough, but less extensive, updating of the V730's reliability status with particular emphasis on the more recent first-failures of these transmissions. Prime attention is given to transmissions with serial numbers above 18481.

*Reliability Evaluation of V730 Transmission, UMTA-MA-06-0120-82-6, March, 1982.

2.3 BACKGROUND

The V730 transmission had reliability problems from the time of its introduction in 1976. The number of warranty claims received by the manufacturer, Detroit Diesel Allison (DDA) during the early service years of the V730 resulted in a series of product improvements. Between 1977 and 1981, 34 modifications were made to the V730, 12 of which were believed would have a significant impact on reliability. The last modification, which was introduced in 1981 with transmission #18481 (eliminating the scarf-cut seal), is considered to have solved the major remaining problem affecting the V730's reliability. This belief was supported by the earlier reliability evaluation conducted in 1981 and early 1982. However, not enough mileage had been accumulated at that time on transmissions with serial numbers above 18481 to lay this issue completely to rest; that is the purpose of the study reported here.

2.4 APPROACH

In the 1981 study, data for the V730 transmission was collected from 24 agencies on 3914 transmissions. A simplified reliability analysis was used in the study wherein the mileage accumulated on a new transmission at the time of its first failure was used as an indicator of reliability. This mileage was correlated with the serial number of the transmission, higher numbers reflecting more corrective modifications and thus a greater potential for improvements. Since "newer" transmissions incorporate more of the manufacturer's improvements, higher-number transmissions can be expected to exhibit greater failure-free mileages than lower-serial number units. Although many environmental and operational factors influence the performance of a transmission (route characteristics, maintenance strategies, etc.), and vary from agency to agency, it was believed that the effect of these factors would be minimized by using data on <u>many</u> transmissions from <u>many</u> agencies. Considering both the number of agencies contacted and the number of transmissions involved, the information collected in the 1981 study represented a viable, statistical sample.

Using the same approach as the earlier study, first-time failure mileages were obtained for V730 transmissions with serial numbers above #18481, the serial number at which the most effective corrective modification was introduced. Data was collected from a range of agencies, large and small, with various geographical and climate conditions, route characteristics and maintenance strategies. Some of the same agencies used in the earlier study are included in this updated evaluation, particularly the Southern California Rapid Transit District (SCRTD) in Los Angeles, which has a large number of V730s above serial number 18481. Two other agencies have been added, namely Columbus and San Diego. The total sample of high serial number transmissions used in this study amounts to 1498, which is approximately 15 per cent of the V730 population above No. 18481, and thus considered representative.

In keeping with the analysis of the earlier study, this update has been limited to distributions and "box scores" associated with the transmission serial number and its mileage at first-failure. There was not enough information available for the 35-foot bus installations of the newer transmissions to warrant a separate analysis as was done in the 1982 report.

3. RESULTS

3.1 GENERAL

The 1982 V730 report used a data sample of 3914 coaches/transmissions and included both 35-foot and 40-foot coaches; this was from an inventory of 24 transit agencies. This inventory included both transmissions with serial numbers below #18481 and also units with numbers above 18481. Information on the lower-serial-number transmissions are repeated from the 1982 report in Table 1; some minor differences may be noted from the earlier report due to the updating process. Information on the high-serial-number transmissions has been expanded and updated to reflect a more complete and current status and is shown in Table 2. These transmissions have serial numbers between 18481 and 26500, with the exception of a few units in the Los Angeles sample which are in the 18200 range.

The majority of these newer transmisssions have accumulated mileages which are well into the range in which the older transmissions of Table 1 had shown a significant number of failures. It can be seen from Table 2 that the reliability of the high-serial number transmissions is good, and far better than that of the lower-serial-numbered units as reported in the 1982 report. Although this is a positive indication of improvement, the data in Table 2 is generally limited, due to the lower number of failures, under the analysis scheme of using first-failure mileages as an indicator of reliability. The Los Angeles data, however, is extensive enough to be an acceptable basis for reaching reasonably valid conclusions on reliability improvement due to high serial number modifications.

Buses represented by the over all sample of high-serial-number V730 transmissions from all of the different agencies in Table 2 are RTS-IIs, Neoplans and Flyers. The sample, totaling 1498 new coaches, is considered adequate for meaningful reliability comparisons with the 1982 study results.

TABLE 1. SUMMARY OF LOW SERIAL NUMBER SOURCES

AGENCY	NUMBER OF TRANSMISSIONS ANALYZED	TRANSMISSION SERIAL NUMBER RANGE	MAKE OF BUS	LENGTH OF BUS
ATLANTA, GA	100	5000-9000	FLXIBLE 870	40'
BOSTON, MA	125	11000-14000	GMC CANADA NEW LOOK	40'
	27	11000	GMC CANADA NEW LOOK	35'
BRIDGEPORT, CT	25	13000	GMC-RTS-II	35'
	12	13000	GMC-RTS-II	40'
DETROIT, MI	109	8000	GMC-RTS-II	40'
	120	12000	GMC-RTS-II	40'
	72	16000	GMC-RTS-II	40'
LOWELL, MA	10	13000	GMC-RTS-II	35'
MIAMI, FL	274	17000	GMC-RTS-II	40'
MICHIGAN (SEMTA)	45	6500-8500	GMC-RTS-II	40'
	33	9500-12000	GMC-RTS-II	40'
	22	16000-17000	GMC-RTS-II	40'
NORWALK, CT	19	12000	GMC-RTS-II	35'
PHILADELPHIA, PA	298	15500-16500	GMC-RTS-II	40'
PROVIDENCE, RI	72	7500-9000	GMC-RTS-II	35'
SAN ANTONIO, TX	116	6000	GMC-RTS-II	40'
	145	16500	GMC-RTS-II	35'
SPRINGFIELD, MA	65	8000-9000	GMC-RTS-II	35'
UNIV. OF MASS.	28	9000-17500	GMC-RTS-II	35'
WASHINGTON, DC	388	3500-8500	FLXIBLE 870	40'
	115	11000	GMC-RTS-II	40'
	2220			

TABLE 2. SUMMARY OF HIGH SERIAL NUMBER SOURCES

AGENCY	DATA DATE	FLEET	V730 SER. NOS.	TOTAL FAILURES	PTO FAILURES	AVG. FLEET MILES	BUS
ATLANTA, GA	1/83	50	21000 22000	6	0	42,824	NEOPLAN
BOSTON, MA	11/82	168	23500 26500	3	NA	12,000	FLYER
COLUMBUS, OH	12/82	99	>18481	0	0	11,000	RTS
DENVER, CO	8/82	127	19000 20500	2	NA	56,176	GM/CAN.
LOS ANGELES, CA	8/82	940	18200 21000	181	75	75,000	RTS
PROVIDENCE, RI	10/82	34	21000 22000	5	0	52,600	RTS
SAN DIEGO, CA	11/82	65	21000 22000	1	NA	69,977	GM/CAN.
WORCESTER, MA	12/82	15	21500	1	0	47,000	RTS
		1498		199	75	60,029	(Weighted) (Average)

3-2 FAILURE DISTRIBUTIONS

It is evident from comparisons between the two histograms of Figure 1 that not only do earlier transmissions show first failures peaking at rather low mileages, but about 40% of the transmissions appeared to have failed by the 100,000 mile point. It is obvious from Figure 1 that the earlier units tend to have their first failures at lower mileages; a substantial percentage of such transmissions first-failed at 10,000 miles or below.

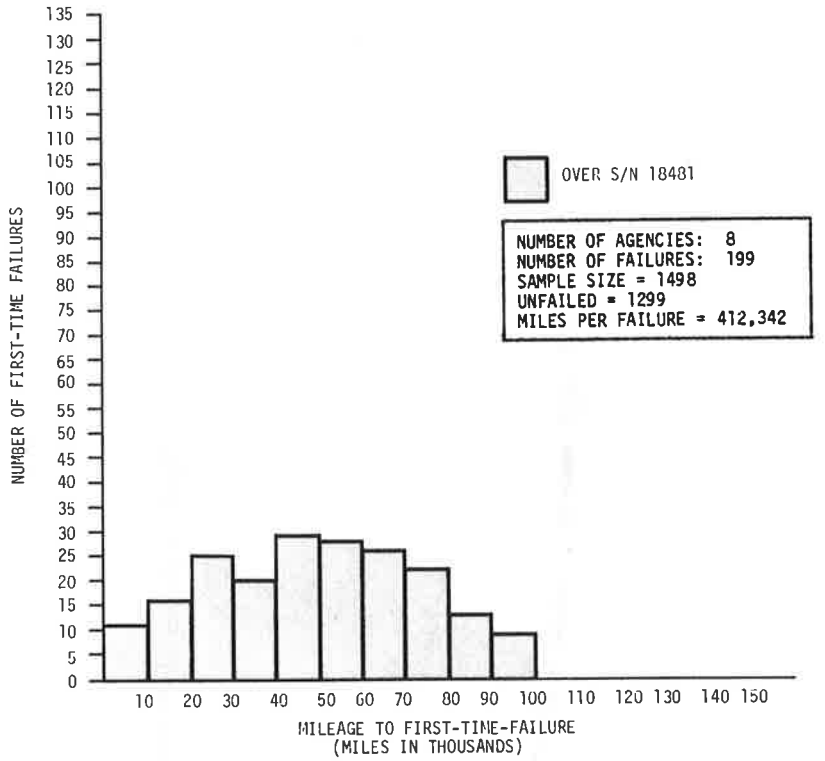
It can also be seen from Figure 1, that the miles per failure $\left[\frac{\text{unfailed miles + failed miles}}{\text{failures}}\right]$ of the over-serial-number 18481 units show a better than two-to-one improvement, showing slightly over 400,000 miles per failure. At about corresponding points in fleet maturity the older product had 61% transmissions still running while the newer product shows 87% still running.

The cumulative failure profiles (percent of fleet) are represented in Figure 2. These curves are based on the successive addition of the failures represented in the histograms of Figure 1. The improvement attributable to the higher serial number transmissions is self evident.

It can be seen that the cumulative failure curves of Figure 2 do not start upward again which, if this did, would imply a wear-out situation.

Transmissions with serial numbers above 18481 show a much reduced incidence of early life failures. Low serial number transmissions showed that 10.9% of the failures mentioned above had occurred at or below 10,000 miles. Higher serial numbered transmissions have had only 5.5% of their total failures to date at 10,000 miles or below. Thus, the number of early failures (under 10,000 miles) is not present to the degree that it was in earlier V730 product.

The above implies several possibilities: 1) quality problems have been solved; 2) potential early failures have been tested out; 3) design causes for early failures have been corrected



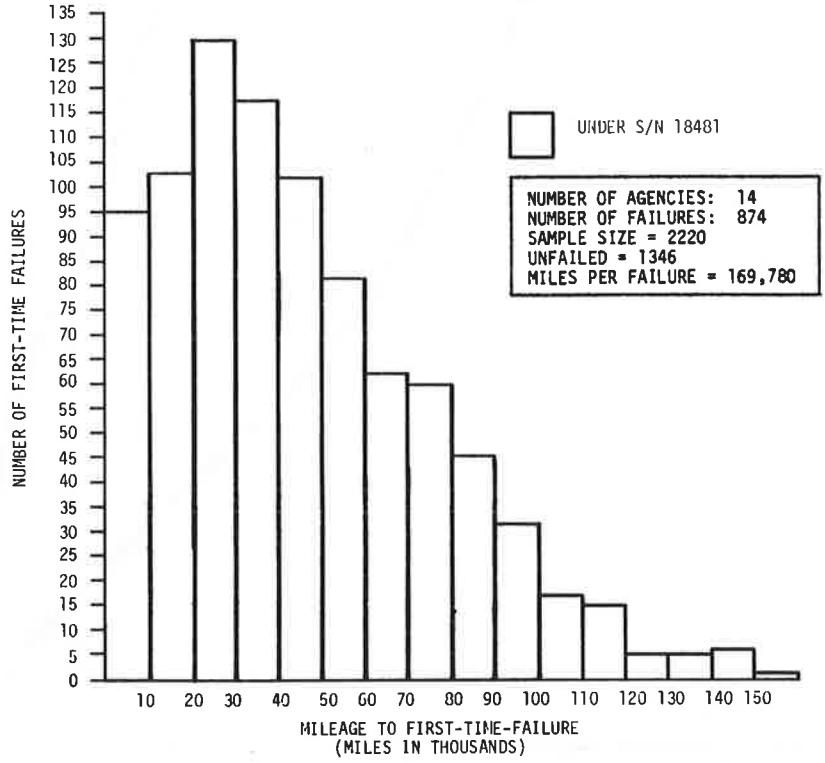


FIGURE 1. DISTRIBUTIONS OF ACTUAL V730 MILEAGES ALL AGENCIES COMBINED

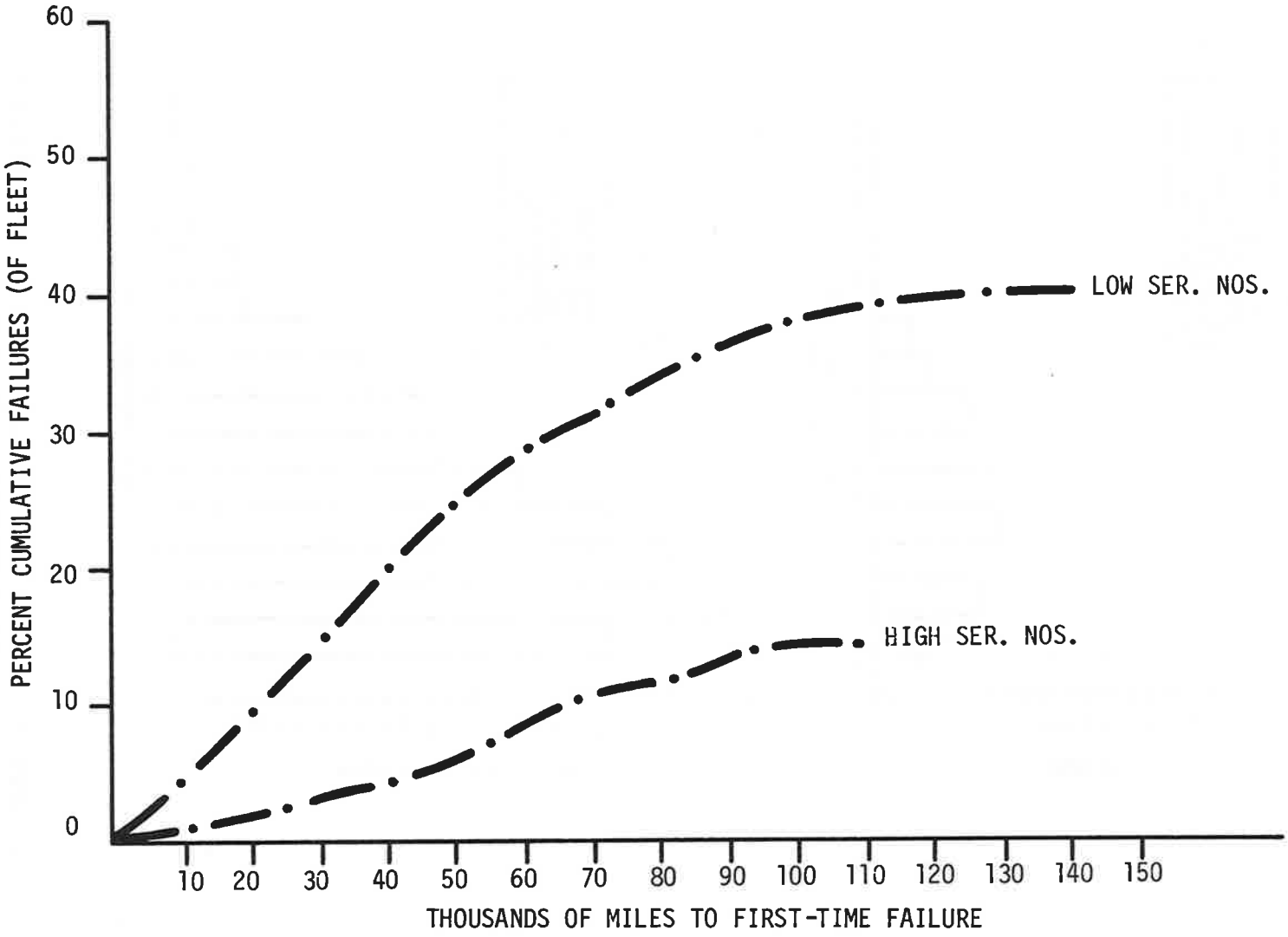


FIGURE 2. FAILURES AS PERCENT OF FLEET

(reliability); and/or 4) some critical item of maintenance (such as fluid level) is being better attended-to. It is believed that each of these has contributed a part of the 5.4% improvement.

The average bus of the high serial number fleet has achieved 60,000 miles. At this point, the older fleet (February 1982 report) had failed 28.3% of their lower serial number V730 transmissions. Only 8.8% of the newer transmissions, including those with power-take-offs have failed; the numbers range from zero to a maximum of 12% (at SCRTD). This contrast is shown by Figure 3. Sufficient mileage has been accumulated for those higher serial numbered transmissions to warrant a reasonable degree of confidence in these results.

3.3 SCRTD

The SCRTD V730-equipped coach data covers a relatively large fleet with a high proportion of high-serial-number transmissions. The combination warrants a reasonably high degree of confidence in the resulting "old versus new." SCRTD data is separately identified in Figure 4.

Figure 4 shows both the failed and still-running portions of the 940 vehicles with transmission serial numbers above 18200. Of the 181 failed transmissions, only 25-30 are between serial number 18200 and the "turning point", serial number 18481. Thus, it is fair to maintain, that the 940 SCRTD units constitute a valid high-serial-number fleet.

The 940 coach fleet is averaging 75000 miles per coach. Figure 4 also shows that about 81% of this fleet is still operating without first transmission failures. The remaining 19% failures are primarily PTO problems. Of the 181 total failures, 75 are PTOs and these failures increased as the Los Angeles weather warmed up. The 181 failures were as follows;

up to 2/5/82 - of the 70 failures, 18 were PTOs (25%)

by 6/8/82 - of the 45 additional failures, 21 were PTOs (45%)

by 8/18/82 - of the 66 more failures, 36 were PTOs (55%)

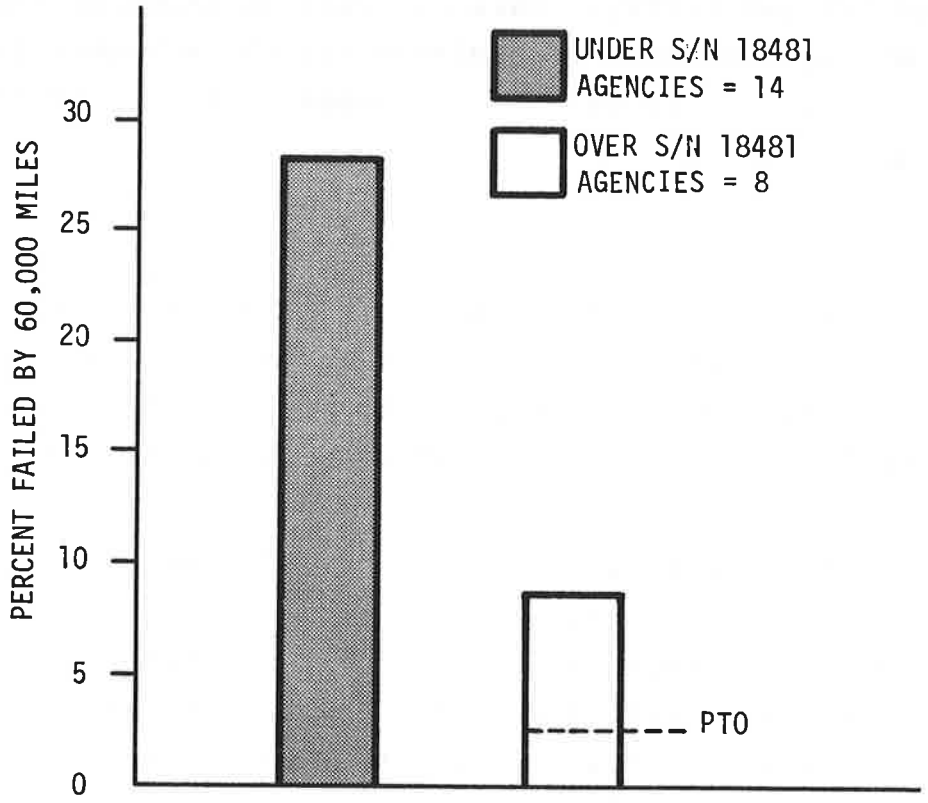


FIGURE 3. PERCENTAGE OF FLEET FAILED BY 60,000 MILES

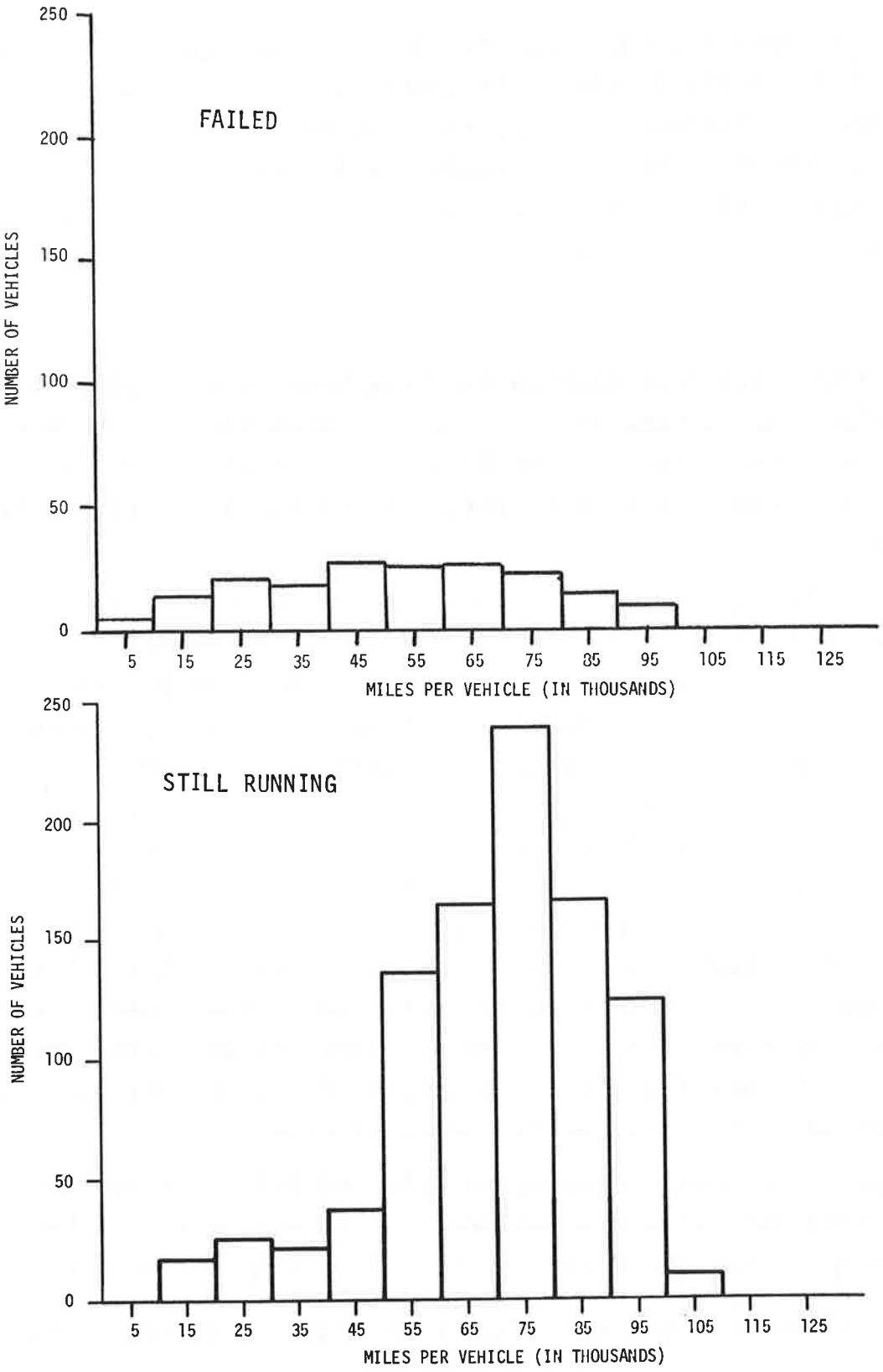


FIGURE 4. SCRTD FLEET MILEAGE DISTRIBUTION FOR V-730'S ABOVE S/N 18200 AS OF AUGUST, 1982

For the six month period, these PTO failures averaged 41% of the V730 problems in Los Angeles. In comparison, it should be noted that of the six failures at Atlanta, none were of PTOs; and that San Diego does not drive their air conditioners off the V730 PTO. The other cities in the study do not have the heavy cooling requirement that these three cities do.

3.4 PTO

The power take off problem has long been recognized as a large part of the V730 difficulties. Figure 3 shows that of the 8.8% high-serial-number transmission failures, 2.5% were PTO related. Thus, DDA has placed a high priority on resolution of this particular problem.

DDA is incorporating a viscous damper attached to the air conditioning compressor pulley to smooth out the damaging vibrations generated by certain compressors and their supporting "system" such as belts, platforms, cushions, brackets, clutch, etc. DDA found that the compressor system was setting up a "clatter" (vibration) in the PTO drive train, especially around 1000 rpm. This speed, of course, is a very common engine speed (fast idle) necessary whenever the bus is parked with its engine running to maintain air conditioning. The viscous damper has been tested in the laboratory and on a few operating coaches. More significantly, forty dampers were installed in Miami and operated throughout the summer of 1982. No PTO problems were experienced. The point to be noted is that a quantity of the devices have shown effectiveness over a reasonable period of time.

Dampers are being provided to selected RTS-II-04 owners. All agencies with over 1500 cooling degree days per year will be shipped dampers for their RTS-II-04s. A cooling degree day is equal to $\frac{(T_H + T_L)}{2} - 65$, where T_H is the day's high temperature in °F and T_L is the day's low in °F. The daily numbers are summed for the year.

GM Truck & Coach is assisting the agencies with installation costs. A total of 3100 dampers are expected to be provided for operating coaches, and each new RTS from GM Truck and Coach will be equipped with one. The first agencies to be provided dampers were Miami (260) with 4000 cooling degree days per year and Puerto Rico (35) with 6000 cooling degree days per year. The manufacturer (Stahl) is said to be able to produce 800 dampers per month.

4. CONCLUSIONS

- Additional data collected during the past year confirm the belief that elimination of the scarf-cut seal (beginning with Serial No. 18481) has resolved the major remaining problem affecting the reliability of the V730 transmission.
- After accumulating, on average, over one-half of the warranty mileage of 100,000 miles, the V730s analyzed in this study with Serial Nos. above #18481 continue to show a significant reliability improvement over the unmodified lower-serial number units. As in the earlier report, reliability has improved in terms of higher accumulated mileage at first-time failure and a larger percentage of V730s surviving beyond 60,000 miles without a failure.

A number of conclusions drawn in the 1982 report still apply at the present time and to the higher serial number transmissions discussed here. They include factors such as variations in reliability due to different kinds of service and/or environment. Better transmissions, as exemplified by the high serial number units discussed here, can still have differences in overall problems and in service life.