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U.S. ENVIRONMENTAL PROTECTION AGENCY

JULY 19, 1985
WASHINGTON, DC

Comments of
AMERICAN TRUCKING ASSOCIATIONS, INC.

On

Motor Carriers Engaged in Interstate Commerce; Noise Standards and Transportation Equipment Noise Emission Controls; Medium and Heavy Trucks

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EPA Docket OPMO-0184
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Foreword

The American Trucking Associations, Inc. (ATA), located at 2200 Mill Road, Alexandria, Virginia 22314, is a federation with affiliated associations in every state and the District of Columbia. In the aggregate, ATA represents every type and class of motor carrier in the country, for-hire and private. As the national representative of the trucking industry, ATA is vitally interested in any regulation affecting the operation of equipment utilized in the nation's trucking fleet.

ATA's comments to Docket OPMO-0184, "Motor Carriers Engaged in Interstate Commerce; Noise Standards and Transportation Equipment Noise Emission Controls; Medium and Heavy Trucks", were prepared by the staff of ATA's Engineering Department, which is responsible for handling issues dealing with the construction, use, and repair of trucks and their components. For many years the Department has developed ATA's major position papers, docket submissions, and testimony relating to truck engineering, design and equipment. Included in these were several submissions on noise emission controls for medium and heavy-duty trucks.

ATA's comments also reflect the guidance and technical input from ATA's Technical Advisory Group (TAG). TAG members are motor carrier maintenance, safety, and research and development executives. The Group's representation is balanced both geographically and by types of fleets, thereby representing a broad spectrum of vehicle users who will be impacted by equipment regulations. Considering both its own expertise and the input from TAG, the ATA Engineering Department is well qualified to comment on the subject at hand.

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Introduction

ATA takes this opportunity to comment on EPA Docket No. OPMO-0184, "Motor Carriers Engaged in Interstate Commerce; Noise Standards and Transportation Equipment Noise Emission Controls; Medium and Heavy Trucks."

These comments will address the following issues.

1. The proposed two-year deferral of the 80 decibel new-truck noise emission standard.

2. The proposed levels of permitted noise emissions for in-use medium and heavy-duty trucks.

Discussion

In Docket No. OPMO-0184, the U.S. Environmental Protection Agency (EPA) proposes concurrently to:

1. Defer the effective date of the 80 decibel (dB) noise standard for newly manufactured medium and heavy-trucks having a gross vehicle weight rating (GVWR) greater than 10,000 pounds, from January 1, 1986 to January 1, 1988 [40 CFR Part 205, Subpart B, ("New-truck" standard)]; and

2. Amend the noise emission regulation for motor carriers engaged in interstate commerce, 40 CFR Part 202, Subpart B ("In-use" standards), to require that 1986 and later model year vehicles having a GVWR greater than 10,000 pounds not exceed a noise level of: 83 dB at speeds 35 miles per hours (MPH) or less; 87 dB at speeds above 35 MPH; and 85 dB when the truck engine is accelerated with the vehicle stationary.

These two closely related actions are proposed in response to petitions for a delay of the medium and heavy-duty truck 80 dB noise standard, which were submitted by ATA, International Harvester, Ford, and General Motors.

While EPA's proposal to lower the permitted in-use emission standards exceeds ATA's petition for coincident new-truck noise and emission standards in 1988, we nevertheless support both of the Agency's proposed actions as effective and economically sound methods of achieving additional noise reductions from truck operations. However, we have some concerns over the specific level of the new in-use levels which will be discussed in detail later in these comments.

1. <u>Proposed Two-Year Delay of the 80 Decibel New-Truck Noise Standard</u>

On January 9, 1984 ATA petitioned EPA to reconsider further the January 1, 1986 effective date of the 80 dB standard for newly manufactured medium and heavy-duty trucks. ATA asked that the effective date be delayed to coincide with, or follow, the effective date of EPA's then-anticipated new heavy-duty truck emission standards for oxides of nitrogen (NOx) and diesel particulates. Since that time, the NOx and particulate standards have been promulgated, and are effective for 1988 and later model year vehicles. EPA's proposed action to delay the 80 dB new-truck noise standard to January 1, 1988, therefore, effectively grants ATA's request.

ATA's petition for the delay was motivated by the clear savings that would be realized by manufacturers and consumers as a result of the elimination of having to test the noise characteristics of trucks in 1986 and then again in 1988, because the characteristics of the engines (significant contributers to overall vehicle noise) in these trucks when tested in 1988 differ from those that existed in 1986 due to new exhaust emission standards. At the same time, we pointed out to EPA that changes in current trucks and their operation (i.e. virtual 100-percent use of "quiet" radial tires and a reduction in the total number of truck trips as a result of the use of more productive STAA equipment) would offset any potential negative environmental impacts from the ephemeral two-year delay in "quieter" vehicles entering the on-the-road fleet. Although EPA did find that the economic savings will be significant, it also found that some short term loss of health and welfare benefits would occur and, therefore, proposed the instant in-use noise standard.

2. Proposed Revision of In-Use Emission Standards

To address what EPA characterizes as a significant loss of short-term health and welfare benefits it expects in the absence of the 80 dB standard in 1986 or a lower increase standard, EPA has proposed to lower the permissible noise emission levels for motor carriers engaged in interstate commerce to those shown in Appendix A. ATA supports the lowering of the in-use noise emission standards from those which presently exist. ATA believes that lower standards are needed not only to reduce the level of noise that may be produced by truck operations, but also to increase enforcement of in-use noise standards and thereby bring those vehicles that are in blatent disregard of the law (no mufflers, leaking exhaust systems, etc.) to an acceptable level. Currently, the in-use noise standards are so far above the actual fleet levels that enforcement agencies have no incentive to do their job.

Notwithstanding that we are in favor of lower in-use noise standards, and genuinely support EPA's actions in this area, we have some concern over the new in-use proposal:

a. We do not believe that lower in-use noise levels are needed to offset any loss of short-term health and welfare benefits. In our opinion, no significant loss of health benefits will occur from the delay in the 80 decibel new-truck standard. Therefore, the two-year deferral could have been issued on its merits alone without having to propose currently the instant in-use noise standard.

b. Under EPA's proposed actions, two model years' production of medium and heavy-duty trucks, 1986 and 1987, must have the same new-truck and in-use noise levels of 83 decibels. We have some concerns with this, primarily because certain trucks will be required to retain virtually "as-new" noise levels throughout their service life. For example, as can be seen in Appendix B, representing selected production compliance data for new trucks manufactured to the 83 dB level, certain trucks will be entering the on-the-road fleet not only very near the new-truck standard but, under the proposed rule, less than 1 dB away from new in-use level. Additionally, due to the statistical nature of production audits, it is likely that a number of trucks will randomly enter the fleet at or above the 83 dB new-truck limit. This is of great concern to us. According to the findings of chapter 5 of a Wyle Laboratories' report (Appendix C), the only in-depth study that we are aware of that has looked at in-use noise behavior of a trucks over time (miles), not only did noise levels fluctuate wildly, but no correlation was found between vehicle maintenance and the measured noise levels. As the report states: "there seems to be no specific relationship between the maintenance or operation of vehicles and the resulting degradation in vehicle noise." Appendix C, p. 5-62, The Wyle report goes on to say, however, that "... there does appear to be some relationship between in-service operation time of a diesel engine and increased noise levels." Thus, based upon the results this study, several important conclusions are demonstrated: (1) as a result of normal operational wear and tear, truck noise levels may increase; (2) such increases in truck noise are not related to maintenance or operational characteristics and, therefore, the vehicle owner or operater has no effective control over the resulting noise; and (3) that while it is apparent that an in-use noise limit is needed, the limit must be one that permits normal, reasonable degradation in a truck's noise characteristics and prevents increases beyond this.

We do not believe that EPA's proposal takes these factors into account for 1986 and 1987 model year trucks, because those vehicles that do come off the assembly line at or near 83 dB will not be afforded their normal degredation in noise characteristics. While ATA does not believe this problem is so serious that we will oppose this combined noise package and thereby forfeit the 1986 to 1988 delay, it is important enough to be pointed out to EPA, and we urge that, in the alternative, EPA:

1. Establish new in-use noise levels of 84, 86 and 88 dB for low speed, stationary, and high speed operations, respectively, to be effective January 1, 1986; or

2. Retain the proposed 83, 85 and 87 dB levels but change the effective date to January 1, 1988.

Each alternative would allow for small, normal increases in a truck's noise characteristics as it goes about its business of moving the nation's freight.

Additionally, alternative (2) above raises one other concern. We feel that there needs to be consideration given to normal vehicle wear and tear, and we would be against any future attempt by the Agency to lower the in-use noise level for 1988 and newer trucks to 80 dB. Our criticism of today's proposed lowering of the in-use level to that of new trucks is somewhat tempered by the fact that it only affects two model years of trucks. In our opinion, it would be unreasonable to expect an entire on-the-road fleet to retain "as good as new" noise levels throughout their useful lives.

Summary

o ATA supports EPA's proposed two-year delay in the effective date of the 80 decibel new-truck medium and heavy-duty truck noise emission standard from 1986 to 1988 so that it can coincide with the heavy-duty engine emission standards effective for 1988 model year trucks. This action will save truck purchasers many millions of dollars. Because of recent changes in trucks and their operation, we do not believe that this ephemeral delay will have a significant impact on public health or welfare, or the environment.

- ATA also supports lower in-use noise emission standards, but we are concerned that certain vehicles purchased during the 1986 and 1987 model years will be required to maintain "as good as new" noise levels throughout their active service life. Available evidence indicates truck noise levels may increase slightly and that this phenomenon is virtually uncontrollable. ATA has offered two alternatives to allow for reasonable increases in noise characteristics. One is to raise EPA's proposed permitted in-use levels by one decibel. The second alternative would retain EPA's proposed in-use levels but delay the effective date to coincide with that of the 80 decibel new-truck standard and thus avoid two model years of trucks having the same new and in-use noise emission requirements.

APPENDIX A - Proposed In-Use Noise Emission Standards For 1986 and Later Model Year Medium and Heavy Trucks

Operating regime	Noise Level (dB) Present	Noise Level (dB) Proposed
High speed (> 35 MPH)	90	87
Low speed (≤ 35 MPH)	86	83
Stationary test	88	85

APPENDIX B - Selected Production Noise Test Results of Vehicles Entering the Fleet at 82 dB or Higher

Model Year	Vehicle Manufacturer	Engine	Sound Level (dB)	Std. Dev.
1984	A	DDA 6-7IN	83.0	--
1984	A	CAT 3208N	82.0	--
1984	A	CAT 3406T	82.9	--
1984	A	CAT 3406T	82.1	--
1984	A	FORD 6.1L	82.3	--
1984	A	FORD 6.1L	82.1	--
1982	B	DDA 6V-92TA	82.1	--
1982	B	DDA 6V-92TA	82.8	1.9
1982	B	DDA 6V-92TA	81.2	1.1
1981	B	DDA 8V-92TA	81.5	1.2
1981	B	DDA 8V-92TA	82.3	--
1984	C	Cummins 400	82.7	--
1983	C	DDA 6-7IN	81.2	1.2

APPENDIX C

Analyis of Truck Noise Emission Degredation

Wyle Laboratories

NOTE: Missing pages contain only poorly reproduced photographs of the test vehicles. Also, please ignore the "mark-up" of the Appendix, the only available copy was in this condition.

5.0 ANALYSIS OF TRUCK NOISE EMISSION DEGRADATION

The EPA Noise Emission Standards for New Medium and Heavy Duty Trucks[34] specify that trucks manufactured after January 1, 1978 must not generate A-weighted levels that are in excess of 83 dB when tested according to a specified test procedure. At the time of promulgation of these standards, it was anticipated that reevaluation of the current in-use standards would be necessary to assess the feasibility of modifying the Interstate Motor Carrier Noise Regulations to coincide with the more strict new product standards. However, there presently exists no current data base by which it is possible to determine if new truck noise emission levels will change significantly over the life cycle of the vehicle. The goal of the test program described in this section, therefore, was to assess the degree of noise degradation apparent in medium and heavy duty under normal operating conditions. Further, through a unique set of component isolation tests, additional data have been acquired which allow for identification of those truck component noise sources which contribute most directly to the degradation of total vehicle noise levels. Because these tests are still going on, the available data are insufficient in some cases to permit unequivocal identification of degradation of truck noise over time. However, where possible, tentative conclusions are summarized.

Equally as critical to the assessment of truck noise emission degradation is the associated maintenance and operational procedures applied to the vehicle. Therefore, information and comments from both manufacturers and drivers have been compiled and evaluated to determine the importance of these factors. A summary of these results is provided in the sections which follow.

5.1 Test Program

The field test program was designed to enable compilation of data on the degradation of truck noise emission levels for a representative sample of medium and heavy duty trucks. It consisted of noise measurements exterior to the vehicle during stationary and passby tests, and interior noise measurements at the driver's location during engine run up tests. A description of the test vehicles and the associated measurement methodology is provided in the following sections.

5.1.1 Test Vehicles

The trucks tested in this study were actual in-service vehicles loaned by rental agencies, motor carriers, private haulers and owner-operators. To qualify for participation in the program, each vehicle was tested prior to placement into fleet service. By July, 1978 a total of 30 trucks were participating in the noise degradation measurement program. A description of each truck according to its key design parameters is provided in Table 5-1. As will be discussed in Section 5.1.2, each vehicle was tested either at the owner's facility or at Wyle's Norco test facility. Therefore, the location of each truck noise test site is also listed in Table 5-1. Note that two of the vehicles which started in the program, Numbers 11 and 12, were subsequently involved in accidents and thereby eliminated from further testing.

Figure 5-1 illustrates the distribution of types of trucks involved in the program according to vehicle weight class, cab type and engine type. The total test sample included engine configurations manufactured by Cummins, Detroit Diesel, Caterpillar, Mack and International Harvester.

All of the trucks utilized in this test program were equipped with fan clutches with the exception of Numbers 10, 14, 16, 18 and 29. Vehicles having standard and automatic transmissions were included in the test sample. An illustration of most vehicle configurations considered under the test program is given in Figures 5-2 through 5-14.

5.1.2 Test Sites

Where possible, truck noise measurements are performed using the test pad located at Wyle's test facility located in Norco, California. However, to facilitate the utilization of trucks supplied by motor carriers and private haulers, noise measurements have been conducted using a standard test site located at the vehicle owners' respective terminals.

Table 5-1

Vehicle Description Owner and Test Site Location

Truck No.	Manufacturer & Model	Engine Make & Model	Rated RPM	Exhaust System	No. of Axles	Fan Clutch	Owner	Test Site Location
1	Peterbilt COE	Cummins NTC-350 Turbo I-6, 4-cycle	2100	Single Vertical Right Side	3	Thermal Air Operated	National Car Rental	Norco, CA
2	Freightliner CONV 12062TGT - H.D.	Detroit Diesel DD6V92TT Turbo V-6, 2-cycle	2100	Single Vertical Right Side	3	Viscous	Redwing Carriers	Tampa, FL
3, 40	Freightliner CONV 12062TG7 - H.D.	Cummins VT903 Turbo V-8, 4-cycle	2100	Single Vertical Right Side	3	Viscous	Redwing Carriers	Tampa, FL
4, 41	Freightliner CONV 12062TGT - H.D.	Detroit Diesel DD6V92TT Turbo V-6, 2-cycle	2100	Single Vertical Right Side	3	Viscous	Redwing Carriers	Tampa, FL
5	Freightliner CONV 12062TGT - H.D.	Cummins VT903 Turbo V-8, 4-cycle	2100	Single Vertical Right Side	3	Viscous	Redwing Carriers	Tampa, FL
6	Freightliner COE H.D.	Detroit Diesel DD6V92TT Turbo V-6, 2-cycle	2300	Single Vertical Right Side	2	Viscous	Consolidated Freightliners	Santa Fe Springs, CA
7	Ford CONV C-600 - M.D.	Ford Gas V361 Naturally Aspirated	4300	Single Horizontal Right Side	2	Viscous	Post Office	Riverdale, MD
8	Ford CONV C-600 - M.D.	Ford Gas V361 Naturally Aspirated	4300	Single Horizontal Right Side	2	Viscous	Post Office	Riverdale, MD
9	Freightliner COE	Cummins VT903 Turbo V-8, 4-cycle	2500	Single Vertical Right Side	2	Viscous	Consolidated Freightliners	Santa Fe Springs, CA
10	International Harvester CONV 2050 - H.D.	Caterpillar 3208 Naturally Aspirated V-8, 4-cycle	2900	Single Vertical Right Side	3	None Direct Drive	Caltrans	Cajon, CA
11	General Motors	Detroit Diesel DD GV92TT Turbo V-6, 2-cycle	2200	Single Vertical Right Side	2	Thermal Air Operated	Arrowhead Water	Norco, CA

Truck No.	Manufacturer & Model	Engine Make & Model	Rated RPM	Exhaust System	No. of Axles	Fan Clutch	Owner	Test Site Location
12	White CONV Road Boss II - H.D.	Cummins NTC 290 Turbo I-6, 4-cycle	2100	Single Vertical Right Side	3	Thermal Air Operated	Burlington Industries	Burlington, NC
13	White COE Road Commander H.D.	Cummins NTC 290 Turbo I-6, 4-cycle	2100	Single Vertical Right Side	3	Thermal Air Operated	Burlington Industries	Burlington, NC
14	International Harvester CONV Loadstar 1750 - M.D.	International Harvester D-190DT-466 Turbo I-6, 4-cycle	2900	Single Vertical Right Side	2	None Direct Drive	National Car Rental	Norco, CA
15	White CONV Road Boss II - H.D.	Cummins NTC 290 Turbo I-6, 4-cycle	2100	Single Vertical Right Side	3	Thermal Air Operated	Burlington Industries	Burlington, NC
16	General Motors CONV P800 Van - M.D.	General Motors 292, Gas I-6 Naturally Aspirated 4-cycle	3600	Single Horizontal Left Side	2	None Direct Drive	U.P.S.	Orlando, FL
17	Mack CONV Dump - H.D.	Mack Turbo I-6 4-cycle	2300	Single Vertical Right Side	2	Viscous	Caltrans	Groveland, CA
18	International Harvester CONV Paystar 5000 - H.D.	Cummins NTC 250 Turbo I-6, 4-cycle	2100	Single Vertical Right Side	2	None Direct Drive (Had Shutters)	Caltrans	Whitmore, CA
19, 20, 27, 28	General Motors CONV 6000 - M.D.	General Motors 114-366, Gas V-8 Naturally Aspirated	3800	Dual Horizontal	2	Viscous	Arrowhead Water	Norco, CA
21, 22	Mack CONV H.D.	Mack 675 Turbo I-6, 4-cycle	2300	Single Horizontal Right Side	2	Viscous	U.P.S.	Charlotte, NC
23, 24, 25, 26	Mack CONV R686 - H.D.	Mack T676 Turbo I-6, 4-cycle	2350	Single Vertical Right Side	3	Thermal Air Operated	Matlack	Swedesboro, NJ
29	International Harvester CONV Paystar 5000 - H.D.	Cummins NTC 250 Turbo I-6, 4-cycle	2300	Single Vertical Right Side	2	None Has Shutters	Caltrans	Whitmore, CA
30	General Motors COE Astro 95 - H.D.	Cummins NTC 270 Turbo I-6, 4-cycle	2300	Single Horizontal Right Side	2	Thermal Air Actuated	U.P.S.	Earth City, MO

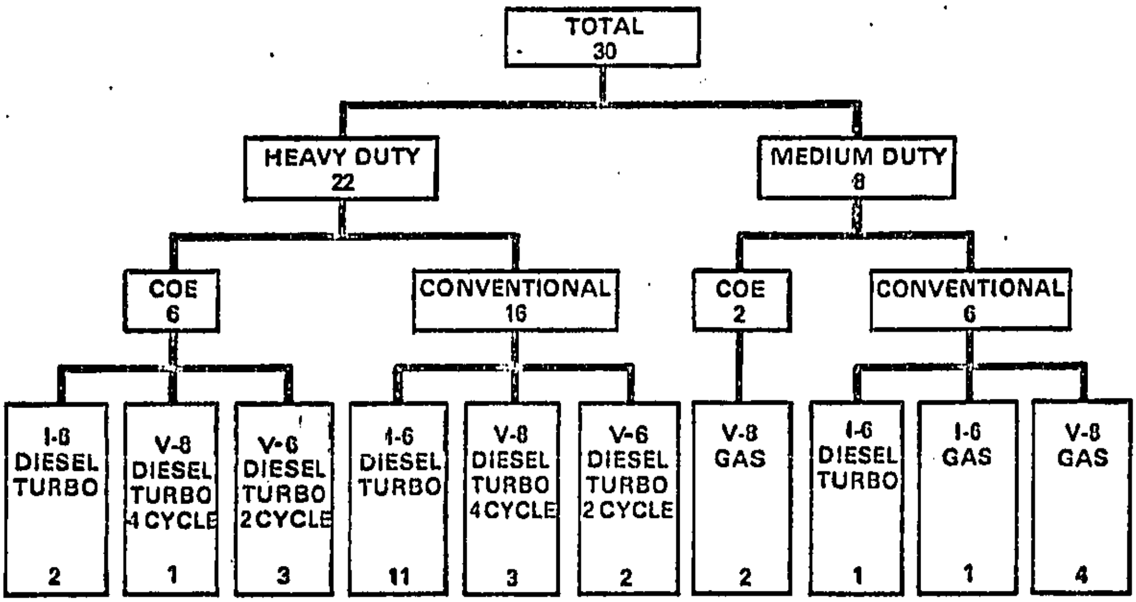


Figure 5-1. TEST VEHICLE CONFIGURATIONS

Figure 5-13 shows the test pad used at Wyle's Norco facility. It consists of a circular asphalt pad 36.5 m (120 ft.) in diameter. This site was developed in accordance with the specifications set forth in Section 205.54-1 of the EPA Noise Emission Standards for New Medium and Heavy Duty Trucks.[34] The test surface was constructed according to EPA paving specifications as outlined in Appendix B of this report.

An underground ducting system was constructed with the pad to allow for component noise measurements. Intake air is drawn through a 30.5 cm (12 inch) diameter steel pipe, with air entering 12 m (40 ft.) from the edge of the pad and exiting at the center of the site. A 20 cm (8 in.) diameter steel pipe is similarly used to route exhaust gases underground and away from the pad. The duct openings at the edge of the pad are shielded by a 1.2 m (4 ft.) berm to assure that each source is 10 dB below the measured truck noise levels. Figure 5-14 illustrates how the ducting system is attached to a truck.

A majority of the trucks were tested at the vehicle owners' facilities, thereby resulting in the use of test sites located in the west, midwest and east. In all cases care was taken to select a stationary test site that met the specifications set forth in Subpart E of the DOT Regulations for Enforcement of Motor Carrier Noise Emission Standards[33], and a passby test site that met the specifications set forth in the EPA New Truck Noise Emission Standards.[34] Figure 5-15 illustrates the site plan used for passby testing. At each site a clean test zone with a diameter of 30 m (100 ft.) was established. The center point of the test zone was established as the "microphone point." A truck acceleration point was established on the vehicle path 15 m (50 ft.) before the microphone point. An end point was established on the vehicle path 30 m (100 ft.) from the acceleration point and 15 m (50 ft.) from the microphone point. An end or test zone was established as the last 12 m (40 ft.) of the vehicle path prior to the end point. All tests were performed on hard surfaces consisting of either asphalt or concrete. With the exception of one site, sufficient space was available to ensure that there were no obstacles within 30.5 m (100 ft.) of the microphone or test zone. The exception was the Caltrans facility at Cajon, California (truck numbers 18, 29). Here, only 24.4 m (80 ft.) of clear space was available

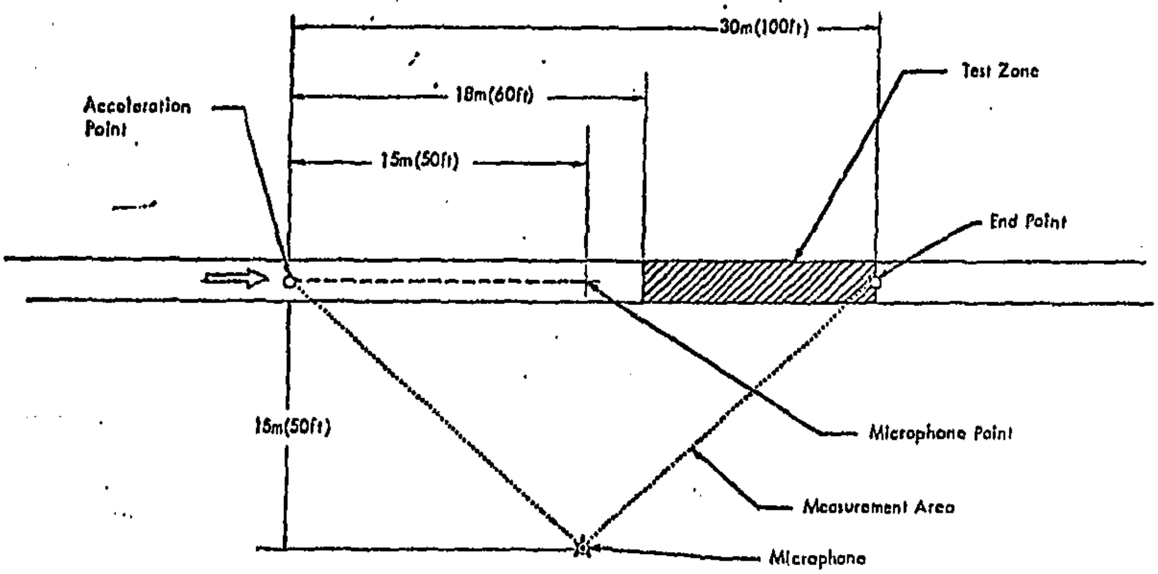


Figure 5-15. Passby Test Site Configuration and Microphone Position

between the microphone and the nearest obstacles. This was considered adequate so as to not severely alter the measured noise levels. At each facility the vehicle and microphone positions were permanently established by painting markers at each position.

Most of the field test sites are illustrated in Figures 5-16 through 5-23. Note that six of these sites were large enough to allow performance of pass by tests. Local highways were used for pass by testing at Norco, California and Groveland, California.

5.1.3 Test Instrumentation

All instrumentation used in this test program met the specifications as defined in Sections 205.54-1 and 205.54-2 of the EPA Noise Emission Standards for New Medium and Heavy Duty Trucks.[34] This includes the instrumentation listed in Table 5-2.

5.1.3.1 Stationary Testing

For stationary run up noise tests, measurements were made at the four microphone positions shown in Figure 5-24. Each microphone was positioned 15 m (50 ft.) from the center of the front axle and 1.2 m (4 ft.) above the ground plane. A-weighted noise levels, using the fast meter response, were read on a precision (Type 1) sound level meter at either measurement position A or C (Illustration Figure 5-24) for each test sequence. Tape recordings of broad-band noise were made simultaneously for all four positions. The number of microphone positions were reduced from four to two, positions A and C, for some vehicles because of time limitations. Measurements were made in succession at each position with a sound level meter and tape recorder. From these sound level meter data, maximum A-weighted noise levels were tabulated for each microphone position for each test run.

5.1.3.2 Passby Testing

Passby testing microphone positions were 15 m (50 ft.) from the vehicle path (see Figure 5-15) and 1.2 (4 ft.) above the ground plane. A-weighted noise

Table 5-2. Primary Instrumentation Used for Truck Noise Degradation Tests

1. Bruel and Kjaer Type 1 Sound Level Meter (Model 2203) with a one inch type 4145 microphone.

2. Recording System:

   - Nagra SIVJ Recorder
   - Bruel and Kjaer one-half inch type 4134 microphone and
   - Kudalski preamplifier.

3. Bruel and Kjaer Calibrator Model 4230

4. Engine-speed tachometer accurate to within ± 2 percent of meter reading.

5. Meteorological instrumentation to record temperature, humidity, wind.

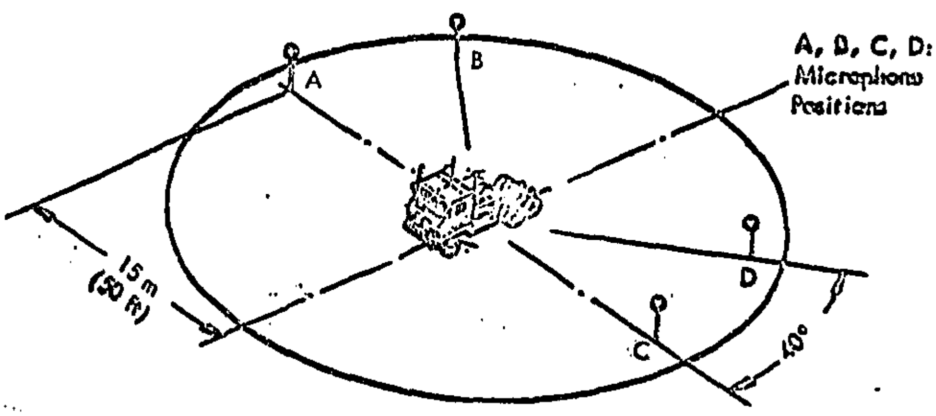


Figure 5-24. Microphone Positions for Stationary Testing

levels, using the fast meter response, were read on a precision (Type 1) sound level meter for each pass by sequence. Tape recordings of broadband noise were made for each run. From the sound level meter data, maximum A-weighted noise levels were tabulated for each microphone position for each test run.

5.1.3.3 Interior Testing

During interior noise measurements the microphone was oriented six inches to the right of and at the same height as the drivers right ear. A-weighted noise levels, using the fast meter response, were read on a precision (Type 1) sound level meter for each run up sequence. Tape recordings of broadband noise were made for each run. From these data, A-weighted noise levels with the engine in a stabilized speed condition were acquired.

5.1.4 Test Procedures

The test program was designed to enable stationary run up, pass by and interior noise level measurements on each of the test vehicles. In conducting these tests, the following standard test procedures were employed:

- Stationary run up tests were performed in accordance with the procedures specified in Subpart E of the DOT Regulations for the Enforcement of Motor Carrier Noise Emission Standards.[33]
- Pass by tests were performed according to the procedures outlined in the EPA Noise Emission Standards for New Medium and Heavy Duty Trucks.[34]
- Interior measurements were conducted in accordance with the procedures set forth in the DOT Regulations for Vehicle Interior Noise Levels.[46]
- Six noise measurements were made for each test sequence.

In addition to the above measurements, on a selected number of vehicles, a series of component noise source measurements were performed so as to further assess any noise degradation characteristics. Of particular importance was an evaluation of the effects of exhaust system deterioration on total truck noise levels. Eleven vehicles were tested in a configuration which allowed for removal of exhaust gas noise from the measured environment. Truck numbers 1, 14, 27, and 28 were tested in this manner using the ducting system at the Wyle Norco facility (see Figure 5-14). Truck numbers 2, 3, 4, and 5 were tested at Redwing Carrier's facility in Tampa, Florida using a 20-foot piece of flexible ducting and a muffler attached to the exhaust stack. Figure 5-25 illustrates this test setup. Truck numbers 7 and 8 were tested at Riverdale, Maryland with a 25-foot length of flexible ducting attached to the exhaust pipe. Figure 5-26 illustrates this test configuration. The flexible duct was routed toward the front of the vehicle. Truck number 6 had a 20-foot flexible duct attached to the exhaust stack. It was routed toward the opposite side of the vehicle from where the microphone was positioned. In this manner the truck acted as a shield to help mask out exhaust gas noise.

In conducting all of the above described measurements, the following general test methodology was employed for each test vehicle:

1. At the outset of testing, information was obtained regarding the truck's specifications and the type of service in which it is typically used.
2. A set of stationary run up, passby and interior noise measurements was performed on each truck prior to its initially entering fleet service.
3. Each vehicle was then subjected to an identical set of noise level measurements at the following approximate accumulated mileage:
   - 16,000 KM (10000 mi)
   - 32,000 KM (20000 mi)
   - 80,000 KM (50000 mi)
   - 160,000 KM (100,000 mi)

For 8 of the 30 test vehicles, it was possible to obtain pass by and IMI test data from tests conducted at the truck manufacturers factory. These data were obtained by the manufacturers using essentially the same procedures followed in the subsequent field tests. Vehicles which did not reach higher mileage levels prior to the end of the test period were subjected to a final set of noise level measurements near the end of the monitoring program.

Trucks were tested on a time interval basis such as monthly if this was more convenient for the truck owner. A time interval was established that would result in at least three sets of measurements prior to conclusion of the test program.

4. When test site construction and truck fleet scheduling permitted, the following idle-max-idle (IMI) tests were also performed:

   - Truck in "as delivered" condition
   - Truck exhaust connected to remote ducting system
   - Engine fan clutch fully engaged.

Maintenance sheets were reviewed for each vehicle at each test interval to determine compliance with manufacturer's recommended maintenance procedures. Particular attention was given to noise-generation sensitive components such as exhaust, intake and cooling systems and special equipment installed for noise control purposes.

The degradation of the total vehicle noise as a function of exhaust components and nonexhaust components was evaluated based upon the noise levels measured over an operating period of approximately 160,000 km (100,000 m). Results of this evaluation are presented in the section which follows.

5.1.5 Component Noise Degradation Testing

Several trucks from the total vehicle noise degradation test program were subjected to additional testing for the analysis of component noise degradation.

The purpose of this test phase was to determine the effects of engine, fan, exhaust and intake component noise degradation on total vehicle noise over a period of approximately 160,000 km (100,000 m).

Test methodologies were identical to those used previously to measure total vehicle noise. Only stationary tests were performed and all measurements were performed at the Norco, California facility.

Truck numbers 1 and 14 were involved in this test phase. Results of this evaluation are presented in Section 5.2.5.

5.1.6 System Calibration Procedures

Each of the truck noise measurements were made using calibration procedures selected early in the program and carefully repeated during each test to assure accurate results. Primary data were obtained using a precision Type 1 sound level meter (specified in ANSI S 1.4, 1971), and simultaneously the data were recorded on a Nagra IV SJ tape recorder. This backup system used a separate 1/2 inch condenser microphone in a system meeting all requirements of SAE J184, 1972 "Qualifying a Sound Data Acquisition System." Calibration of both the sound level meter (SLM) and tape recorder were obtained using a B & K 4230 acoustic calibrator. The 94 dB SPL at 1 KHZ provided a means of accurately adjusting the sensitivity of the SLM and was also recorded on tape. The data recorded on tape were later analyzed in the laboratory to confirm the levels measured in the field. These dual measurements with corresponding calibrations will produce data results with high validity.

[illegible]

[illegible] subjected to additional testing [illegible]

WYLE LABORATORIES

5.2 Test Results

5.2.1 Total Vehicle Noise Levels

A summary of the truck noise level data acquired to date is presented in Table 5-3. All values shown represent the arithmetic average of the two highest recorded levels observed during the test. There were no data corrections made to compensate for variations in site, calibration or temperature changes.

- Each truck was tested at the same site using identical positions for the vehicle and microphone.
- Calibration was performed before, during, and after each test sequence using the same procedure.
- No procedure exists for correction of truck noise levels due to temperature change. Data from automobile testing indicates an 0.5 to 1.0 dB change for a 6.67°C (20°F) change in temperature.[20,31]

Noise degradation curves have been plotted by using the highest noise level for each test regardless of whether it was measured on the right or left side of the vehicle. In some instances, these values did vary by more than 2 dB from one side to the other. Figures 5-27 through 5-35 graphically illustrate the noise level of the test vehicles as a function of kilometers of accumulated travel.

Two curves have been plotted for those vehicles where it was possible to obtain measurements with the exhaust gas ducted away. There are certain relationships that can be interpreted from the comparison of the two curves:

- An increase in the total vehicle noise curve with the engine noise curve remaining constant indicates the change is the result of increased exhaust gas noise levels.
- An increase in the total vehicle noise curve and the engine noise curve indicates the change is the result of increased engine noise levels.

Table 5-3

Truck Noise Degradation Test Results, L_A (dB)

Truck Number	Factory Test				Test 1						Test 2				Test 3				Test 4				Test 5				Pass-By*	
	Pass-By		IMI		Pass-By		IMI		Exhaust Relocated		IMI		Exhaust Relocated		IMI		Exhaust Relocated		IMI		Exhaust Relocated		IMI		Exhaust Relocated			
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1					77.6	76.3	78.3	77.0	77.3	75.7	77.1	76.8	76.2	76.2	78.0	78.0			77.5	77.7	76.0	76.6						
2	81.6	81.0	80.0	79.5	79.9	79.6	81.6	78.1	78.7	77.2	82.0	80.8	78.8	78.0	82.7	81.6	78.4	78.9	82.8	81.0	79.0	79.6	81.0	79.7	79.5	77.6	81.5	81.2
3	83.0	82.0	84.0	84.0	84.2	83.0	85.1	84.3	85.9	85.5	86.1	87.2	85.2	85.6	85.0	85.7			86.8	84.2	86.0	83.4	82.3	82.6	81.5	81.9	83.4	83.9
4	82.0	81.5	81.0	80.5	79.4	78.8	80.6	79.0	78.3	77.3	82.2	81.1	78.6	77.8	81.2	80.7	78.6	78.6	83.5	82.6	80.8	79.0	80.8	79.7	75.9	76.6	83.1	81.5
5	83.0	83.0	84.5	85.0	82.5	81.8	84.4	84.8	84.3	84.2	85.7	86.8	86.0	86.8	85.1	85.6	85.6	86.6	86.8	86.2	86.0	85.5	83.4	83.6	82.0	83.9	83.5	84.2
6							80.4	79.9			86.2	85.7	80.0	79.2	83.6	82.8											86.2	86.5
7					77.6	77.2	79.6	77.3	78.8	78.0	79.9	79.4	79.3	78.1	79.6	79.8	79.2	78.4									77.9	[illegible]
8					74.5	73.9	76.2	74.7	74.2	75.1	77.8	78.3	78.0	78.5	79.4	81.3	80.7	80.0									77.1	76.4
9					85.3	84.5	86.0	85.2			86.2	85.0																
10					85.4	83.2	85.0	82.3			85.0	83.0																
11							80.7	78.3																				
12					77.7	78.4	79.7	79.3																				
13					78.6	78.4	80.6	80.5			79.3	78.9			80.4	79.2			79.0	80.1							79.8	79.7
14							81.9	81.0	80.9	81.0	83.7	81.2			83.8	82.5	82.8	82.3										
15					79.0	79.0	79.5	79.3			77.2	76.5			82.3	81.5			79.4	79.3							79.5	79.9
16					77.0	78.0	85.5	87.0			82.7	85.0			81.7	82.8											76.5	79.8
17					76.4	77.0	76.5	75.0			77.5	76.0			77.3	74.4											76.5	[illegible]
18							81.3	82.1																				
19	78.1	78.2	77.9	78.1			76.1	77.0																				
20	77.9	79.3	78.8	78.8			75.8	77.5																				

*Pass-by Data Corresponds to Last IMI Test Performed.

Table 5-6 (Cont.)

Truck Number	Factory Test				Test 1						Test 2				Test 3				Test 4				Test 5					
	Pass-By		IMI		Pass-By		IMI		Exhaust Relocated		IMI		Exhaust Relocated		IMI		Exhaust Relocated		IMI		Exhaust Relocated		IMI		Exhaust Relocated		Pass-By*	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
21							79.3	78.3			77.8	77.4			80.3	79.6												
22							79.5	79.2			79.8	77.5			80.3	80.7												
23							81.5	80.6			81.0	80.7			80.8	80.2												
24							81.2	79.8			79.8	79.2																
25							81.8	80.0			83.0	81.0			81.7	81.7												
26							81.5	80.1			81.6	80.5			80.1	79.8												
27	77.7	77.4	77.7	78.5			78.2	77.2			79.7	80.2	79.2	79.7														
28	78.6	79.2	77.9	77.5			78.0	77.3			83.2	83.7	83.2	82.7														
29							85.2	84.2																				
30					80.6	79.8	79.6	80.1			79.2	80.4			78.2	79.4											79.9	80.2

*Pass-by Data Corresponds to Last IMI Test Performed.

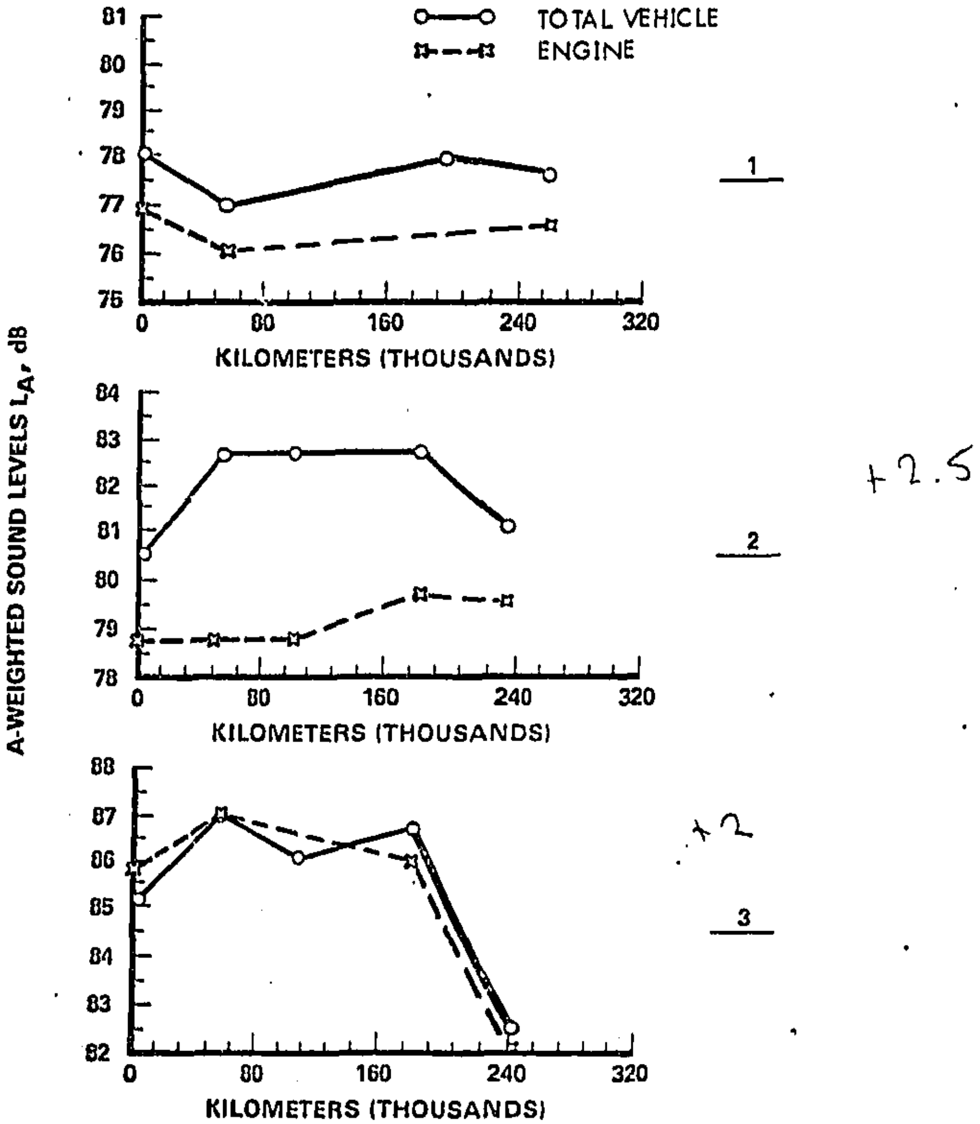


Figure 5-27. Vehicle Exterior Noise Levels versus Cumulative Kilometers

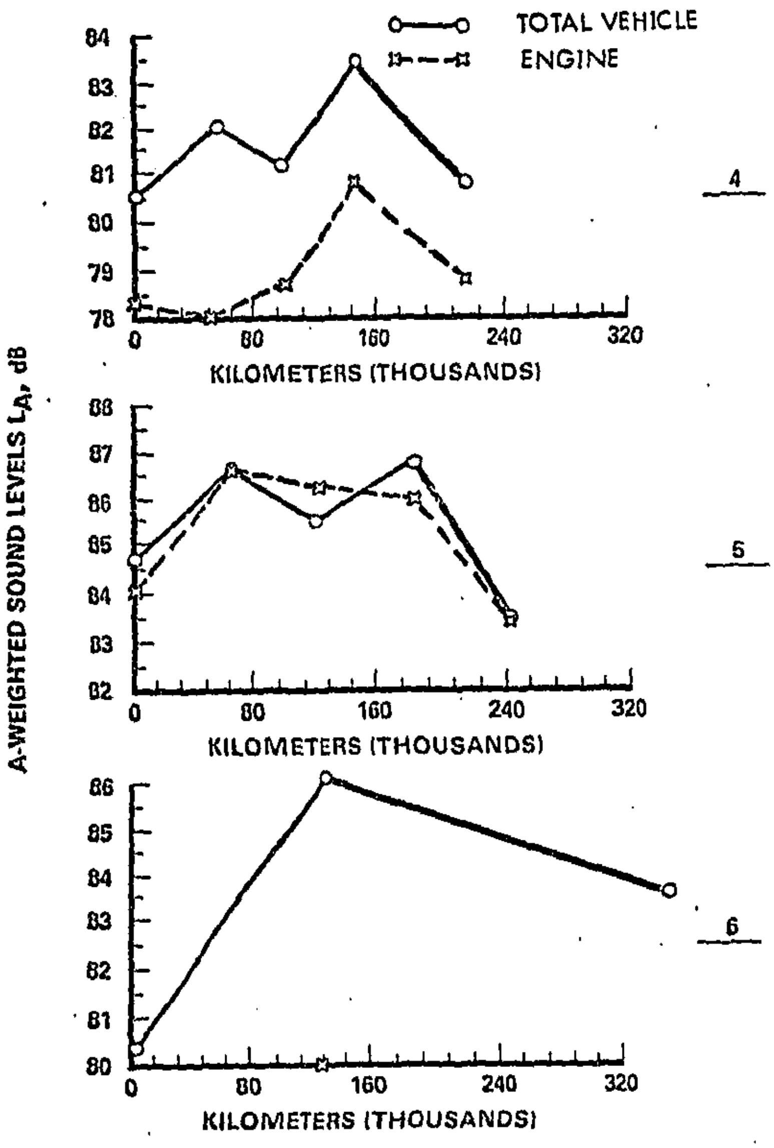


Figure 5-28. Vehicle Exterior Noise Levels versus Cumulative Kilometers

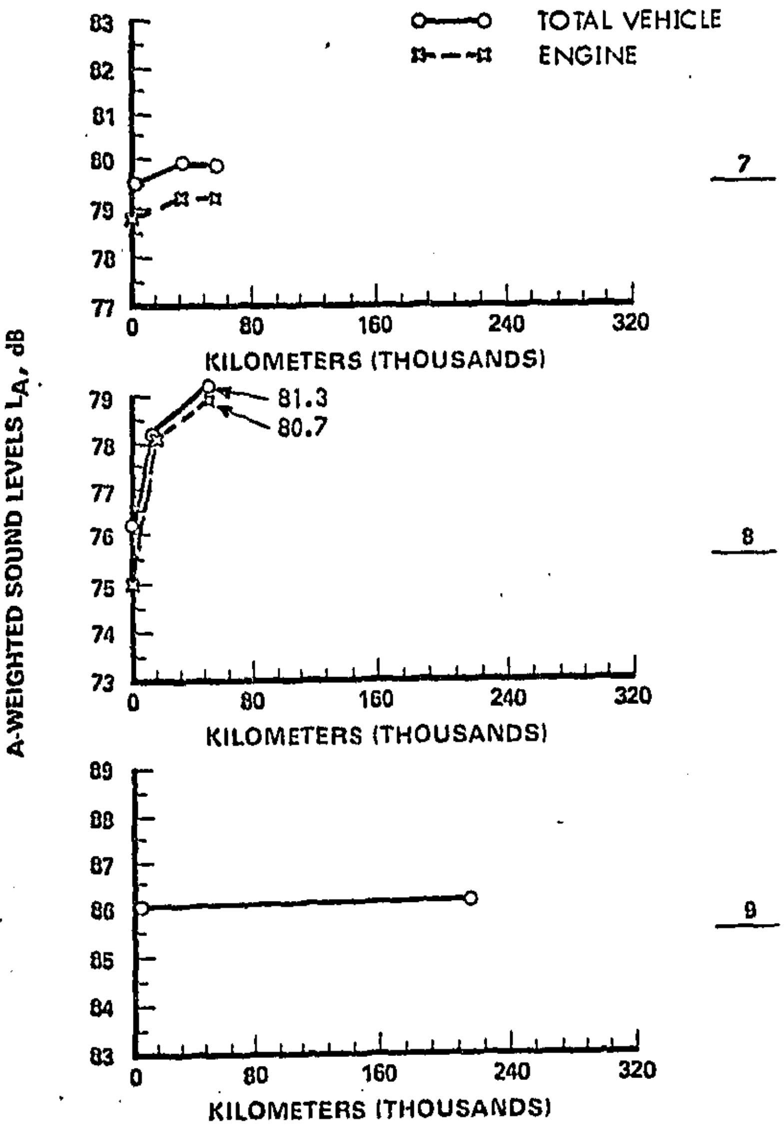
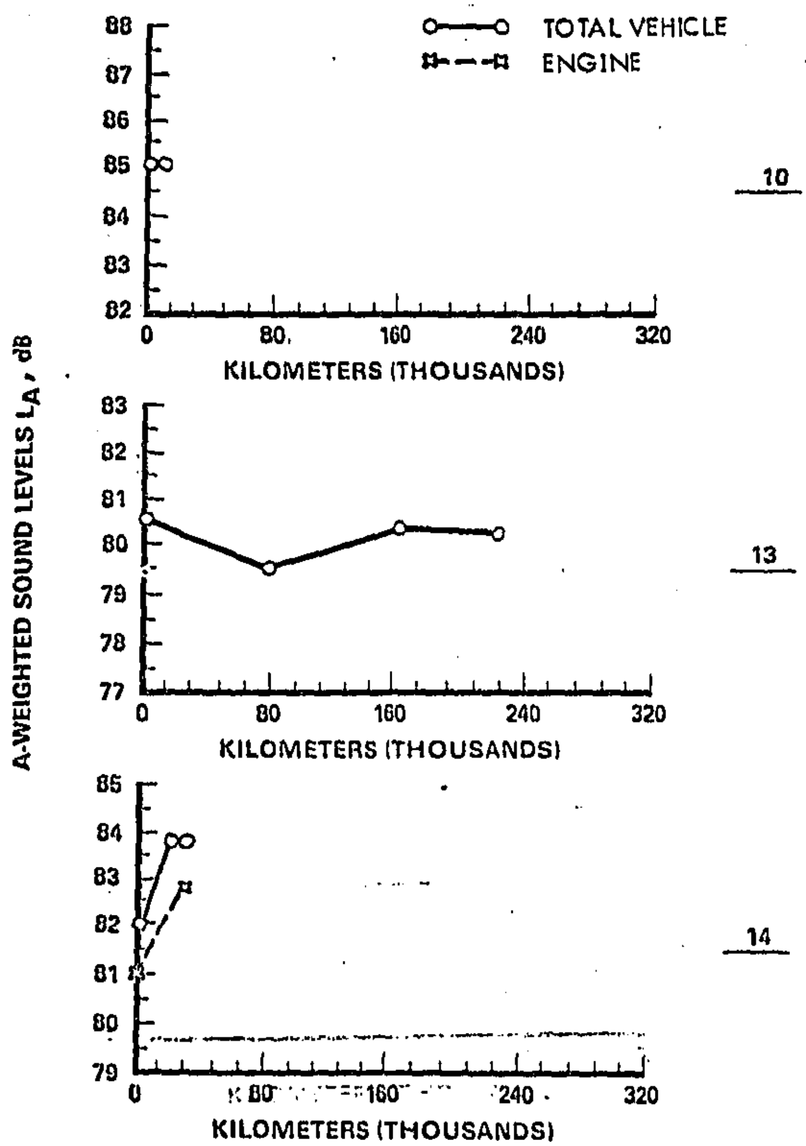
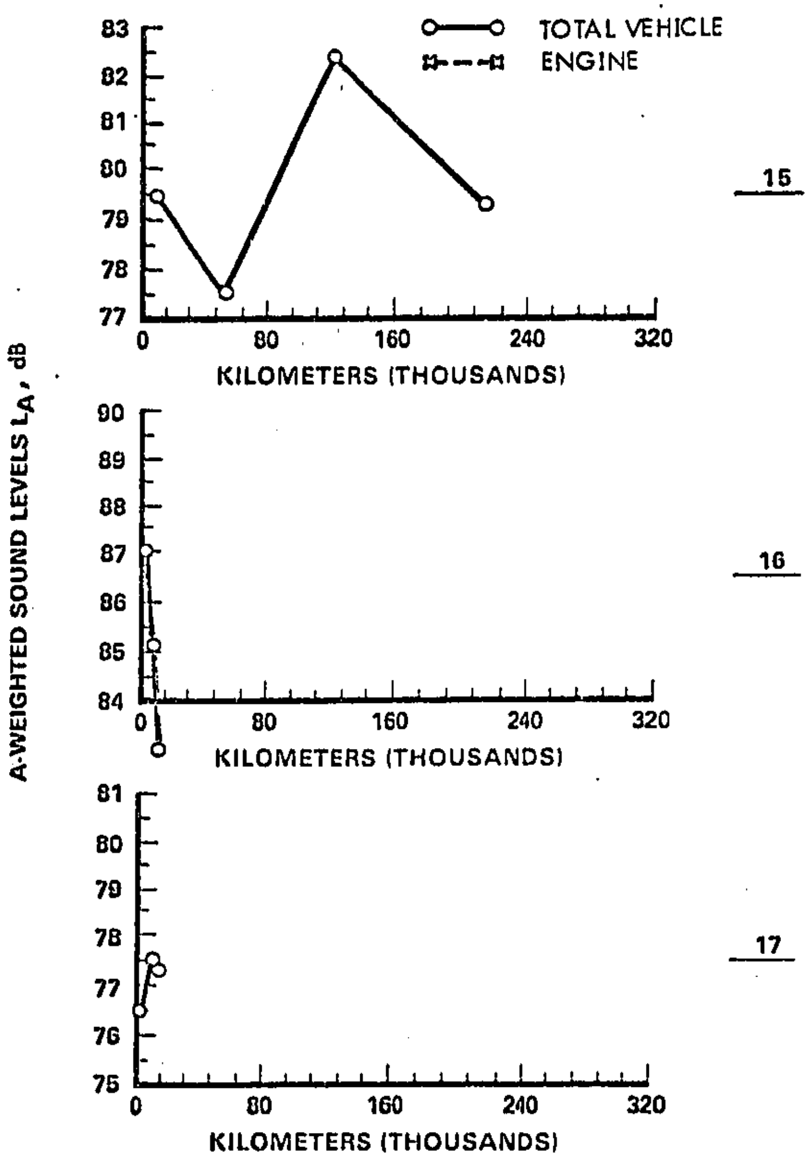


Figure 5-29. Vehicle Exterior Noise Levels versus Cumulative Kilometers



+2

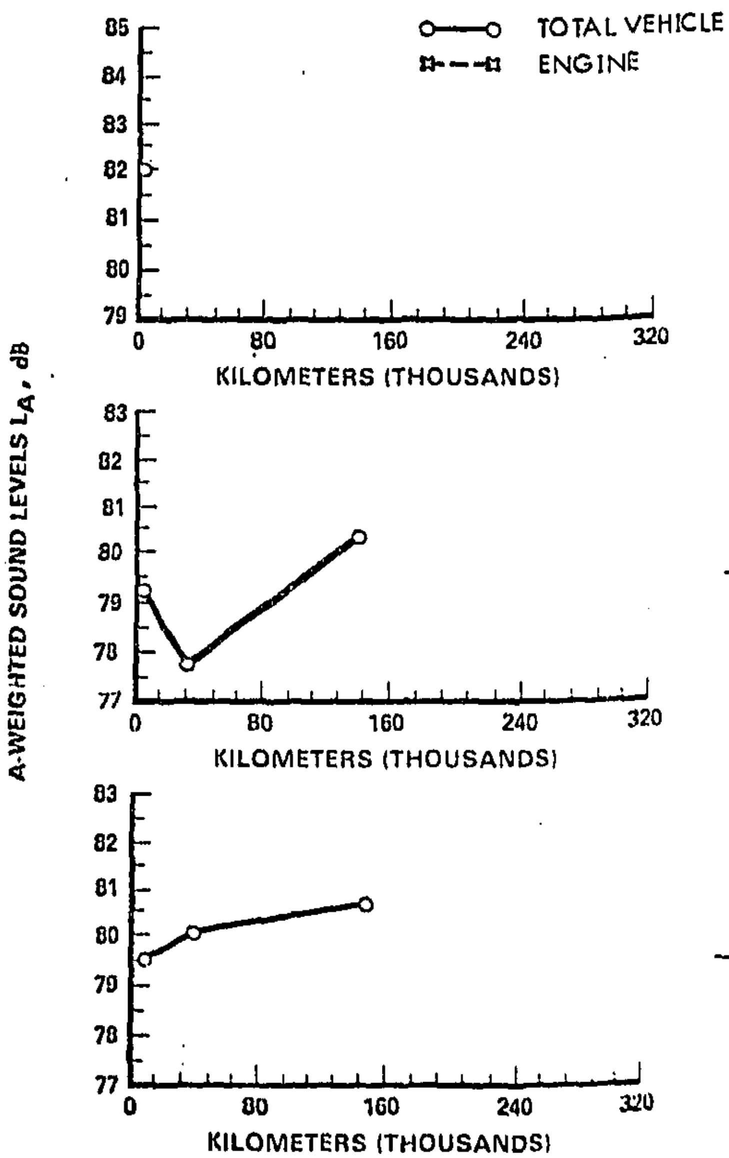
Figure 5-30. Vehicle Exterior Noise Levels versus Cumulative Kilometers



+3

+1

Figure 5-31. Vehicle Exterior Noise Levels versus Cumulative Kilometers



18

21 +1.5

22 +1

Figure 5-32. Vehicle Exterior Noise Levels versus Cumulative Kilometers

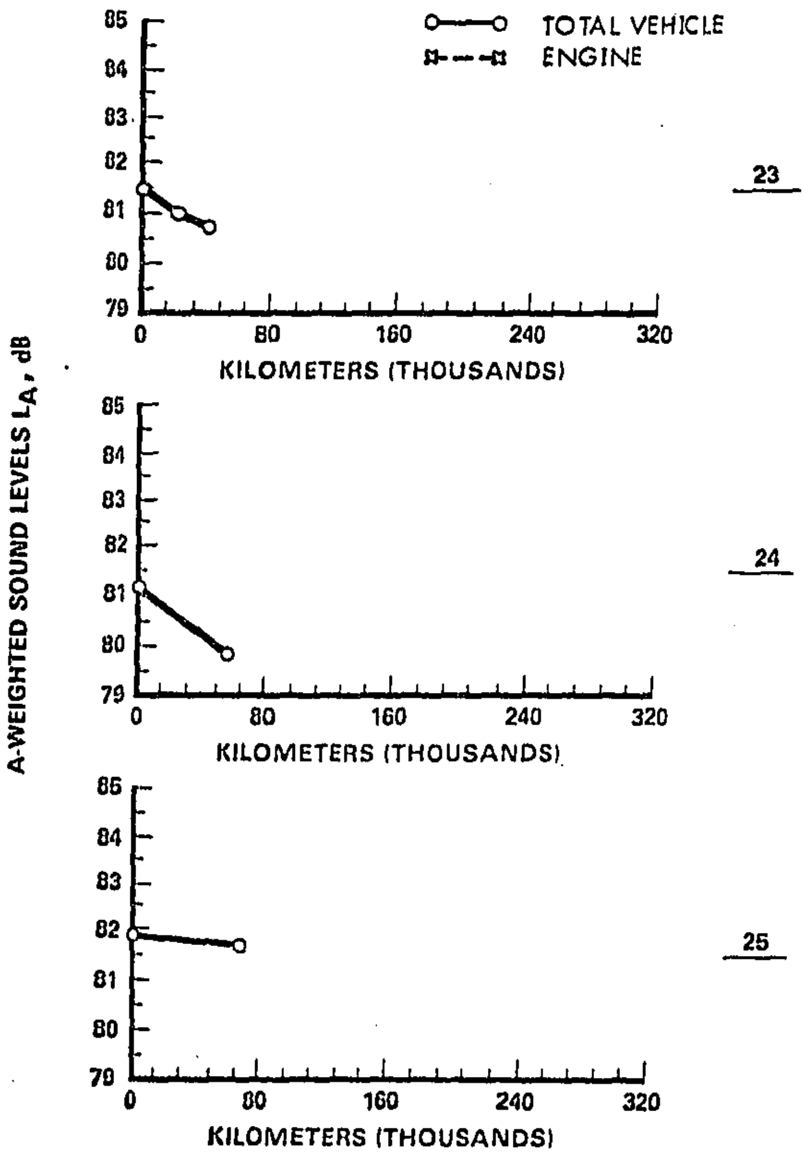
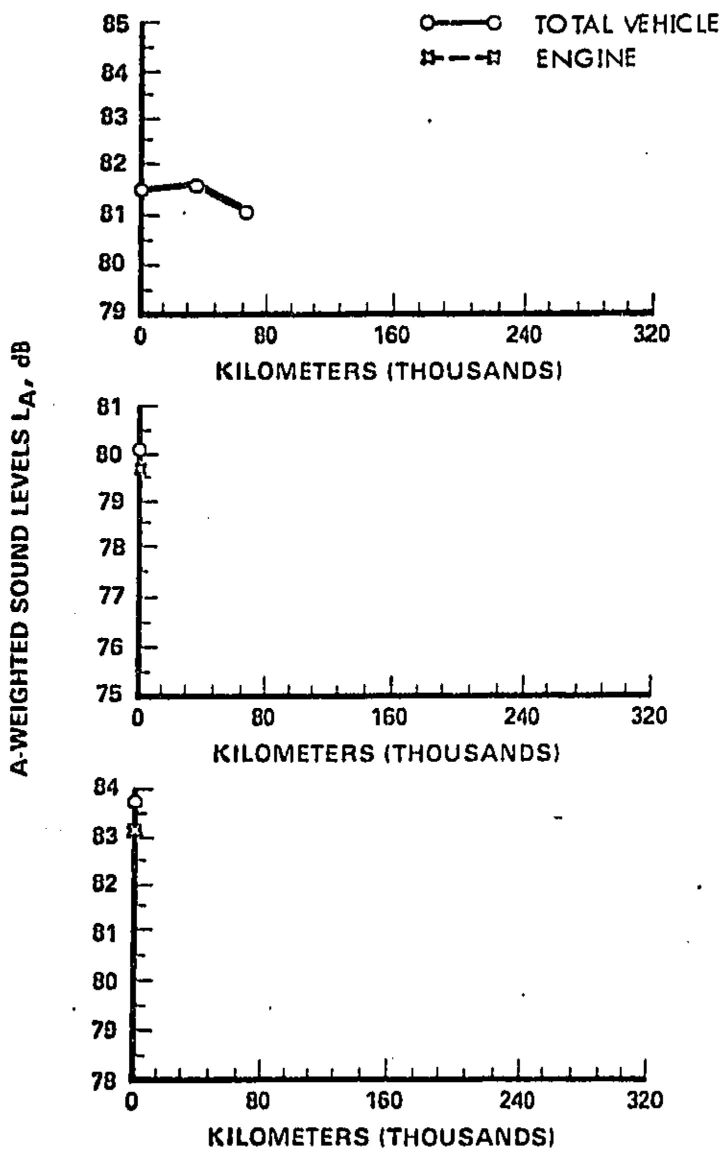


Figure 5-33. Vehicle Exterior Noise Levels versus Cumulative Kilometers



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27

28

Figure 5-34. Vehicle Exterior Noise Levels versus Cumulative Kilometers

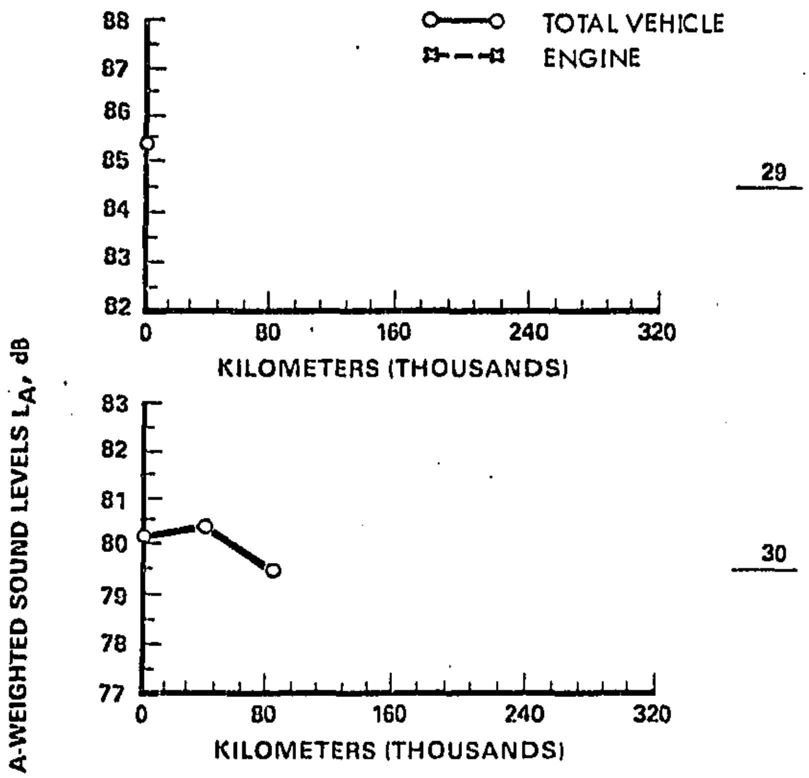

Figure 5-35. Vehicle Exterior Noise Levels versus Cumulative Kilometers

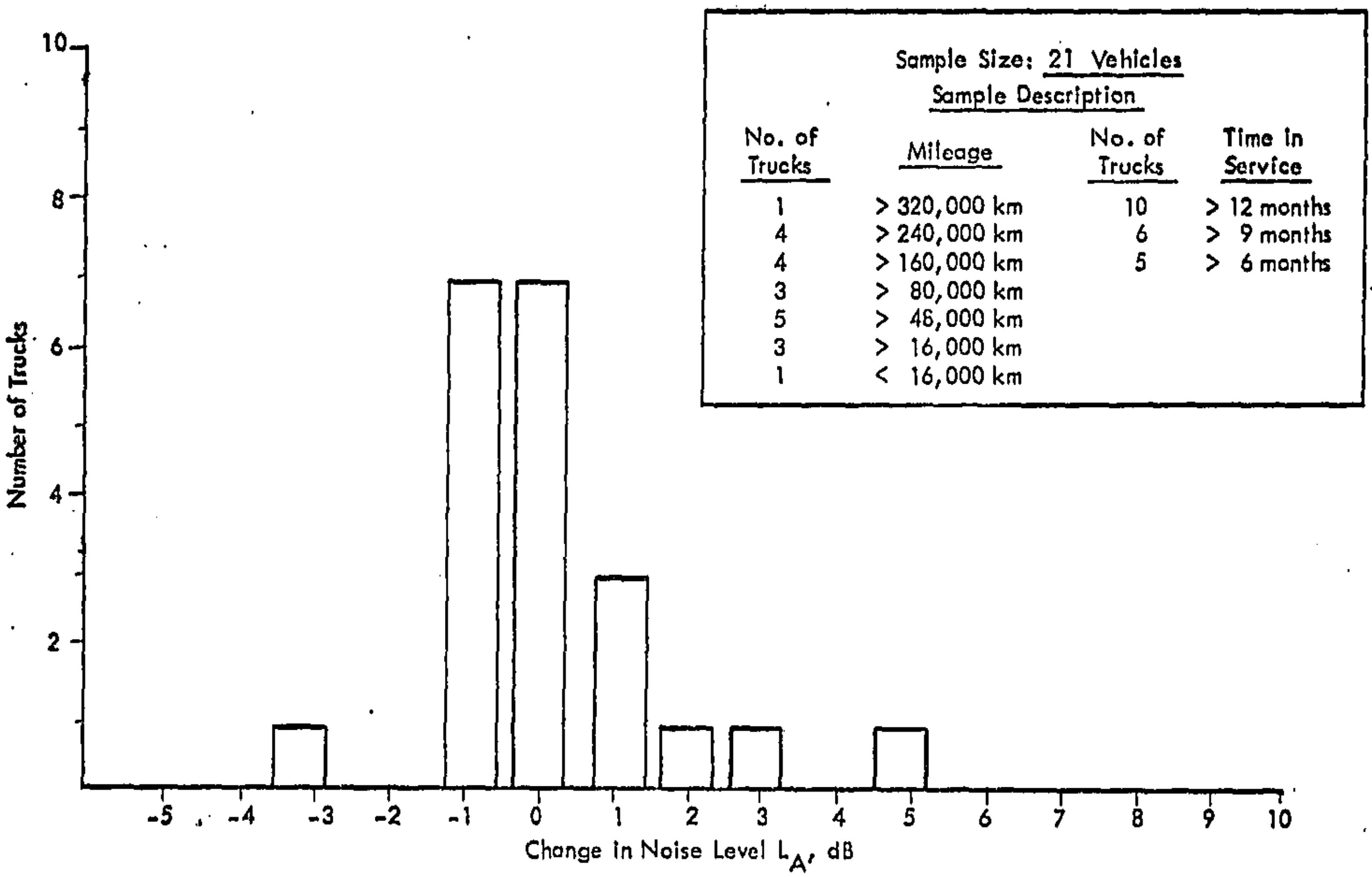

Figure 5-36. Change in Noise Levels with Time as Measured by Stationary (IMI) Testing

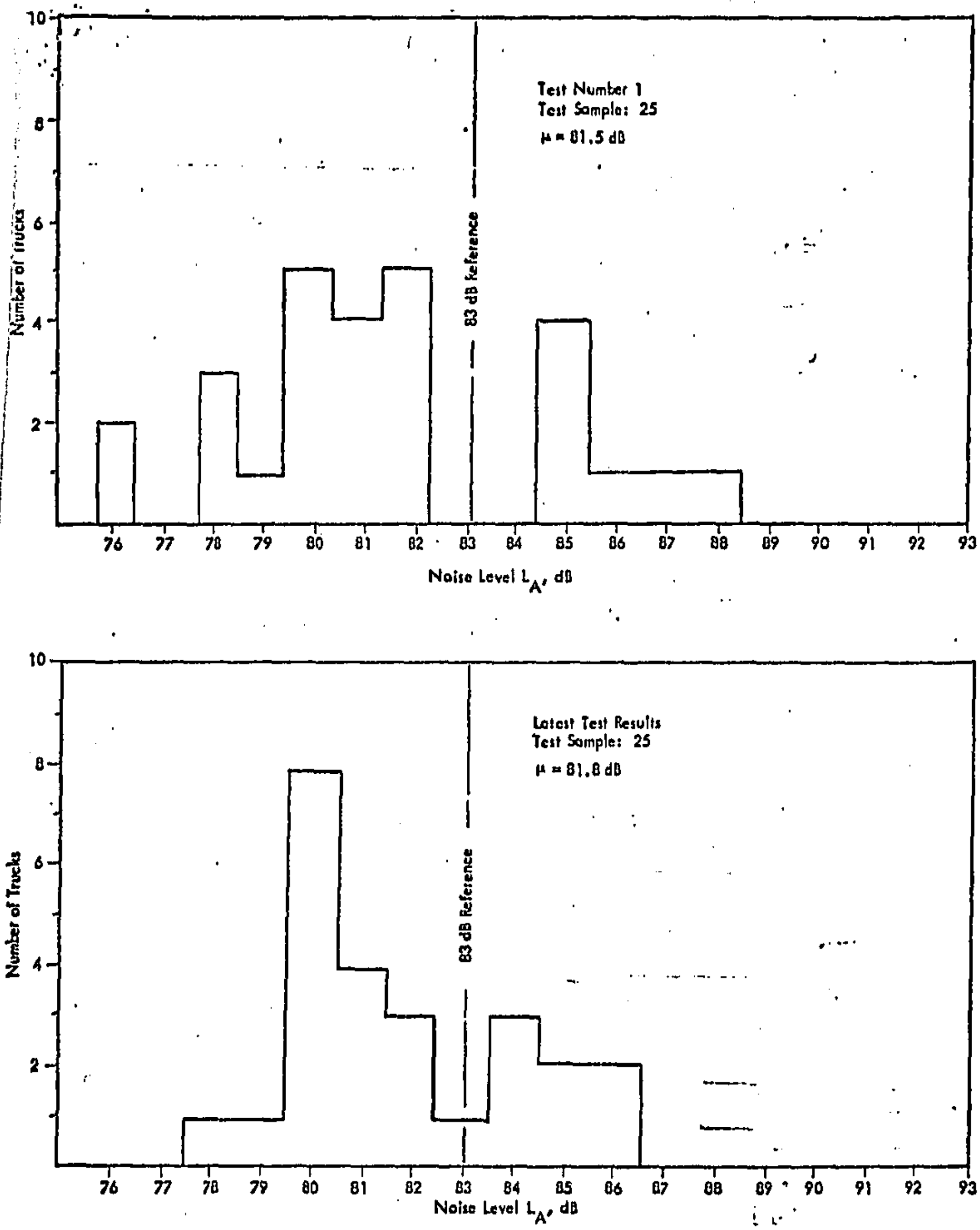

Figure 5-37. Measured Noise Levels Compared to New Truck Regulation (83 dB)

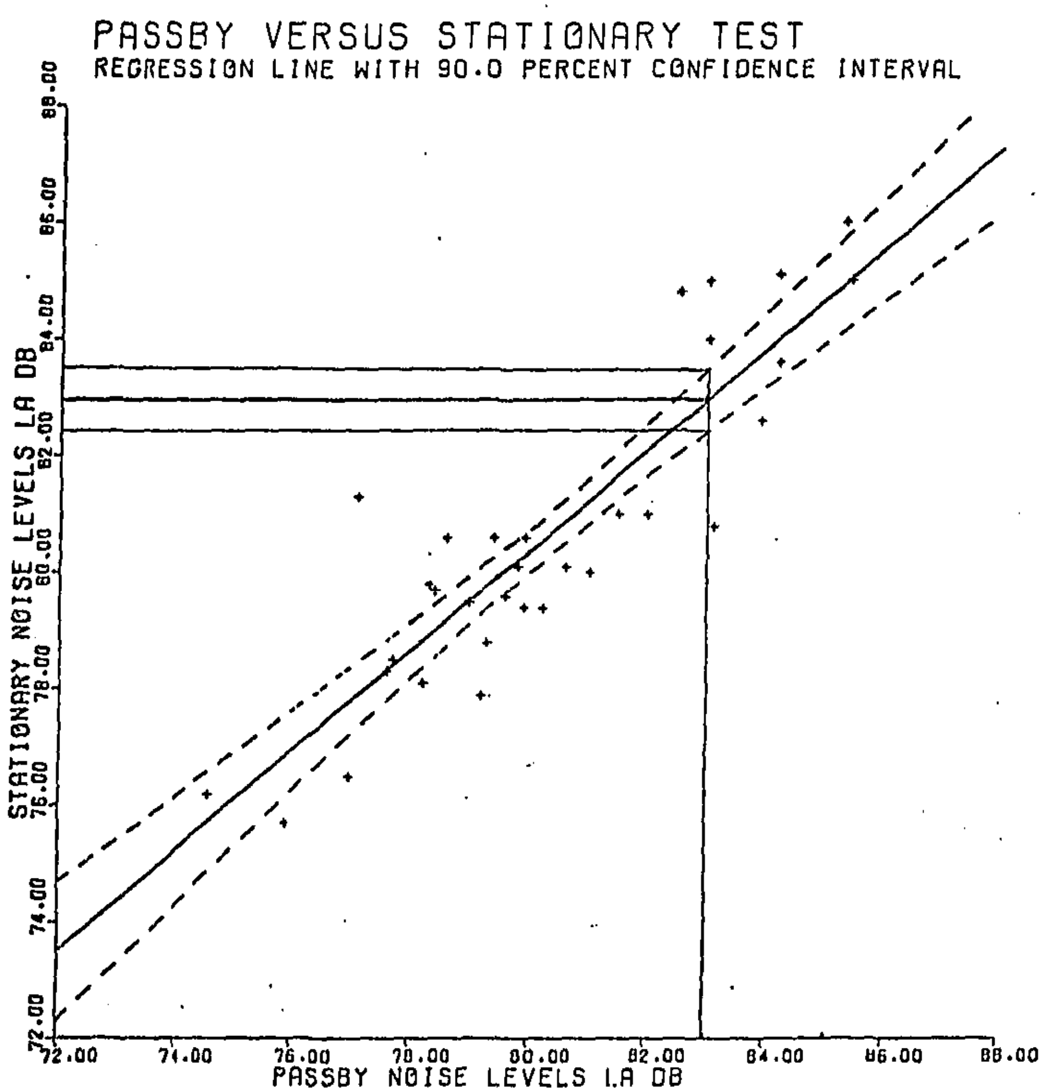

Figure 5-38. Passby Versus Stationary Test.

Figure 5-36 illustrates the change in noise levels, to date, for 21 trucks. The levels were calculated by subtracting the results of the latest test from test number one. (Reference Table 5-3). The resulting graph does not show the maximum change in noise levels for all of the 21 trucks. Some trucks indicated a higher noise level during an interim test.

The results can be used as a guide in establishing an allowable level of noise degradation. For example, if a noise degradation of 2 dB were allowed with the truck sample shown, two trucks out of 21 or 10% would be out of compliance.

5.2.2 Change in Noise Levels Referenced to 83 dB

The data collected from this sample of trucks is not representative of all trucks required to meet the 83 dB New Truck Noise Regulation. Only eight of the trucks were sold in 1978 and therefore required to meet that regulation. A distribution of the measured noise levels are shown graphically in Figure 5-37 using 83 dB as a reference point. The first graph is plotted from test Number 1 data, the lower graph is plotted with the latest test results. All data are from stationary testing only.

These graphs were prepared to determine if any trend was evident for 1977 trucks, when the noise levels were plotted using 83 dB as a reference point.

There is little change between the two graphs if the mean level of 81.5 dB and 81.8 dB are compared. The range of noise levels decreased by 4 dB from the first test to the most recent, seven trucks exceed 83 dB during both of the test sequences. ?

5.2.3 Correlation Analysis of Pass-by Versus Stationary Testing

Most of the noise tests performed on this truck sample were stationary tests. Passby testing was performed on eight vehicles by the respective manufacturers. Twelve vehicles were subjected to repeat pass-by tests during the program. The results of all of the passby test compared against corresponding stationary tests have been plotted in Figure 5-38. A linear regression line and 90 per cent confidence interval have been calculated for the respective data points.

The resulting curve indicates a mean of 80.24 dB for pass-by testing and 80.58 dB for stationary testing, a difference of only 0.34 dB.

An example application of the data is shown on the graph. For a passby level of 83 dB, the corresponding stationary noise level would be approximately 83 dB. There would also be a 90% confidence level that the stationary test results would fall between 82.5 dB and 83.5 dB.

5.2.4 Vehicle Noise with Exhaust Gas Component Minimized

Eight of the eleven vehicles on which exhuast gases were ducted away have had sufficient measurements taken such that the following preliminary conclusions may be drawn:

- Five of these trucks (Numbers 1, 2, 4, 5 and 7) show no increase in exhaust gas noise level.
- Two trucks (Numbers 8 and 14) increased in overall noise because of an increase in engine noise.
- Vehicle Number 3 noise levels decreased as a result of reduced engine noise.

Visual observations of exhaust systems indicated exhaust gas leaks and/or replacements of exhuast system components. For example, it was noted prior to initiation of the second set of measurements on truck Number 2 that it had exhaust gas leakage as shown in Figure 5-39. However, the results of test number 2 did not indicate any increase in exhaust gas noise levels. Truck number 7 had a new muffler and tailpipe installed just prior to the performance of test number 2. The original installation is illustrated in Figure 5-40. Similar muffler deterioration was noted on truck number 8 and is illustrated in Figure 5-41. No measured increase in exhaust gas noise was recorded for truck number 2.

5.2.5 Interior Noise Levels

A tabulation of interior noise levels is shown in Table 5-4. These measurements were initiated after the vehicle noise program was in process.

Of the 21 vehicles where some trend is indicated:

- Sixteen have shown an increase in interior noise level,
- Five have shown a decrease in interior noise level.

As summarized in Table 5-5, there is no consistency in the change of interior noise levels when compared to the change in exterior noise levels. The differences in the indicated trends could be explained by the following:

- Change in exterior to interior noise leakage paths that are not pertinent to changes in exterior noise level
- Changes in spectral content of source noise which could be more significant for the interior noise transmission path.

5.2.6 Factory Versus Wyle Test Results

As described earlier, factory data were obtained for eight of the 30 test vehicles. These data are used here for the purpose of identifying possible variations between new truck noise levels as measured at the factory and those measured at the customer facility prior to the truck entering service. Table 5-6 summarizes the results of this comparative analysis. Maximum variations between the factory and Wyle test results are 2.6 dB for the passby tests and 1.1 dB for the IMI tests. In general, correlation between the factory and field noise measurement is very good.

Table 5-4

Interior Noise Levels L_A, dB

Truck Number	Test Number					
	1	2	3	4	5	6
1		78.5	77.5	80.7		
2		87.3	85.9	81.8	85.3	
3		84.2	84.1	84.3	86.5	
4		84.4	83.7	83.0	85.4	
5		83.9	84.6	83.0	86.7	
6		85.1	87.8			
7		87.0	82.5			
8		82.4	84.0			
9		87.7				
10		85.0				
11	85.0					
12	80.7					
13	75.4	74.9	78.5	77.0		
14	86.7	87.5	87.8			
15	83.5	80.5	84.5	82.3		

Table 5-4 (Continued)

Truck Number	Test Number					
	1	2	3	4	5	6
16	100.5	99.0	101.0			
17	79.2	80.8	80.0			
18	87.5					
19	88.5					
20	85.0					
21	80.4	79.0	81.9			
22	84.5	84.5	82.2			
23	83.5	85.0	84.7			
24	84.0	86.4				
25	83.5	85.0	86.0			
26	83.5	84.9	86.4			
27	87.2	87.0				
28	82.8	83.2				
29	85.8					
30	78.0	78.9	82.9			

Table 5-5

Change in Exterior and Interior Noise Levels

Truck Number	Exterior Noise ΔL_A, dB (1)	Interior Noise ΔL_A, dB (1)
1	-0.6	+2.2
2	+0.4	-2.0
3	-2.5	-2.0
4	+0.2	+1.0
5	-0.8	+2.8
6	+3.2	+2.7
7	+0.2	-4.5
8	+5.1	+1.6
13	-0.5	+1.6
14	+1.9	+1.1
15	-0.1	-1.2
16	+1.8	+0.5
17	+0.8	+0.8
21	+1.0	+1.5
22	+1.2	-2.3
23	-0.7	+1.2
24	-1.4	+2.4
25	-0.1	+2.9
26	-1.4	-0.2
30	-0.7	+4.9

(1) Change in A-weighted sound levels from initial test to current test results.

Table 5-6

Factory Data Versus Wyle Data L_A (dB)

VEHICLE NUMBER	PASS-BY		Δ	IMI		Δ
	FACTORY	WYLE	dB	FACTORY	WYLE	dB
2	81.0	79.9	-1.1	80.0 - 1	80.6 + .7	+0.6
3	83.0	84.2	+1.2	84.0 + 1	85.1 + .9	+1.1
4	82.0	79.4	-2.6	81.0 - 1	80.6 + 1.2	-0.4
5	83.0	82.5	-0.5	85.0 + 2	84.8 + 2.3	-0.2
19				78.1	77.0	-1.1
20				78.8	77.5	-1.3
27				78.5	78.2	-0.3
28				77.9	78.0	+0.1
		Mean	-0.5 dB			-0.19 dB
		Standard Deviation	1.6 dB			0.80 dB

5.2.7 Component Noise Degradation

Figure 5-42 presents results of component noise testing on truck number 1. Four sets of data have been recorded. Total vehicle noise levels only were recorded during test number 3 because the vehicle was not available for the extra time required to measure component noise.

Attention is focused initially on that case in which engine plus fan noise was measured alone (labeled as curve 3). The component noise level is higher than the total vehicle noise level due to the contribution of the fan. This particular vehicle is equipped with a fan clutch. Under standard noise compliance test procedures (as used in this study), total vehicle noise is measured with the fan clutch disengaged. Thus, for the engine plus fan component case in which the fan is continuously running, the noise level increases by approximately 2 to 3 dB above that for the total vehicle. The present results indicate less than a 1 dB change in total noise level for this truck after 262,000 Km (163,000 mi).

Truck number 14 was the second vehicle initiated into the component noise test program. This truck is equipped with a fixed fan. The component test configuration for this vehicle were as follows:

1. Total vehicle
2. Engine plus fan and exhaust
3. Engine plus fan and intake
4. Engine plus fan

Three sets of measurements has been performed at this time. Results of these tests are tabulated below in Table 5-7:

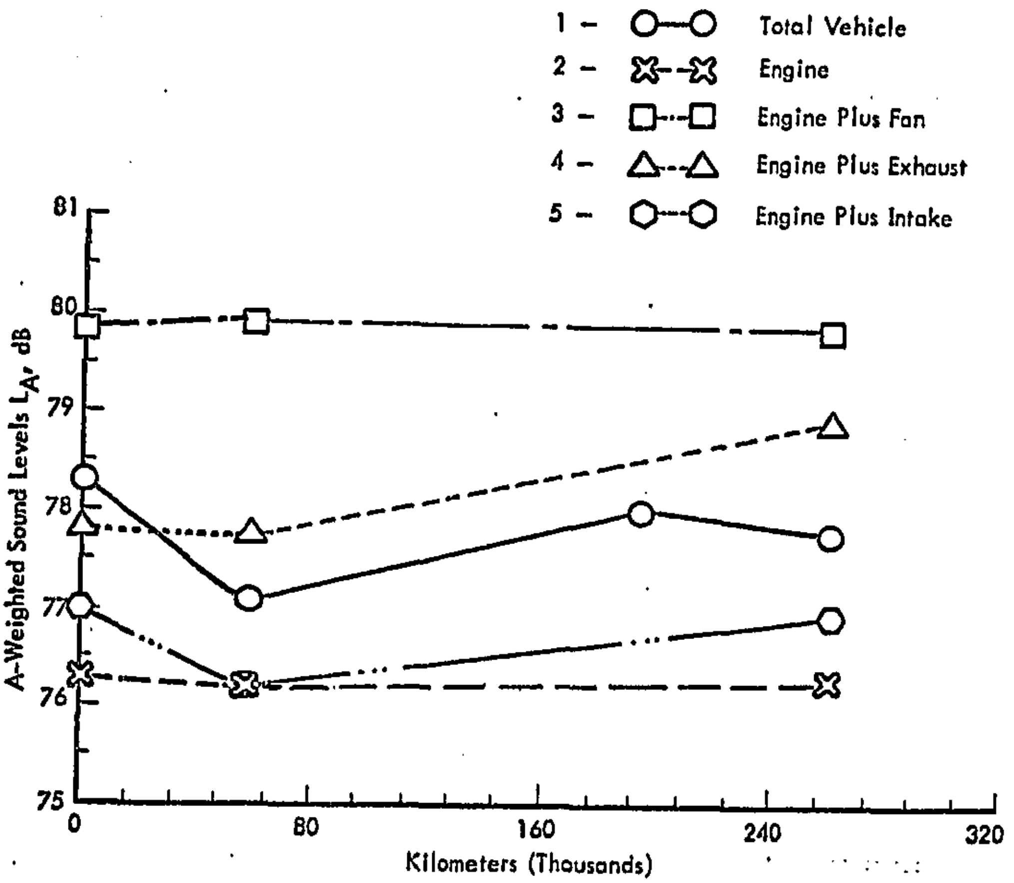

Figure 5-42. Component Exterior Noise Level Versus Cumulative Kilometers

1

Table 5-7

Stationary Test, Component Noise Levels
Truck Number 14, Test Number 1, 2 and 3

Test Condition	A-Weighted Sound Level, dB		
	1	2	3
Total Vehicle	81.9	83.7	83.8
Engine, Fan and Exhuast	81.0		
Engine, Fan and Intake	80.9		
Engine and Fan	81.0		82.8

The data shown in the above table for truck number 14 is representative of a vehicle where fan noise is the predominant noise source.

If the engine and fan noise levels of 81 dB are subtracted, on an energy basis, from the total vehicle noise level of 81.9 dB, a resultant noise contribution for the intake and exhuast would be approximately 75 dB. This would indicate that small changes in fan and engine noise would have a noticeable effect on total vehicle noise. On the other hand, significant changes in intake or exhuast component noise would have to occur before any measurable difference would be noted in total vehicle noise. From the first to most recent tests, the total truck noise has increased by 1.9 dB. Engine and fan noise have increased by 1.8 dB indicating the source of total vehicle noise increase. Engine RPM has not changed so it is further indicated that the engine, only, is responsible for the noise increase.

5.2.8 Existing Data on Truck Noise Degradation

Supplemental data on truck noise degradation were solicited from publications and through direct contacts with the trucking industry. Data were found from two truck noise degradation programs performed by two separate organizations.[57, 47] Other manufacturers and operators expressed personal opinions on truck noise degradation, but none had supporting data. Opinions indicated that some believed trucks became noisier after they had been in service, while others thought they became quieter.

Two truck noise degradation programs have been performed in recent years which resulted in the publication of data. International Harvester measured noise levels of the four heavy duty trucks involved in the DOT Quiet Truck Program.[47] Wyle Laboratories performed a truck noise degradation program for the Motor Vehicle Manufacturers Association.[57]

All four of the International Harvester trucks had been modified for noise reduction on the DOT Quiet Truck Program. Two of the trucks had partial engine enclosures while the other two had full engine enclosures. Results of this program are shown in Figure 5-43. The number of kilometers over which this data was taken is high enough to consider a trend being established with regard to noise degradation. The results have been interpreted by International Harvester as showing a maximum change of 0.5 dB in noise level. Increases in noise levels above 0.5 dB were the result of damage and are so indicated on the graphs.

The Wyle/MVMA data were accumulated on eight heavy duty vehicles over a much shorter period of time. The maximum kilometers accumulated on a given truck was 64,000 kilometers. All vehicles involved in the program were production vehicles being used in normal service. Results are shown in Table 5-8 and indicate an average increase in total vehicle noise level of 0.5 dB. Both of these test programs indicate a very small increase in noise levels. In the case of the previous Wyle data, the trend over such a low mileage is not statistically reliable since, as indicated in the last column in Table 5-8, the observed changes in level could have occurred by chance with a probability of 30 to 80 percent.

It is not advisable to consider the results of these two previous programs for application to present day truck noise degradation for the following reasons:

- International Harvester trucks were not representative of production vehicles.
- The Wyle/MVMA test program was too short and the data too sparse to place any reliance on the indicated trends.

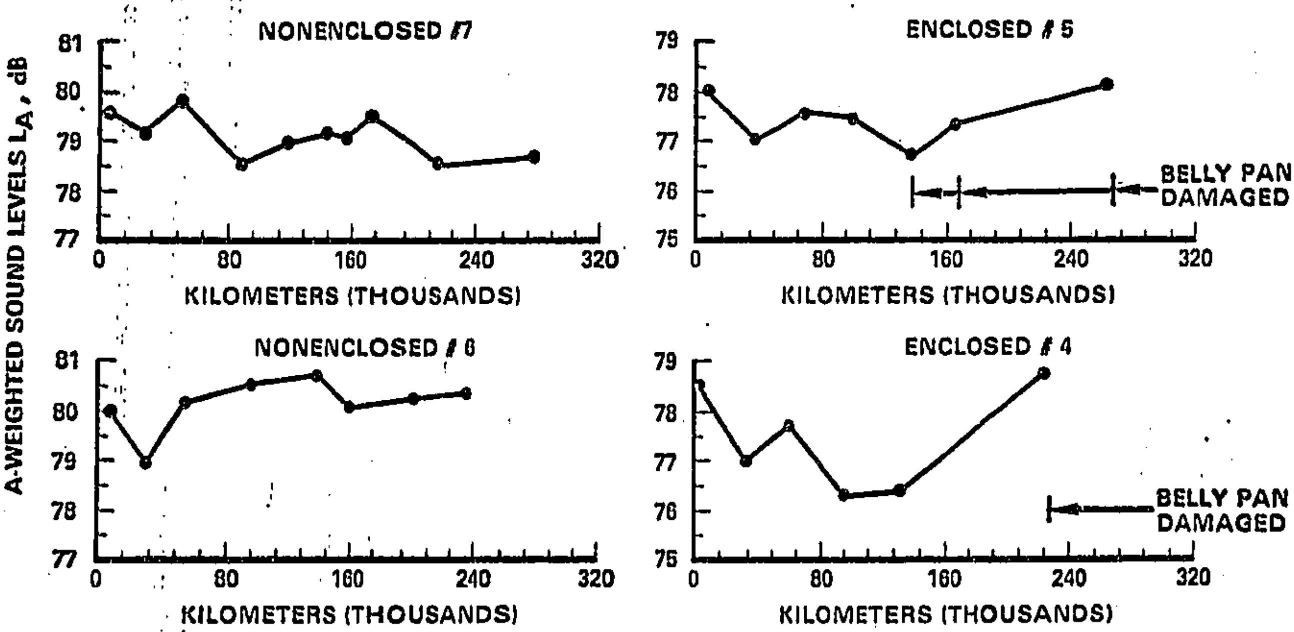

Figure 5-43. Vehicle Exterior Noise Levels versus Cumulative Kilometers
Source: International Harvester, Reference U16

Table 5-8

SUMMARY OF OBSERVED CHANGES IN AVERAGE NOISE LEVEL
WITH CUMULATIVE KILOMETERS
Source: Wyle Report to MVMA, Reference W6

APPROXIMATE KILOMETERS COMPLETED	NUMBER OF VEHICLES	AVERAGE CHANGE FROM INITIAL VALUE (dB)	STANDARD DEVIATION (dB)	PROBABILITY THAT CHANGE WAS DUE TO CHANCE (%)
16,000	8	+0.4	1.1	35
32,000	7	+0.5	1.0	30
48,000	7	+0.2	1.1	60
64,000	4	-0.2	1.7	80

5.3 Component and Vehicle Noise Degradation Related to Proper Maintenance and Operations

Information has been compiled on both the recommended and actual maintenance and operational procedures associated with each test vehicle in order to assess their effects on component and vehicle noise degradation. Sources for this information include the following:

- Arrangements for testing of the 30 trucks utilized in this program included a request to each vehicle owner for a copy of or access to the maintenance records for each vehicle. Response to this request varied from agreement to supply copies of the records to verbal communication of maintenance performed.
- A sample of drivers was contacted to accumulate information on typical vehicle operating procedures.
- Manufacturer's recommended maintenance and operational procedures for the various engine types considered in this study were obtained from either the factory or local manufacturer's representatives.
- Manufacturer's data on component noise specifications were also acquired through the respective representatives.

5.3.1 Manufacturer Recommended Operational Procedures

Factory operational procedures for the different diesel engines are very similar for all manufacturers. Warnings are given to not overspeed the engine when using it as a brake on a downhill grade. Efficient operating ranges for highway driving are recommended at three-quarter to full rated RPM. Specific recommendations by manufacturers are as follows:

- Detroit Diesel

    a. Run the engine at 10 to 20 percent below governed speed for highway speed.

b. In the city and other reduced speed zones, match engine speed to the lower load requirement to conserve fuel and lower vehicle noise level.

c. Avoid overspeeding the engine.

d. The recommended cruising range for various engines is shown in the following table 5-9:

Table 5-9

Recommended Engine Cruising Ranges

Engine	Governed Speed (RPM)	Highway (RPM)	City (RPM)
Series 71 & 92	2100	1650 to 1850	1400 to 1600
Series 71 & 92 Fuel Squeezers	1800 to 2100	1400 to 1900	1250 to 1600 8V-92TT 1400 to 1600
Series 53	2400 to 2800	2250 to 2400	1800 to 2000

- Cummins

  a. For improved operating efficiency (fuel economy and engine life) operate in top gear at reduced RPM rather than in the next lower gear at maximum RPM.

  b. Cruise at partial throttle whenever road conditions and speed requirements permit.

  c. Care should be exercised when using the engine as a brake not to overspeed the engine.

- Caterpillar

  a. Cruising speed should be between three-fourths and full governed RPM.

b. On upgrade, downshift until a gear is reached in which the engine will pull the load without lugging.

c. On downgrade, do not allow engine speed to exceed high idle.

5.3.2 Manufacturer Recommended Maintenance Procedures

Manufacturers all supply recommended schedule of maintenance with their respective vehicles. The owner is given a range of maintenance intervals to select from, based upon fleet operational characteristics. Table 5-10 lists the specified change or adjustment schedule for the most important engine components. Daily inspections are also recommended for oil level and coolant depending upon number of miles driven.

5.3.3 Manufacturer Data on Component Noise Specifications

Literature published since the issuance of the Background Document[40] is support of the New Truck Noise Standards has been primarily on muffler configurations. By using the muffler manufacturers' specification sheets, the matrix can be developed as in Table 5-11 to show the lowest noise level muffler systems for the engines used in this program. These data, when combined with results from the noise degradation-remote exhaust testing, would enable one to project noise degradation for these engine-muffler configurations.

The cooling fan is another component for which only limited noise data are available from a manufacturer. Only one fan manufacturer, who was working with a truck manufacturer to reduce overall truck noise levels, was able to provide such data. He revealed that fan noise has been successfully reduced to a level whereby the overall truck noise level of 83 dB was not affected by having the fan on or off. The fan used slightly more than 3 HP. In this case, fan noise is not expected to be a contributor to observed degradation of truck noise levels. For fans with higher noise levels which contribute significantly to the overall levels changes in fan noise levels with use are not likely to be significant unless airflow through the fan changes. Thus, any degradation in overall truck noise is unlikely to be attributed to changes in fan noise. However, fan noise does increase overall truck noise where fan clutches are used and the fan clutch is engaged.

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Table 5-10

Factory Recommended Maintenance

Make	Oil Change	Oil Filter Replacement	Fuel Filter Replacement	Valve Adj.	Injector Pump Adj.
GM					
Detroit Diesel (D1)	*4,000-6,000	4,000-6,000	8,000-12,000	50,000	50,000
Cummins (C1)	10,000	10,000	10,000	50,000	50,000
(D2) Gas (4500-6500)	3,000	**3,000	12,000	***12,000	---
INTERNATIONAL HARVESTER					
Diesel (I2)	4,000	8,000	4,000	16,000-20,000	10,000
Gas (I2)	2,000	4,000	2,000	8,000-10,000	---
MACK TRUCK					
+++Diesel (M3)	16,000	16,000	180,000	200,000	300,000
CUMMINS					
Diesel (C1)	10,000	10,000	10,000	50,000	50,000
CATERPILLAR					
(C2) 3208 Diesel	+6,000	6,000	24,000	24,000	As Needed
3306 Diesel	+10,000	10,000	As Needed	100,000	As Needed
3406 Diesel	+10,000	10,000	As Needed	100,000	As Needed
1100 Diesel	+6,000	6,000	24,000	++6,000	As Needed

*Initial Oil Change at 3,000 Mi. and 4,000-6,000 Mi. thereafter

**After Initial 3,000 Mi. Check, every 6,000 Mi. thereafter

***After Initial 12,000 Mi. use 50,000 Mi. thereafter

+Intervals Depend on Sulphur Content. If between .4% and 1.0% reduce interval by 1/2. If content is above 1.0% use 1/4 of the mentioned intervals.

++Every 6 months after initial adjustment regardless of mileage.

+++Guidelines depend heavily on type of usage. These intervals are for E.S.I. usage.

Table 5-11

Exhaust Noise Levels for Engines Used in Noise Degradation Test Program (Taken from Muffler Manufacturers Specification Sheets) L_A, dB

	Muffler Manufacturer		
Engine	Donaldson	Walker	Stemco
Cummins NTC 350	73 Dual	76	73.5
DD 6V92 TT	71	78	
CUM VT 903	72	75	
Ford Gas V361			
Cat V8 3208	69	70 Dual	68
CUM NTC 290	71		73.5
Mack END7675		73	66.5
CUM NTC 250	71	72	70

*All of the specified noise levels are referenced to a 50 foot noise measurement at a test site complying with the Federal noise measurement specification 40 CFR 205.

5.3.4 Total Truck Noise Degradation as Related to Component Noise Degradation

Results of the test program discussed previously have thus far singled out two primary components, the engine and the mufflers, as contributing to vehicle noise degradation. Specifically, increases in engine noise have been measured for several V-8 diesels, and increases in exhaust noise have been measured for several V-6 diesels.

There seems to be no specific relationship between the maintenance or operation of vehicles and the resulting degradation in vehicle noise. However, there does appear to be some relationship between in-service operation time of a V-8 or V-6 diesel engine and increased noise levels. Data from the three vehicles using V-6 engines, truck numbers 2, 4 and 6 (Figures 5-27, 5-28) show an indicated increase in noise for all three vehicles. Truck numbers 2 and 6 exhibit increased exhaust gas noise. Number 4 shows increased engine noise.

Data from two vehicles using V-8 engines, truck numbers 3 and 5 (Figure 5-27) 5-28) show an indicated increase in noise level as a result of increased engine noise. Changes in maximum RPM were noted for both cases of increased engine or exhaust noise levels.

Further test data on component noise degradation will be necessary in order to project total vehicle noise degradation as a function of component noise degradation.

5.3.5 Vehicle Operational Procedures

The vehicles involved in this program are typically utilized in the following modes of operation:

- Line Haul - "slip seat" operation
- Line Haul - single driver
- Pick up and delivery - shift work by two or more drivers
- Pick up and delivery - single driver

Discussions were held with various drivers and shop managers to acquire direct feedback on the operation of vehicles in their fleets. Typically, line haul operators will tend to be more experienced than those who drive smaller pick up and delivery vehicles. This difference in experience translates into a difference in level of knowledge of truck operation and maintenance.

Experienced line haul drivers know the speed/RPM relationship in each gear and thus will use the tachometer rather than the speedometer as a more accurate measure of speed. In comparing this with pick-up and delivery operations, one fleet found the use of automatic transmissions saved money because of the too frequent clutch changes or transmission repairs required with standard transmissions.

A distinct difference was noted in the care and operation of vehicles driven by the same driver versus those used by many drivers. Pride resulted in an overall cost savings for the carrier because of better care and maintenance by the driver.

Most heavy duty drivers who were questioned indicated driving habits corresponding to factory recommended procedures. Medium duty trucks are mostly involved with traffic conditions which govern the type of operation. The inherent nature of city traffic operation is more severe than line haul operation.

The present trend of motor carriers is toward the use of high-torque-rise engines which allow use of transmissions with fewer gears. Fuel consumption has been the primary goal of this trend, but noise reduction has been a spin-off. One manufacturer, General Motors, relates engine operation directly to noise levels; "in city and reduced highway zones, cruise on Series 71 and 92 engines between 1400 and 1600 RPM and Series 53 between 1800 and 2000 RPM. By utilizing a gear that will enable you to do this, you will increase public acceptance by reducing noise level."[D1]

One other concept being used by some motor carriers is to "de-rate" the engine by reducing the maximum allowable RPM. This procedure will allow the driver to operate the engine only at engine speeds below maximum rated RPM which corresponds to the factory recommended mode of operation.

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The results of driver contact and shop manager interviews reveal a specific trend in actual vehicle operation which tends to correspond with factory recommended operation. While individual drivers will tend to form their own habits, the use of high torque engines and the de-rating of engines by some carriers appears to help considerably in confining operational procedures to those recommended by the factory.

Two large motor carriers cited problems associated with drivers operating new trucks which are much quieter inside the cab. Drivers are used to hearing the engine and use this as an audio monitor. Specific instances were quoted where the engine had developed a mechanical problem but the driver continued driving resulting in extensive damage to the engine. It was the feeling of these motor carriers that noise reduction had presented them with another problem in the operation of vehicles.

5.3.6 Vehicle Maintenance

Actual Versus Factory

All the motor carriers within this program have Preventative Maintenance (P-M) schedules established and procedures for collecting driver comments on any vehicle problems. Medium duty and some heavy duty trucks used in local mountain areas had P-M schedules every 12,800 kilometers (7936 miles). Heavy duty vehicles ranged from 48,000 to 80,000 kilometers (29,760 to 49,600 miles) for their P-M schedules. One carrier using heavy duty vehicles uses 64,000 kilometers (39,680 miles) or one month as his inspection interval. All the P-M discussed above were compatible with factory recommended procedures.

Maintenance Performed Versus Noise Sensitive Components

A review of maintenance records at each test interval indicated only three types of noise sensitive component repair or replacement.

- Replacement of injector pump on a heavy duty diesel, no change in noise level.

- Replacement of muffler and exhaust pipe on medium duty gasoline engine truck. Accomplished just prior to measurement; no data to determine prior effects.
- Tightening of exhaust pipe connections; no measurable difference in noise level.
- Replacement of shift boot inside cab. The following Table summarizes the maintenance performed on each vehicle:

Table 5-12

Maintenance Summary

Vehicle Number	Maintenance Performed Which Might Affect Noise Sensitive Components
1	None
2	Exhaust Leak Repaired (208,000 Km), Replace Shift Boot (220,000 Km)
3	Replace Shift Boot (191,000 Km), Replace Flexible Exhaust Pipe (240,000 Km), Repair Exhaust Leak (240,000 Km)
4	None
5	Exhaust Repair (64,000 Km)
6	None
7	Replace Muffler and Tailpipe (27,000 Km)
8	None
9	None
10	None
13	None
14	None
15	Replace Injector pump
16	None
17	None
18	None
21	None
22	None
23	None
24	None
25	None
26	None
27	None
28	None
29	None
30	None

5.4 Component Tampering: Unlawful Modification, Removal or Replacement of Parts

An analysis of component tampering on a truck must take into consideration the concepts associated with truck purchasing. Trucks are purchased to perform an established task. This task will be defined by type of cargo, terrain, weather conditions, type of operation, the present type of trucks in service and the operator's prior experience. These constraints will then combine to determine the engine size and type, transmission, differential, exhaust system, intake system, fan drive and accessories such as air conditioning. The actual truck which is delivered to the motor carrier is a pre-selected vehicle with the desired components. It is not surprising to find, therefore, that most of the motor carriers contacted indicate no improper modification, removal or replacement of parts.

However, discussions with motor carriers did reveal the following types of acceptable component modifications or substitutions:

- Substitution of mufflers at the dealer to correspond with existing types used on the present fleet;
- Reduction of the governed RPM of the engine;
- Replacement of exhaust pipe clamps.

A review of the literature indicates that additional components which are sometimes added are turbochargers and engine noise covers, and different fan clutches are sometimes substituted for original equipment. However, no specific instances of these component additions or substitutions were reported with the vehicle operators cooperating in this program.

Decreasing the maximum RPM of the engine can reduce the noise level of the truck. Engine RPM is typically not changed for noise reduction purposes, but rather to enhance engine life and fuel economy. As noted earlier, the engine manufacturers specify a method of operation in which 3/4 to full throttle is recommended for maximum efficiency. Comments were received from some of the drivers indicating their displeasure with operating a vehicle de-rated to 1900 RPM from 2100 RPM. None of these drivers expressed any desire to try to readjust the RPM as they realize it is not a simple task with an injector pump. More importantly union regulations restrict them from working on the truck.

Exhaust leaks are sometimes reported by drivers. Other exhaust leaks show up during preventative maintenance checks. During this program exhaust gas leakage was documented through visual observation (see Section 5.2). When the trucks were subjected to noise testing, however, there was no indication that the noise level had increased. Most exhaust leaks were corrected by tightening clamps or installation of sheet metal sealing clamps during preventative maintenance checks.

Muffler Substitution Testing

The results of inquiries substantiated muffler substitution as a primary component in determining whether noise levels of the trucks were affected by the use of substitute components. Muffler manufacturers indicated that no problems with deterioration should be experienced for 160,000 kilometers (100,000 miles).

For three trucks, numbers 7, 40 and 41, muffler substitution testing was carried out under this program. Truck number 7 was one of the thirty trucks involved in the Total Vehicle Noise degradation program. Trucks number 40 and 41 were used only in the muffler substitution testing. These vehicle configurations were given earlier in Table 5-1. Vehicle No. 7 had already required a muffler replacement at 27,000 kilometers (16,740 miles).

Mufflers used in this substitution study were procured from truck parts stores by specifying the truck model and engine. Intentionally, in order to reflect industry practice, no efforts were made to use the guides published by muffler manufacturers in selecting the quietest muffler. The heavy duty mufflers were ordered by the owner of the vehicles. Note that none of the parts stores mentioned noise levels relative to muffler selection. Three to four different makes of mufflers were purchased for each vehicle configuration.

A stationary test was performed with vehicles number 40 and 41 to establish a baseline since they had not been one of the existing test vehicles in the noise degradation program. Noise measurements were performed in accordance with procedures outlined in Section 5.1.4.

Each new muffler configuration was then installed and a stationary test was repeated. Table 5-13 summarizes the results of these tests. It is worthwhile noting that one muffler specified by the suppliers catalog as being suitable, proved to be the wrong size and this could not be used.

The results of this muffler substitution testing can be summarized as follows:

- Aftermarket purchase of mufflers should be based on factory supplied hardware.
- Substitute mufflers can result in a noticeable increase in measured noise levels.
- In only one out of the 10 substitution tests did the replacement muffler result in lower noise levels than achieved with the factory muffler.
- Most motor carriers do not have any procedures for verifying the resulting noise levels after mufflers have been replaced.

Engine Noise Panel Removed

None of the vehicles utilized in the muffler substitution tests were equipped with removable side panels. These vehicles were all of the 1977 models and were not required to meet the EPA New Truck Noise Emission Standards. Hence, no data on the effect of side panel removal was obtained.

Table 5-13

Change in A-Weighted Noise Levels (L_A) in dB

Resulting from Muffler Substitution IMI Tests

Vehicle Number	Factory	Muffler Configuration				Maximum Increase (dB)
		Substitute 1	Substitute 2	Substitute 3	Substitute 4	
#7 Medium Gas V-8 28,000 Kilometers	79.9 (1)	79.7 (2)	82.5 (3)	Didn't Fit		+2.6
#40 Heavy Duty V-8 Diesel 4 Cycle Turbo 90,000 Kilometers	85.8 (4)	86.1 (5)	85.9 (6)	86.2 (7)	86.2 (8)	+0.4
#41 Heavy Duty V-6 Diesel 2 Cycle Turbo 54,000 Kilometers	81.7 (4)	81.9 (5)	84.9 (8)	80.4 (6)	83.5 (7)	+3.2

Muffler Manufacturers and Part Numbers:

(1) Not Available
(2) Maremount TDT 20 566
(3) Maremount KE 4118G
(4) Donaldson MPM09 0183F7
(5) Walker 22829
(6) Riker 43-003-001
(7) Heavy Duty A8 080074
(8) Stemco

5.5 Fan Clutch Evaluation

The fan clutch has become a very significant noise reduction component on heavy duty trucks within recent years. This is due primarily to the following:

- Fan clutch reliability has been dramatically improved resulting in increased confidence in the product by truck manufacturer and user;
- Test programs by various organizations have shown a definite fuel savings when fan clutches are used;
- The Interstate Motor Carrier Noise Regulation allows testing with the fan clutch in the off-mode.

In order to assess the impact of this retrofit device on reducing truck noise emissions, current information on fan clutch usage, acceptance, maintenance and projected usage has been compiled and reviewed. Results of this evaluation are presented in this section.

Published literature on fan clutch evaluation was acquired from three sources: International Harvester for Department of Transportation;[47] Wyle Laboratories for Motor Vehicle Manufacturers Association;[57] and Regular Common Carrier Conference Maintenance Committee cooperating with the Society of Automotive Engineers and the Department of Transportation.[3]

The results of the International Harvester study were presented in the EPA Background Document for New Truck Noise Emission Standards[40] and are the most comprehensive to date. Program objectives were to determine total fan-on time and noise significant fan-on time. No data were collected that would allow the determination of noise levels with the fan on and off. It was concluded that the significant fan-on time never exceeded 1 percent of the engine time. The "significant" fan-on time was defined as the time that the fan speed exceeds two-thirds of its maximum possible speed for a modulating type fan clutch and 1600 rpm for on-off clutches. Figure 5-44 graphically depicts the results of the International Harvester Test Program.

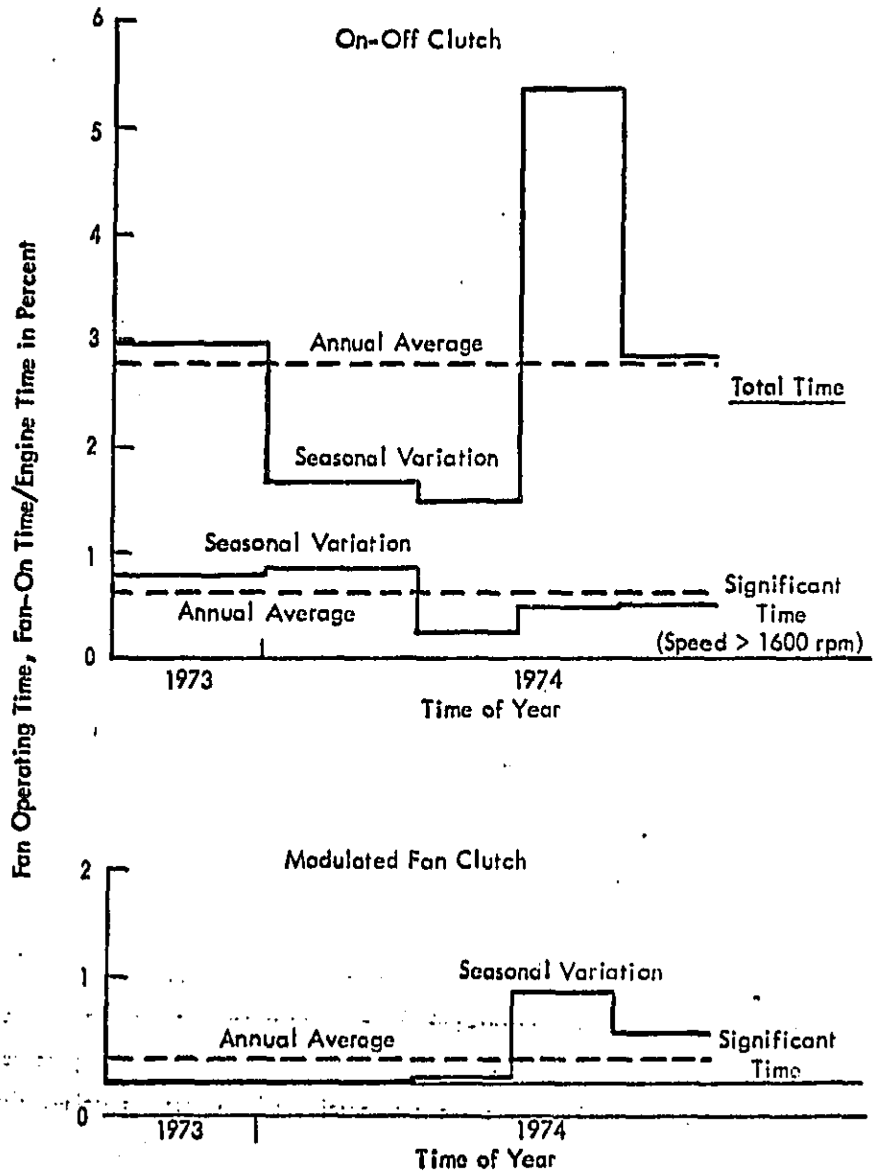

Figure 5-44. Fan Clutch Operating Time (Reference 47)

The data shown in Figure 5-44 were accumulated for the on-off clutches by using elapsed time meters on the engine and fan clutch. A multichannel tachograph was also used to monitor engine rpm and provide an event marker indicating clutch engagements. The top curve represents the total fan-on time as a percentage of engine-on time. The lower curve depicts fan-on time occurring above 1600 rpm, which is "significant fan-on time" by definition.

Data for the modulating type fan clutch were recorded on a strip chart recorder. Parameters recorded were engine rpm, fan rpm, coolant temperature and ambient temperature as a function of time. The "significant fan-on time" curve represents the time duration relative to the total engine (in percent) for which the fan speed exceeded two-thirds of its maximum possible speed.

Consideration must be given as to what total truck noise level was used in establishing the significant fan-on time. This IH project was completed in 1974. Figure 5-45, taken from the Background Document,[35] shows that 95 percent of the trucks manufactured in 1973 produced levels less than 88 dB, with the remaining 5 percent ranging up to 92 dB.

The typical heavy duty truck configuration in 1973 had two major noise sources: the cooling system (fan), and the exhaust. The trucks on which fan noise was the predominant noise source had direct driven fans. The fan drive ratios used ranged from 1.0 to 2.0, meaning that if, for example, the engine was rated at 2100 rpm, the fan speed range would be from 2100 to 4200 rpm depending on the drive ratio used.

Extensive component noise analysis performed during the DOT Quiet Truck Program resulted in data relating fan rpm to fan noise.[7,47,52] These results indicated that for those truck configurations where total vehicle noise ranged from 86 to 88 dB, fans operating at less than 1600 rpm would not be contributing to total truck noise. It was on that basis International Harvester used 1600 rpm in determining significant fan-on time for the fan clutch evaluation program.

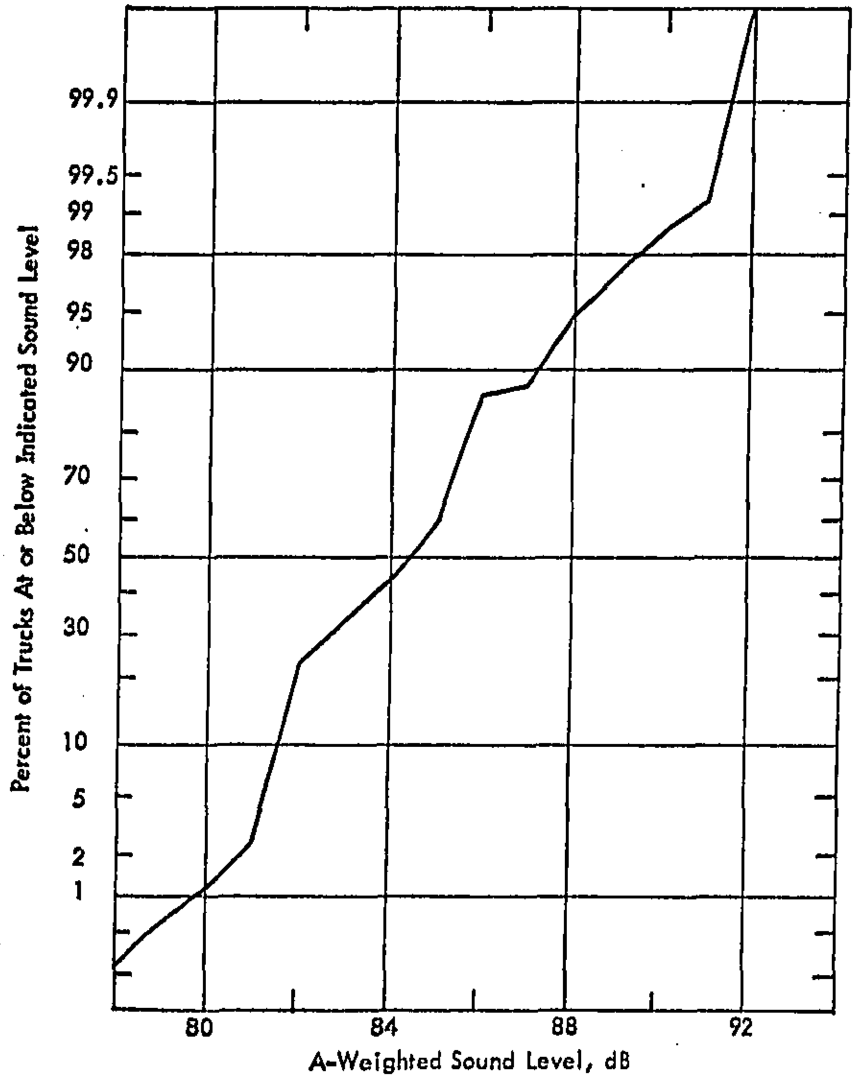

Figure 5-45. Cumulative Distribution of New Diesel Truck Noise Levels (Reference 35)

In order that fan noise has no influence on total vehicle noise, it must be 10 dB below the total truck noise level. Thus, it can be estimated that with a truck noise level of 86 dB in 1973, the fan noise level would be on the order of 76 dB. New 1978 trucks are required to meet an 83 dB level. Based on the 10 dB down criteria, the fan noise would be required to not exceed 73 dB. Fan noise varies approximately 1.6 dB per 100 rpm.[47] Therefore, in order that fan noise does not influence new truck noise levels, the new significant rpm would be 1400 rpm. This would indicate that significant fan-on time may be higher than one percent for present vehicles as shown in the International Harvester test results.

The study done by Wyle for the Motor Vehicle Manufacturers Association[57] indicated a fan-on time of 13.8 percent of engine-on time for summer, and 2.6 percent for winter. Seven of the eight fan clutches monitored were on-off type. No fan rpm measurements were recorded so it is not possible to assign a noise significant fan-on time to these data.

A Fuel Economy Demonstration study was performed in St. Louis by the Regular Common Carrier Conference Maintenance Committee in 1977. Fan on-time was not monitored, but fuel consumption testing with and without a fan clutch resulted in a 3.7 percent to 7.9 percent decrease in fuel consumption.

Seven of the major manufacturers of fan clutches were contacted under this study. Based upon discussions with these manufacturers, the following key observations can be made:

- Most of the fan clutch manufacturers have done testing by themselves or by some other organization such as RCCC and International Harvester. International Harvester, under the DOT Quiet Truck Program, tested 24 trucks with on-off and modulating type fan clutches.[47] One manufacturer indicated that they are in the process of setting up a lab for fan clutch noise testing.

- Manufacturer estimates as to the number of 1978 trucks equipped with fan clutches vary from 52 to 60 percent for Class VII and VIII trucks. Truck users estimate that 80 percent would be using fan clutches to meet the 1978 Interstate Noise Regulation.[3] Almost all the fan clutch manufacturers agreed that in 1982, approximately 90 percent of the Class VII and VIII trucks will be equipped with a fan clutch.

- Noise degradation as a result of in-service use of the truck fan clutch is very small. Most of the manufacturers agreed that there is not enough test data to prove or disprove that noise levels increase or decrease as the fan clutch is engaged.

- Noise reduction from 2 to 6 dB can be obtained by the use of fan clutches.

- Failure of the fan clutch system will cause an increase in noise levels. However, most of the manufacturers point out that the failure rate of the fan clutch is less than 1 percent. Failure usually occurs in the bearings, loss of viscous fluid, or air leaks in the clutch.

- All of the manufacturers pointed out that the fan clutch not only reduces noise but saves fuel from 5 to 12 percent. Therefore, fuel economy would be expected to be the dominant selling point for use of fan clutches.

Table 5-14 presents a summary of operational and noise data collected from the following manufacturers of fan clutches, not necessarily presented in the same order as shown in the Table: Horton, Schwitzer, Rockford, Evans, Eaton, Facet and Bendix.

Table 5-14

Summary of Operational and Noise Data Collected from Manufacturers of Fan Clutches

Manufacturer	Type of Fan	Time On %	Noise Reduction	Predicted % for Classes VII & VIII: 1978	Predicted % for Classes VII & VIII: 1982	Warranty Kilometers/Year	Failure %	Fuel Saving %
A.	Modulated	1.25	3-6 dB In-Cab	25-30	90		< 1	-
B.	On/Off	3.0	-	75	100		< 1	6-10
C.	On/Off	5.0	2 dB Exterior	55-60	95	All Have	0.9	12
D.	On/Off	5.0	-	-	-	160,000	-	10
E.	On/Off	1.0 2.0	3 dB Exterior	52	90	or More	-	10
F.	On/Off	5.0	-	-	-		-	5
G.	On/Off	-	-	-	-		-	5.33

Summary

The inputs received from the fan clutch manufacturers indicate a pronounced trend toward fan clutch usage on Class VII and VIII vehicles in the future. Test data indicate that fan-on time varies from 1 to 5 percent of engine-on time. The guarantees offered by the fan clutch manufacturers indicate their level of confidence in their products. The cost savings in fuel consumption seem to justify the use of fan clutches. These facts all apply to the existing truck which is required to meet an 83 dB noise level. The 1982 noise level of 80 dB may require more shielding on the vehicles and result in a higher percentage of on-time for fans. The significant on-time with regards to noise contribution to total vehicle noise by the fan will be dictated by individual designs.