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SOUND ATTENUATION KIT FOR DIESEL-POWERED BUSES

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JUNE 1976

FINAL REPORT

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16. Abstract

The Transportation Systems Center (TSC), on behalf of the U.S. Department of Transportation (DOT), initiated a project to assess, demonstrate and document the noise reduction potential of optimized commercially-available exhaust, intake, and fan subsystems on a typical diesel-powered city bus. These subsystems were to be retrofitable designs in current vehicle fleets while maintaining public safety and established vehicle exhaust emission regulations.

This report, in response to this effort, is intended to provide a reference for manufacturers, owners, and operators to consult for recommendations or instructions on installing a proven noise-reduction kit. It provides an insight into the causes of diesel-powered bus noise and demonstrates an effective means for its reduction.

Appendixes give standard noise measurement procedures, acoustic and performance test data on the various design configurations, and service information on sound attenuation kits.

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PREFACE

The authors would like to extend their appreciation to the Donaldson Company, Nelson Muffler and Riker Manufacturing Inc. for their help and advice with muffler systems, the Flex-a-lite Corporation for the supply of a cooling fan, H.L. Blachford, Inc. and Specialty Composites Corporation for their assistance with sound absorbing materials and the San Diego Transit Corporation for their co-operation and information regarding their own operations.

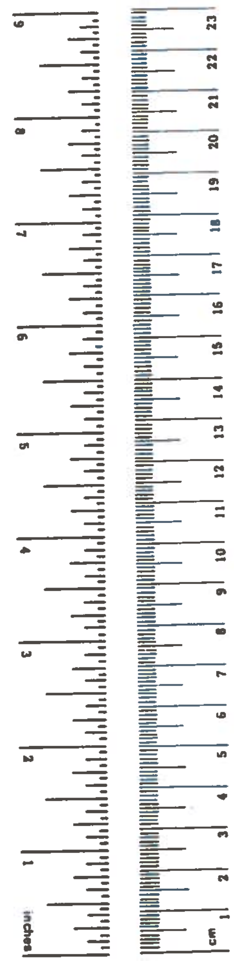
Thanks are also due to Mr. Robert Mason of the Transportation Systems Center for his help with the preparation of the report for publication.

The authors would also like to thank Mr. Paul Alstetes, our tireless driver/mechanic and Ms. Joan Kimmich for analyzing miles of recording tape.

METRIC CONVERSION FACTORS

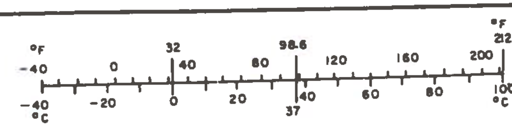
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ILLUSTRATIONS (CONTINUED)

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1/ INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This report is intended to communicate with the owner and/or operator of the nation's city bus fleets the results of a series of tests conducted on a "typical city bus." These tests were conducted on various configurations of engine exhaust, air induction, and cooling fan subsystems which are retrofitable to current and future vehicle fleets to reduce these subsystem noise levels.

The tests were designed to measure the noise levels produced by the bus when traveling in normal transit conditions with a full load of passengers and fuel. Maximum noise levels occur when the bus is accelerated at wide-open throttle up to the shift point between the converter and lock-up stage of the automatic transmission at approximately 30 mph. This condition was reproduced using the test procedure of SAE J366a. Typical cruise conditions were tested by constant speed passbys.

The bus was tested to establish a typical baseline to judge the effects of any modification. Baseline performance tests were also conducted to establish a reference point to check for any performance loss.

The vehicle was then tested with each individual component in the system being isolated, turned off, or removed. This allowed a compilation of data that indicated which items would yield the most noise reduction.

The Sound Attenuation Kits (SAK) used the best individual components or noise reduction techniques determined during the test program in order to produce two total retrofit packages. Testing of the kits included a series of SAE J366a accelerations, constant-speed passbys, stationary run-ups, and idle-max-idle tests, with the microphone at 3 feet and 50 feet from the vehicle. An additional test was also conducted to measure the noise level to which a pedestrian would be subjected if he were standing on the curbside as the bus pulls away from a bus stop. Performance tests were also conducted with the kits to record any changes in performance.

Kit installation time/motion studies were also conducted, along with a cost analysis, to ascertain the cost-effectiveness of retrofitting the kit to a production bus found in the fleet.

It is of special interest that large noise reductions were achieved early in the program simply by performing a routine maintenance procedure. The bus was first tested as delivered, after a cross-country drive from Loudonville, Ohio, and the SAE J366a acceleration passby noise level was 95 dB(A). Performing such actions as checking for loose bolts or fittings, tightening the latches on the engine access doors, lubricating the chassis, stopping all air leaks, and, most significantly, replacing a deformed tail pipe, resulted in a 12 dB(A) reduction.

Table 1-1 gives a brief outline of the results of the complete testing program.

TABLE 1-1

OUTLINE OF COMPLETE TESTING PROGRAM
RESULTS

SAE J366a TEST COACH @ GVWR - 27,000 LBS

	Noise Level at 50 Feet in dB(A)	
	Left Side	Right Side
Bus, as received	95	80
Bus, after maintenance and new bus baseline	83	78
SAK #1, prototype parts	80	76
SAK #2, prototype parts	77	75

1.2 BACKGROUND

The need for a quiet bus has long been a wish of both passengers and bystanders, but until recently little had been done or was known about bus noise emissions. During the early 1970's, several research studies provided background which led to a "Transit Bus Noise Control Feasibility Study", conducted by DOT in December of 1972. This feasibility study determined that specific techniques and individual components could be developed into a retrofit kit for installation on existing vehicles. Based upon the results of this feasibility study, a program was initiated to develop a bus noise-reduction kit that could be retrofitted to the current bus fleets. This report will detail the noise reduction kit.

2/ TEST VEHICLE

The bus used in this project was a 35-foot long, 96-inch wide, 45-passenger Flxible bus, manufactured in 1970. The bus was powered by a Detroit Diesel 6V-71, naturally-aspirated engine, using C60 injectors and an Allison VS-2-6 transmission. See Table 2-1 for complete bus specifications.

Although the test vehicle was selected as being a "typical" city bus, it actually represents an acoustic "worst case" of the Flxible buses. It is the shortest and narrowest of all models but has the highest gross vehicle weight rating (GVWR) per horsepower -- 28,000 lb./188 hp = 149 lb./hp. The 40-footlong, 102-inch wide bus with the 8 V-71 engine has a GVWR/hp ratio of 123 lb./hp.

The cooling subsystem on the test vehicle used a 26-inch diameter six-blade fan driven from the engine crankshaft through a thermostatically-controlled hydraulic coupling.

TABLE 2-1

BUS SPECIFICATIONS

Length	35 feet
Width	96 inches
Height with Air Conditioning	124.25 inches
Wheelbase	225 inches
Track: Front	79.25 inches
Rear	70.50 inches
Turning Radius:	
Wheel - right and left	354 inches
Body Corner - right and left	410 inches
Tire Size	12.50 x 22.5
Fuel Tank Capacity	95 gallons
Cooling System Capacity (including heater)	92 quarts
Electrical System	12 volt
Engine Oil Capacity (crankcase)	30 quarts
Converter Oil Capacity	8 gallons
Air Conditioning System:	
Oil in Compressor	7 pints
Freon 22	33 pounds
Axle Ratio	4.71
Engine Data	
Engine Model	6V71
Displacement	426 cubic inches
Bore	4.25 inches
Stroke	5 inches
Compression Ratio	18.7:1
Fuel Injectors	C-60
Maximum Governed Speed	2100 rpm
Firing Order	1L, 3R, 3L, 2R, 2L, 1R

The engine, transmission, and radiator were all rubber mounted on a frame which is itself rubber mounted to the rear understructure of the coach, providing two levels of vibration isolation.

The tires were of the regroovable retread design* which has a simple zigzag or sawtooth tread pattern with few sipes and were approximately 20% worn. These represent typical retread bus tires. The normal procedure was to warm up the tires prior to any testing. The warm-up procedure was found necessary to eliminate the periodic vibration caused by flat spots typically present on cold tires.

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* Design Designation per Truck Tire Noise Report P.B. 204-188.

3/ TEST SITE

3.1 ACOUSTIC TEST SITE

The Rohr acoustic test site is laid out in accordance with Section 3, and Figure 1 of SAE-J366a. The site is a rarely-used cul-de-sac, Quay Street, located between the Rohr Industries main plant in Chula Vista and San Diego Bay.

The Quay Street test site is ideal for acoustic testing because of the even temperatures and the normally low-speed wind conditions. The road surface is smooth asphalt, 35 feet wide with a 9-inch high concrete curb at the eastern edge. There are no sidewalks and the surrounding ground is flat, hard-packed and with sparse, short vegetation and free of any large reflecting surfaces. The road surface was marked with the microphone point and the end zone boundaries. Two microphone locations were established, one at each side of the road and 50 feet from the centerline of the vehicle path.

Tests of interior noise levels with the vehicle stationary and the wide-open throttle (WOT) accelerations were also carried out at the

Figure 3.1-1. Acoustic Test Site

Quay Street site. Constant speed tests were measured over a fixed route on smooth asphalt streets near the plant.

3.2 ACCELERATION TEST SITE

The acceleration test site was established at the Border Field State Park located in the most southwestern part of the United States. This park is an unimproved state park which contains a good, smooth asphalt service road. The service road to the park was blocked off and used for testing the bus. Like the Quay Street test site, the fair weather and level, beach-front terrain provided excellent test conditions.

4/ TEST CONDITIONS

All testing was carried out under prevailing ambient weather conditions. No extremes of temperature were experienced during the test series, and measurements were rarely interrupted by precipitation.

The main cause of test interruptions was excessive wind. The bulk of the measurements were made in the morning before the onset of the daily on-shore ocean breeze. Although the wind velocity limit was set at 12 mph in the test plan (as per SAE recommendations), it was found that this limit is acceptable only for measurements made on the A scale of the sound level meter and that winds of only 5 mph can affect measurements made with a flat frequency response. As a compromise, measurement and recordings of all tests except the SAE accelerations were made via the C scale of the sound level meter which attenuates the very lowest of wind-induced frequencies. Also, the lower frequency band noise levels were treated with some reserve when wind noise was known to be present.

The ambient noise level in the area was normally 45 dB(A) on a calm day, caused mainly by the steady traffic flow on Interstate Highway 5, one-half mile distant. Levels of 50 dB(A) were typically measured on days when the wind was blowing on-shore at 10 mph. Octave band analyses and overall A-weighted sound levels for a calm day and a windy day are shown in Figure 4-1. Any recordings containing unwanted aircraft noise or other disturbances were discounted.

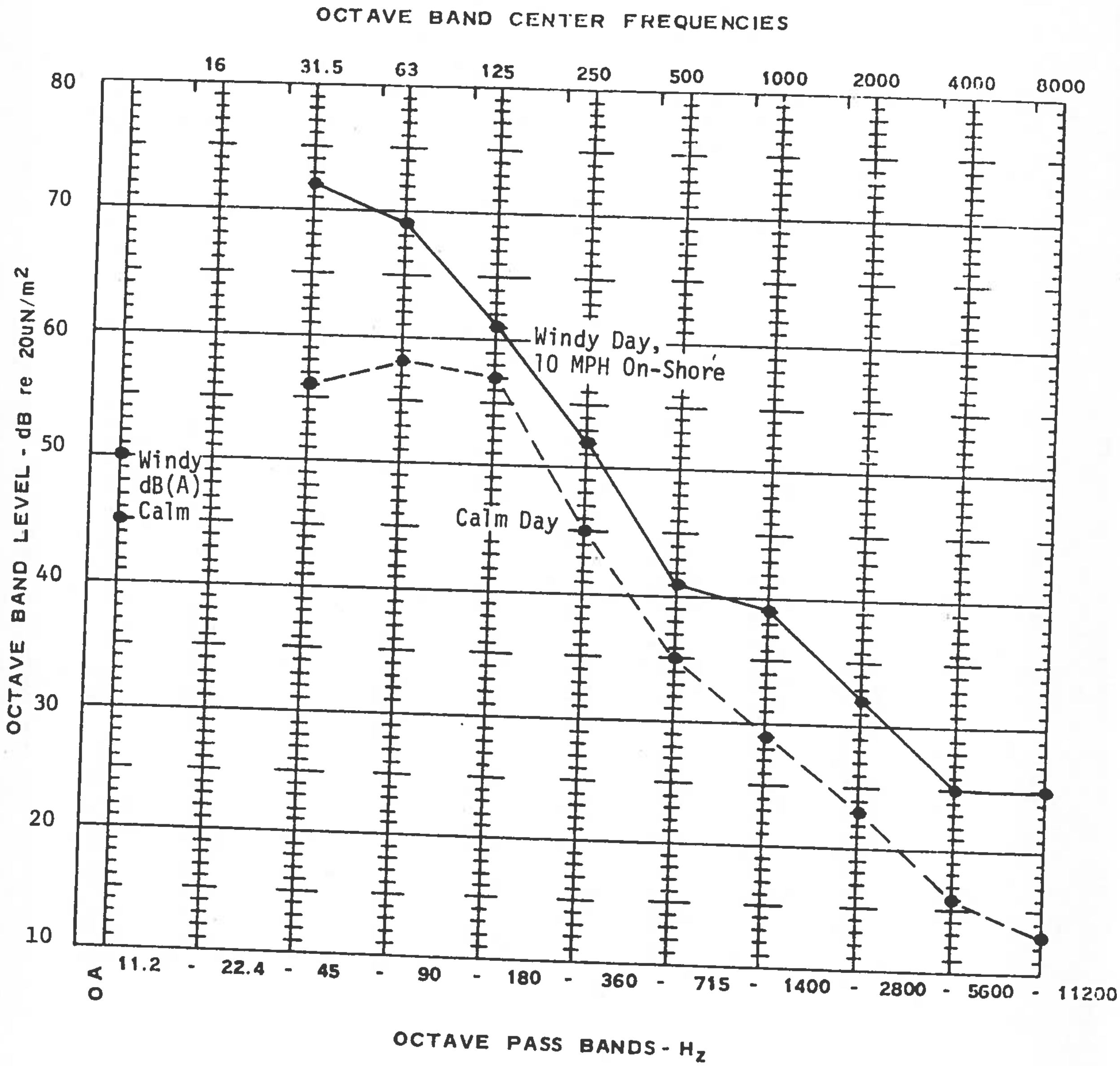

Figure 4-1. Typical Test Site Ambient Sound Level

5/ TEST EQUIPMENT

The following equipment was used for the measurements required.

5 .1 ACOUSTIC EQUIPMENT

5 .1.1 Fixed Facility Equipment

A. Bruel and Kjaer Audio Frequency Spectrometer, Type 2112, with 1/3 octave band analysis capability

B. Bruel and Kjaer High-Speed Level Recorder Type 2305

C. Spectral Dynamics Real Time Analyzer Type SD310D with ensemble averager Type 309

5 .1.2 Portable Equipment

A. Bruel and Kjaer Precision Sound Level Meter Type 2203, which meets the ANSI S 1.4-1971 and IEC 179 requirements for Type 1 meters. Accessories for the sound level meter included a microphone extension cable, an adjustable tripod, a wind screen for the exterior measurements, and a random incidence corrector for interior measurements.

B. Kudelski Nagra Tape Recorder IV-S which, when used in conjunction with the sound level meter, meets the overall system frequency response specified in SAE J 184.

C. Bruel and Kjaer Octave Band Filter Set Type 1613, which meets the ANSI S-1-11-1971 requirements for Class II filters.

D. Dwyer Wind Meter

5.2 PERFORMANCE EQUIPMENT

5.2.1 Fixed Facility Equipment

A. Taylor 800 Horsepower, 3-roll chassis dynamometer and associated auxiliary instrumentation for continuously monitoring horsepower, torque, speed, fuel flow, RPM, back pressure, and temperature

5.2.2 Portable Equipment

A. Honeywell "Electronik 16," 24-channel thermocouple recorder with thermocouples and wiring

B. Honeywell "Visicorder" Model 1508A, with two, seven-channel accudata amplifiers

C. AVNOR Model 6006A volometer

D. Two Auto Meter Series 730 Tachometers with Series 701 sender generators and appropriate ratio cartridges

E. Weston Model 750 Fifth Wheel with Digital Mileage Recorder and Displacement Needle Speedometer

6/ TEST PLAN AND PROCEDURES

6.1 TEST PLAN

This noise control program was performed to provide operators of city buses, with detailed and tested vehicle modification instructions to enable them to reduce noise emissions from their fleets while maintaining established standards of vehicle safety and exhaust emissions.

Specifically, the program accomplished the following:

1. Determined the level and spectral content of noise emissions from the total vehicle including the engine, exhaust, cooling fan, and air-induction subsystems.
2. Provided tested, retrofitable designs to reduce these subsystem noise levels
3. Determined the effect of these designs on overall vehicle noise levels and vehicle performance, including operation costs
4. Published and disseminated to vehicle operations and purchasers, vehicle modification instructions and information regarding the side effects of such modifications.

The basic test plan subjected the coach to a series of baseline tests including noise level, acceleration, top speed, gradeability, and cooling tests.

A series of noise component identification tests were then performed and various noise-reduction modifications made. After an extensive series of tests were completed and an analysis of the data obtained, a selection of the most effective modifications was made and a retrofit kit constructed, installed, and tested.

6.2 TEST PROCEDURES

In order to verify that the modifications made to the vehicle did not adversely affect the performance of the vehicle, a series of performance tests were also conducted.

Tests were carried out according to the document, "Test Plan - Evaluation of Sound Attenuation Kit - Flxible Bus," (see Appendix) with the following exceptions:

A. Paragraph 3.1: The engine revolution rates used were 75%, 85%, and 95% for both the constant speed passby and stationary conditions. It was found that 100% passby condition could not be achieved because the transmission shifted up during the run and could not be locked into low gear. 95% was found to be satisfactory and the other speeds were adjusted accordingly at 10% intervals.

B. Paragraph 5.0 (b): The air intake system was an optimum system; therefore, except where noted, no alterations were made to it.

C. Additions to the testing were as follows:

1. For evaluations of radiator cooling fan noise, some measurements were made 3' from the center of the radiator grill.

2. At a distance of 50' and with the bus stationary, some idle-max-idle tests were made according to a proposed SAE procedure. In this test, the throttle is rapidly opened wide and then immediately closed so that the engine will run quickly up to governed speed and then return to idle. These measurements may be compared with the normal SAE J366a acceleration tests.

3. The microphone was placed 2' from the rear door in the position of a newly-alighted passenger, the bus then being accelerated away at wide-open throttle. These measurements have been called "curbside pullaways".

7/ NOISE SOURCES - GENERAL

7.1 DESCRIPTION OF MAJOR NOISE SOURCES

Work was concentrated on reducing the magnitude of the major bus noise sources.

7.1.1 Engine Mechanical Noise

The engine in the test vehicle was a Detroit Diesel 6V71, two-cycle diesel engine operating between an idle speed of 500 rpm and a maximum governed speed of 2100 rpm. The critical rotational frequencies of the crankshaft, therefore, vary between 8 1/2 and 35 Hz. At the normal test speeds of 75%, 85%, and 95% of maximum, the rotational and firing frequencies were 26, 29, and 33 Hz and 157, 178, and 199 Hz, respectively. On occasions, the engine firing frequency exhibits strong second harmonic content.

The magnitude of the crankshaft-generated noise levels is dependent upon such parameters as the balance of the shaft, end float, and condition of the bearings. Also critical, especially at lower speeds, is the type and condition of the engine anti-vibration mounts. Because the wavelength of sound in the 8 1/2 to 35 Hz range is approximately 100 to 300 feet, it is difficult for the engine itself to radiate these frequencies, but if the energy is coupled to the bus structure through engine mounts, the low frequency becomes apparent because of radiation through the body.

The engine firing frequency can be radiated more easily by the engine structure but is not usually apparent due to excessive noise from engine air inlet and exhaust systems.

Diesel "knock" usually occurs in the mid-frequency range, say 500 to 2000 Hz. It is caused by mechanical excitation of the whole engine structure by the sudden gas pressure rise and high compression explosion within the cylinders. It is easily radiated into the air, especially from thin, metal sidewalls and covers.

7.1.2 Air Intake Noise

Air intake noise is a mixture of two sources: the engine firing frequency and intake valve noise passing out through the intake system; and restricted flow, causing broad band turbulent air noise.

7.1.3 Exhaust Noise

Once again, exhaust noise has two basic components, the major one being the engine firing frequency as the hot gases are rapidly released through the exhaust valves into the muffler system. If the exhaust pipes are of small diameter or the engine is operating at high power settings, jet noise may also be noticeable.

7.1.4 Radiator Cooling Fan Noise

Cooling fan noise is dependent upon a number of factors. The blade passage frequency is controlled by the speed of rotation and the number of blades. The magnitude of the blade noise and that of the turbulent air passing through the radiator is controlled by blade size, angle, tip speed, tip clearance, spacing of the fan to the radiator, type of fan shroud, and the position of any obstructions in the air flow path.

7.1.5 Transmission Noise

Transmission noise is controlled by the quality of the gears, shafts, and bearings. Vibrations within the transmission may be radiated by the casing unless it is suitably damped. Normally, the transmission is not a major source of noise and will only become significant if the unit is badly maintained or excessively worn.

7.1.6 Aerodynamic Noise

Aerodynamic noise is a function of the design of the vehicle and its speed. Most buses are "blunt-ended" and have a number of appendages which can cause whistles and howls. However, this is not considered to be a major noise source.

7.1.7 Tire Noise

Tire noise is not part of the scope of this program and will not be discussed.

7.1.8 Air Conditioning Noise

The problem of air conditioning noise was not addressed during this program.

7.2 TREATMENT OF NOISE SOURCES

7.2.1 General Philosophy

Although this was basically a research and development program, the thrust of the effort was to make the modifications as practical as possible, bearing in mind manufacturing cost, materials, and impact on vehicle maintainability. Therefore, efforts were concentrated on replacing existing items with acoustically-superior units and adding extra treatment only where necessary.

7.2.2 Engine

Total encapsulation can provide the greatest reduction in noise generated by the engine and its auxiliaries. Experimental enclosures have reduced radiated engine noise by between 10 dB(A) and 20 dB(A). However, the effect on the total system noise reduction depends upon the contribution of the other components, and tests have shown that the total reduction is generally less than 10 dB(A) when an engine capsule is used. In addition, total encapsulation causes difficulties by increasing the cost, weight, engine cooling problems, and maintenance interference.

A specially-designed engine capsule was not attempted on the Rohr test vehicle. However, by using existing parts of the bus structure, e.g. the hood, engine compartment sidewall, and forward bulkhead, and adding sheet metal at the left-hand end, underneath, and on top of the engine, it was possible to construct a compartment within a compartment which enclosed the engine, transmission, air compressor, and several other small auxiliaries. This compartment was fully lined with acoustically-absorbent material.

This technique did achieve a good measure of sound attenuation but as expected, the engine quickly overheated and testing with this configuration was discontinued.

One of the worst components for radiating valve noise and diesel knock were the valve rocker arm covers which were made from thin pressed steel. These covers were replaced by parts made from a non-resonant metal/plastic/metal laminate.

7.2.3 Engine Air Intake System

The test vehicle was already fitted with a very good air intake system. Air was drawn in through vents on either side of the coach at the rear roofline and down into a plenum chamber. It then passed through an oil bath type air cleaner and a resonator silencer before entering the engine. Test runs were made with the air cleaner and resonator removed and also with a dry type air cleaner installed. As a result of these tests it was decided that the system was acoustically optimized and that further modification was not justified for the sound attenuation kit program.

7.2.4 Engine Exhaust System

The approach regarding the exhaust system was to contact major suppliers of mufflers and resonators and ask them to improve the acoustical performance of the system. It was felt that the existing system might be deficient in three areas:

A. The muffler was a single shell type which tended to radiate noise through its own structure. This was proved by wrapping the muffler in asbestos and lead-faced acoustic foam and noting the reduction in noise levels.

B. The exhaust pipe system was 3 inches in diameter, which gave rise to "jet" noise at high engine power settings. The effect of restricting the exhaust pipe was dramatically demonstrated when the first baseline measurements were performed and the SAE J 366a acceleration passby yielded a level of 95 dB(A). This was known to be far too high and an examination of the bus revealed that the exhaust tail pipe had been damaged and was crimped. A new tail pipe was installed and the passby noise level dropped to 84 dB(A). With this experience, it was felt that in order to reduce jet noise and back pressure, the exhaust tail pipe diameter should be increased to 4 inches.

C. The system had no resonator and thus could not be fully efficient in reducing engine firing frequency pulses.

Many different configurations were tested -- both single and dual mufflers, with and without resonators, and with exhaust pipes of different diameters and different lengths.

Other models of the Flxible bus have a vertical tail pipe, exhausting at roof level. The test vehicle did not have provision for this modification. However, the effects of a vertical pipe were tested by mounting it externally on the left rear corner of the bus, thus enabling the kits to be effective on buses which are equipped with the vertical tail pipe system.

7.2.5 Radiator Cooling System

This is one of the most difficult noise sources to treat on any vehicle. Ideally, the solution would be to increase the size of the radiator and the fan and to slow down the revolution rate. Additionally, the fan can be made more efficient by correct radiator-to-fan spacing and full venturi-type shrouding. The test vehicle came with a 26-inch diameter, 6-bladed fan inside a square box shroud. It was determined that the radiator-to-fan spacing was optimized and that the only modifications possible were to contour the shroud, enclose the fan blade tips, and develop a means for obtaining a minimum fan blade tip clearance.

The ever-present problem was that every configuration tried which attempted to stop noise leaking from the engine compartment (such as enclosures, engine underpans, or other sound barriers) caused engine overheating and made the fan run at full engine speed all of the time. Finally, the policy was adopted to remove as many obstructions to the airflow as possible and make the fan as efficient as possible.

Alternative fans supposedly quieter and more efficient were tested during the program, but proved to be ineffectual.

7.2.6 Transmission Noise

An attempt was made to isolate the transmission noise but this was unsuccessful. However, the importance of having a well-maintained transmission in order to minimize noise was accidentally but graphically illustrated during the program and is discussed in section 7.2.9 - Prevention of Noise by Maintenance.

7.2.7 Aerodynamic and Tire Noise

Aerodynamic and tire noise was not a problem during the tests because the vehicle speed was kept below 30 mph.

7.2.8 Engine Compartment Acoustical Treatment

With the failure of the engine encapsulation, the next logical step seemed to be to use the entire engine compartment as an acoustical enclosure by blocking up as many holes as possible and providing sound-absorbent materials inside the compartment. In addition, it was felt that thin metal panels such as the hood and sidewalls required an increase in their sound transmission loss. Accordingly, complete underpans were fitted, all holes, slots, and gaps were filled or sealed (where practical), and the hood and other hatches were made to fit snugly against rubber seals. Acoustical material was fitted to the inside of the hood and on any other available surfaces. This material consisted of an impervious, mylar-faced acoustical foam absorption layer, a flexible septum, and an isolation layer. A number of materials were studied and two configurations were tested. Both had 1" thick acoustical foam absorption layer and a 1/4-inch thick isolation layer. One material had a partially-adhered mylar facing and a lead septum, the other had a totally-adhered aluminized mylar facing and a loaded urethane septum. Both materials proved satisfactory; but for maintainability, durability, and appearance, the totally-adhered facing was chosen for the sound attenuation kit.

The only major opening now remaining in the engine compartment was the radiator. The standard radiator grille was an expanded metal grille with a high percentage of open area. During the program, two methods were tried to reduce noise coming out via the radiator grille. The standard grille was first replaced by an inverted V non-line-of-sight louver and secondly, a forward-facing air scoop was installed. As with the engine capsule, however, the overheating problem and consequent cooling fan noise became a serious problem using the above approaches. It was decided to use only the absorption/barrier material on the compartment surfaces and a line-of-sight barrier between the engine and the radiator opening.

7.2.9 Prevention of Noise by Maintenance

It is most important to keep the vehicle well maintained in order to minimize noise. For example, loose bolts and fasteners can cause the body to creak and rattle and suspension components to bang. Loose pipe clamps can cause excessive exhaust or intake noise. Lubrication is vitally important and all rotating machinery should be regularly checked for incorrect or abnormal operation. All anti-vibration mounts, especially those on the engine and sub-frame, must be inspected regularly for failure.

Unwanted sounds can be a warning of impending failure. For example, during the program the test vehicle developed what was described as a "chirp" in the transmission during the SAE J 366a acceleration tests. Maximum noise levels occured in the end zone just as the transmission shifted out of the converter range into lockup and the "chirp" raised the noise levels some 2 dB(A) over a normally quiet shift. Later, the transmission failed. After repair the "chirp" disappeared and subsequent gear shifts were smooth and quiet.

8/ TEST CONFIGURATIONS

The following sections briefly describe the test configurations. Because of the "cut-and-try" method used during the program, there is not always a logical sequence to the events indicated by the configuration numbers. The description does not always give full details of how the bus was configured, but rather indicates which component or area was being investigated at the time. For more details of the configurations, see Table 8-1.

8.1 BASELINE

Bus, as delivered. Bare engine, standard radiator grille, standard Nelson muffler with 3-inch diameter pipes, oil bath air cleaner, and inlet resonator, engine underpan covering the L.H. side of the engine compartment.

8.2 FIRST-STAGE ENGINE ENCAPSULATION

Partial steel capsule around the engine. Everything else standard.

8.3 SECOND-STAGE ENGINE ENCAPSULATION

One inch thick fire-retardant acoustical foam with a 1 lb/ft^2 lead facing was

TABLE 8-1. CONFIGURATIONS TESTED

VEHICLE CONDITION	ENGINE CAPSULE	SOUND ABSORBING MATERIAL	MAIN RADIATOR GRILLE	SMALL RADIATOR GRILLE	UNDER PANS	MUFFLER	RESONATOR	TAIL PIPE	VALVE COVERS	AIR INLET SYSTEM	RADIATOR COOLING FAN	COOLING FAN SHROUD	OTHER
Baseline 1	No	No	Std	Open	Std	Std Nelson	No	Std	Std	Std	Automatic Operation	Std	
1st Stage Capsule	Yes	No	Std	Open	Std	Std Nelson	No	Std	Std	Std	Auto	Std	
2nd Stage Capsule	Yes	On Capsule	Std	Open	Std	Std Nelson	No	Std	Std	Std	Auto	Std	
2-Final Capsule	Yes	On Capsule & Eng. Compt.	Std	Open	Full Width	Std Nelson	No	Std	Std	Std	Auto	Std	
3*	Yes	"	Std	Blocked	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	Muffler wrapped in Asbestos and Lead
3	Yes	"	Inverted V Louver	Blocked	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	"
3a	Yes	"	Std	Blocked	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	"
3b	Yes	"	Inverted V Louver	Open	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	"
3c	Yes	"	Inverted V Louver	Blocked	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	Muffler unwrapped
4	No	In Eng. Compt.	Std	Open	Full Width & under muffler	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	
5	Tunnel Open at Both Ends	On Tunnel & Eng. Compt.	Std	Open	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	
5a	"	"	Inverted V. Louver	Blocked	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	
5b	"	"	Std	Blocked	Full Width	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	Plain access panel on right side of bus replaced by Inverted V Louver
6	"	"	Std	Blocked	Full Width & under muffler	Std Nelson	No	Vert. Roof Level	Std	Air Cleaner Replaced by Plain Pipe	Auto	Std	
7a	No	In Eng. Compt.	Std	Open	"	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	Absorption in Engine Compt. was 1" thick foam with lead facing.
7b	No	In Eng. Compt.	Std	Open	"	Std Nelson	No	Vert. Roof Level	Std	Std	Auto	Std	Absorption increased to 2" depth with addition of Mylar faced foam

TABLE 8-1 CONFIGURATIONS TESTED (CONTINUED)

VEHICLE CONDITION	ENGINE CAPSULE	SOUND ABSORBING MATERIAL	MAIN RADIATOR GRILLE	SMALL RADIATOR GRILLE	UNDER PANS	MUFFLER	RESONATOR	TAIL PIPE	VALVE COVERS	AIR INLET SYSTEM	RADIATOR COOLING FAN	COOLING FAN SHROUD	OTHER
7c	No	As 7b	Standard	Blocked	Full Width & under Muffler	Standard Nelson	No	Vertical Roof Level	Standard	Standard	Locked On	Standard	
7d	No	As 7b	Standard	Blocked	"	Standard Nelson	No	Vertical Roof Level	Standard	Standard	Locked On	Standard	Transmission & Air Compressor Wraped in Lead-Faced Foam
7e	No	As 7b	Standard	Blocked	"	Standard Nelson	No	Vertical Roof Level	Standard	Standard	Locked Off	Standard	"
7f	No	As 7b	Standard	Blocked	"	Standard Nelson	No	Vertical Roof Level	Standard	Standard	Locked Off	Standard	Transmission Wrapped in Lead-Faced Foam
7g	No	As 7b	Standard	Blocked	"	Standard Nelson	No	Vertical Roof Level	Standard	Standard	Locked Off	Standard	Air Compressor Wrapped in Lead-Faced Foam
8a	No	As 7b	None	Blocked	"	Standard Nelson + Donaldson	No	Standard	Standard	Standard	Locked On and Off	Standard	Forward-Facing Air Scoop Fitted Over Radiator Aperture. Also, the two mufflers were placed in series.
8b	No	As 7b	Standard	Blocked	"	"	No	Standard	Standard	Standard	Locked Off	Standard	
9a	No	As 7b	Standard	Blocked	Full Width	New Dual Nelson	No	Dual	Standard	Standard	Auto	Contoured	
9b	No	As 7b	Standard	Blocked	Full Width	New Dual Nelson	No	Dual	Standard	Standard	Locked On	Contoured	
10a	No	As 7b	Standard	Blocked	Full Width	New Dual Riker	No	Dual	Standard	Standard	Locked On	Contoured	
10b	No	As 7b	Standard	Blocked	Full Width	New Dual Riker	No	Dual	Standard	Standard	Auto	Contoured	
11a	No	As 7b	Standard	Blocked	Full Width	New Dual Donaldson	No	Dual	Standard	Standard	Auto	Contoured	
11b	No	As 7b	Standard	Blocked	Full Width	New Dual Donaldson	No	Dual	Standard	Standard	Locked Off	Contoured	
12a	No	As 7b	Standard	Blocked	Full Width	New Nelson	No	Standard 4-inch	Standard	Standard	Locked Off	Contoured	
12b	No	As 7b	Standard	Blocked	Full Width	New Nelson	Donaldson	Standard 4-inch	Standard	Standard	Locked Off	Contoured	
13	No	As 7b	Standard	Blocked	Full Width	New Dual Nelson	Donaldson	Standard 4-inch	Standard	Standard	Locked Off	Contoured	

TABLE 8-1 CONFIGURATIONS TESTED (CONTINUED)

VEHICLE CONDITION	ENGINE CAPSULE	SOUND ABSORBING MATERIAL	MAIN RADIATOR GRILLE	SMALL RADIATOR GRILLE	UNDERPANS	MUFFLER	RESONATOR	TAIL PIPE	VALVE COVERS	AIR INLET SYSTEM	RADIATOR COOLING FAN	COOLING FAN SHROUD	OTHER
14	No	As 7b	Standard	Blocked	Full Width	New Donaldson	Donaldson	Standard 4-inch	Standard	Standard	Locked Off	Contoured	
14a	No	As 7b	Standard	Blocked	Full Width Plus Muffler & Drive Shaft	New Donaldson	Donaldson	Standard 4-inch	Standard	Standard	Locked Off	Contoured	
14b	No	As 7b	Standard	Blocked	"	New Donaldson	Donaldson	Standard 4" Exhausting Rearwards	Standard	Standard	Locked Off	Contoured	
14c	No	As 7b	Standard	Blocked	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked On and Off	Contoured	
14c-1	No	Alternative	Standard	Blocked	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked On and Off	Contoured	
14d	No	As 7b	Standard	Blocked	"	New Donaldson	No	"	Isolated	Standard	Locked Off	Contoured	
14e	No	As 7b	Standard	Blocked	"	New Donaldson	No	"	Isolated	Dry Air Cleaner	Locked Off	Contoured	
15	No	As 7b	Standard	Blocked	"	New Donaldson	Nelson	"	Isolated	Standard	Locked Off	Contoured	
16	No	Alternative	Standard	Blocked	3/4 Width Plus Muffler & Drive Shaft	New Donaldson	Donaldson Wrapped	"	Isolated	Standard	Locked Off	Contoured	
16a	No	As 16	Standard	Blocked	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked Off	Contoured	
17	Partition Left Side	As 16	Standard	Blocked	"	New Donaldson	Donaldson	"	Isolated	Standard	Variable	Contoured	
18	Partition Left Side	As 16	Standard	Open	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked On	Contoured	
18a	Partition Left Side	As 16	Standard	Open	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked Off	Contoured	
18b	Partition Left Side	As 16	Inverted V Louver	Open	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked Off	Contoured	
18c	Partition Left Side	As 16	Inverted V Louver	Open	"	New Donaldson	Donaldson	"	Isolated	Standard	Locked On	Contoured	
19	No	As 16	Standard	Open	No	New Donaldson	Donaldson	"	Standard	Standard	Locked On	Standard	

TABLE 8-1 CONFIGURATIONS TESTED (CONTINUED)

VEHICLE CONDITION	ENGINE CAPSULE	SOUND ABSORBING MATERIAL	MAIN RADIATOR GRILLE	SMALL RADIATOR GRILLE	UNDERPANS	MUFFLER	RESONATOR	TAIL PIPE	VALVE COVERS	AIR INLET SYSTEM	RADIATOR COOLING FAN	COOLING FAN SHROUD	OTHER
19a	No	As 16	Standard	Open	No	New Donaldson	Donaldson	Standard 4" Exhausting Rearwards	Standard	Standard	Locked Off	Standard	
19b	No	As 16	Standard	Open	No	New Donaldson	Donaldson	"	Isolated	Standard	Locked Off	Standard	
19c	No	As 16	Standard	Open	Standard	New Donaldson	Donaldson	"	Standard	Standard	Locked Off	Standard	
19d	No	As 16	Standard	Open	Standard	New Donaldson	Donaldson	Standard 4-inch	Standard	Standard	Flex-a-Lite Locked On and Off	Contoured	
19e	No	As 16	Inverted V Louver	Open	Standard	New Donaldson	Donaldson	Standard 4-inch	Standard	Standard	"	Contoured	
19f	No	As 16	Standard	Open	Standard	New Donaldson	No	Standard 4-inch	Standard	Standard	Standard Locked Off	Standard	
19g	No	No	Standard	Open	Standard	New Donaldson	No	Standard 4-inch	Standard	Standard	Locked Off	Standard	
19h	No	No	Standard	Open	Standard	New Donaldson	Donaldson	Standard 4-inch	Standard	Standard	Locked Off	Standard	
2nd Baseline	No	No	Standard	Open	Standard	Standard Nelson	No	Standard 3-inch	Standard	Standard	Locked On and Off	Standard	
Kit #1	No	Alternative	Standard	Open	Full Width	New Donaldson	Donaldson	Standard 4-inch	Isolated	Standard	Locked On and Off	Standard	
Kit #1	No	"	Standard	Open	No	New Donaldson	Donaldson	Standard 4-inch	Isolated	Standard	Locked Off	Standard	This is final Kit #1 configuration.
Kit #1	No	"	Standard	Open	No	New Donaldson	Donaldson	Vertical Roof Level	Isolated	Standard	Locked Off	Standard	
Kit #2	Partition Left Side	"	Standard	Open	No	New Donaldson	Donaldson	Standard 4-inch	Isolated	Standard	Auto	Contoured	

added to the interior of the steel capsule. Everything else standard.

8.4 THIRD-STAGE ENGINE ENCAPSULATION

At this stage the engine was fully enclosed by the steel capsule, the hood, left side of the bus, and the passenger bulkhead. In addition, a full-width underpan was installed and as many holes and joints as possible were sealed. All available surfaces in the engine compartment were treated with 1-inch thick acoustic foam with a strip adherred Mylar facing.

8.5 "FULL TREATMENT"

In addition to the items listed in Section 8.4, the small grille below the main radiator grille was blocked, the muffler was wrapped in asbestos and lead-faced foam, and the tail pipe was extended vertically to exhaust at roof level. In order to determine the effect of certain items of the full treatment, these tests were performed:

1. The inverted V radiator grille was removed and the standard grille reinstalled
2. The small grille below the main radiator grille was unblocked
3. The muffler was unwrapped

8.6 FULL TREATMENT WITHOUT ENGINE CAPSULE

The steel capsule and its attached acoustic treatment were completely removed and the standard radiator grille was fitted; otherwise, the conditions were similar to Section 8.6.

8.7 MODIFIED ENGINE CAPSULE (TUNNEL)

The engine capsule was modified to try and achieve better airflow.

A tunnel was constructed from the radiator fan shroud to the right-hand end of the engine. The radiator grille was standard and the muffler was not wrapped. Some variations on modified engine capsule are:

A. Left side of the bus: The inverted V radiator grille was once more installed and the small grille beneath it was blocked

B. Right side of bus: The plain access panel was replaced by an inverted V grille equal in size to the radiator grille.

8.8 EFFECTIVENESS OF STANDARD INLET SYSTEM

Basically, the bus was in the condition described in Section 8.7, except that the small radiator grille was blocked and there was a pan under the muffler compartment. The standard oil bath air cleaner and inlet resonator were removed and replaced by a flexible hose from the exit of the plenum chamber to the engine inlet.

8.9 VARIATIONS ON ABSORPTION AND WRAPPING

The engine capsule was completely removed and an attempt was made to install as much acoustical absorption material as possible within the engine compartment.

1. 1-inch thick foam with a lead facing was installed, the lead facing toward the engine
2. 1-inch thick foam with a strip-adhered mylar facing was installed over the lead-faced foam, thus yielding a 2-inch deep treatment

3. As in item 2, except that the radiator fan was locked ON
4. As in item 3, except that the transmission and the air compressor were wrapped in lead-faced foam
5. As in item 4, except the radiator fan was now locked OFF
6. As in item 5, but the air compressor was unwrapped
7. As in item 6, but the transmission was unwrapped and the air compressor rewrapped

8.10 EFFECT OF AN AIR SCOOP OVER THE RADIATOR GRILLE

In order to reduce muffler noise, the bus was fitted with an extra muffler, in series with the standard Nelson, and a standard tail pipe was installed.

1. Air scoop over the radiator grille, fan off and on
2. Air scoop removed, fan off

NOTE: At this point a contoured fan shroud was installed and remained installed until Section 8.21, item 1.

8.11 DUAL NELSON MUFFLERS

1. Radiator cooling fan on AUTO
2. Radiator cooling

8.12 DUAL RIKER MUFFLERS

1. Radiator cooling fan locked ON
2. Radiator cooling fan on AUTO

8.13 DUAL DONALDSON MUFFLERS

1. Radiator cooling fan on AUTO
2. Radiator cooling fan locked OFF

8.14 SINGLE NELSON REPLACEMENT MUFFLER AND DONALDSON RESONATOR

1. Replacement muffler only, Radiator fan OFF, 4-inch pipe
2. Muffler and resonator, radiator fan OFF, 4-inch pipe

8.15 DUAL NELSON MUFFLERS AND DONALDSON RESONATOR

Radiator cooling fan locked OFF, 4-inch exhaust pipe

8.16 VARIATIONS WITH DONALDSON SINGLE MUFFLER AND RESONATOR

Donaldson single muffler with two, 3-inch diameter inlets and one, 4-inch outlet plus Donaldson resonator with 4-inch tail pipe in standard location.

1. A pan was installed under the drive shaft
2. Tail pipe was relocated to a central position and a pan was installed under the drive shaft
3. The engine was fitted with isolated rocker covers in addition to item 2
4. The same as item 3 except that the acoustical foam in the engine compartment of the alternate manufacture.
   (Note: This was run after Section 8.18, item 1)
5. The same as item 3 except the resonator was removed
6. The same as item 5 plus the oil bath air cleaner was replaced with a dry type

8.17 DONALDSON SINGLE MUFFLER WITH NELSON RESONATOR

The bus was in condition 8.16, item 3, except that the Donaldson resonator was replaced by a Nelson resonator.

8.18 MORE VARIATIONS WITH DONALDSON SINGLE MUFFLER AND RESONATOR

Production 4-inch tail pipe. Part of engine underpan near radiator removed. Alternative acoustical material installed:

1. Resonator wrapped in asbestos wool
2. Resonator wrapping removed

8.19 ENGINE PARTITION AND VARIATION IN RADIATOR COOLING FAN SPEED

The bus was basically as in Section 8.16, item 4. A steel partition was installed between the engine and the radiator. The cooling fan was varied in speed to try and achieve adequate cooling with minimum noise.

Note: At this point in the program, the bus transmission failed.

8.20 AFTER TRANSMISSION REPAIR

The bus was in the same condition as Section 8.19 except that the transmission was repaired.

1. Cooling fan ON - standard radiator grille
2. Cooling fan OFF - standard radiator grille
3. Cooling fan OFF - inverted V louver grille
4. Cooling fan ON -- inverted V louver grille

8.21 VARIATIONS RETURNING TO BASELINE

All underpans and partitions removed. Isolated rocker covers removed. Standard radiator grille and cooling fan shroud reinstalled. Cooling fan ON.

1. Same as Section 8.21 except cooling fan OFF.
2. Same as Section 8.21 but isolated rocker covers replaced
3. Standard rocker covers reinstalled. Standard Flxible underpan fitted
4. Standard cooling fan replaced by a lightweight fan, contoured shroud
5. Same as item 4 except inverted V louver grille fitted
6. Standard radiator grille reinstalled. Standard cooling fan and shroud reinstalled. Resonator removed
7. Acoustical absorption material removed
8. Resonator reinstalled

8.22 SECOND BASELINE

The bus was returned to its "as-delivered" status except for a new tail pipe to replace the damaged one. The bus was also retested with the original damaged tail pipe.

8.23 FINAL SOUND ATTENUATION KIT

As testing progressed, it was decided to finalize on two sound attenuation kits. Number one has the improved exhaust system consisting of a double-wrapped muffler and resonator with 4-inch diameter pipework, the damped steel rocker arm covers, and the acoustical material on the hood and transmission door. In addition, kit number two has the contoured fan shroud and an engine partition.

8.23.1 Kit Number One - Donaldson double-wrapped muffler: two, 3-inch diameter pipes in; one 4-inch diameter pipe out; Donaldson resonator; 4-inch diameter tail pipe pointing down left center rear of bus; acoustical absorption material on inside of hood; isolated valve rocker covers on engine. This kit was tested with and without underpans and with cooling fan on and off. The kit was also tested with a vertical roof-level exhaust pipe to simulate a coach fitted with an Environmental Improvement Package (EIP). In addition to the catalytic mufflers and inline resonators, EIP's also include a vertical tail pipe, with ejector, exhausting at roof level.

8.23.2 Kit Number Two - In addition to the items listed for kit number one, kit number two had the contoured cooling fan shroud and the partition on the left-hand side of the engine. The fan was allowed to run on automatic and because of increased efficiency, does not have to run up to full speed in order to achieve adequate cooling.

9/ PERFORMANCE TEST RESULTS

Performance testing of the SAK bus was carried out continuously throughout the program according to the vehicle test plan. Highlights of the testing program were the major test efforts to establish the baseline performance curve and then the comparison of the finalized kits with that baseline.

9.1 ACCELERATION TESTS

The first baseline test run on the bus was an acceleration test. The baseline bus was accelerated from rest at wide-open throttle on a flat, level, straight road until the various speeds were attained. The results were then analyzed to verify that the bus was operating properly. From this data an operating profile was established so that during the acoustical testing, if a component was modified and it made a difference in the performance, it would be noticed. In conjunction with this first baseline test, the SAK #1 and #2, and the second baseline configurations were tested for acceleration. These results are recorded on the appropriate data sheets in the appendix and the results plotted in Figure 9.1-1. As can be seen from the vehicle

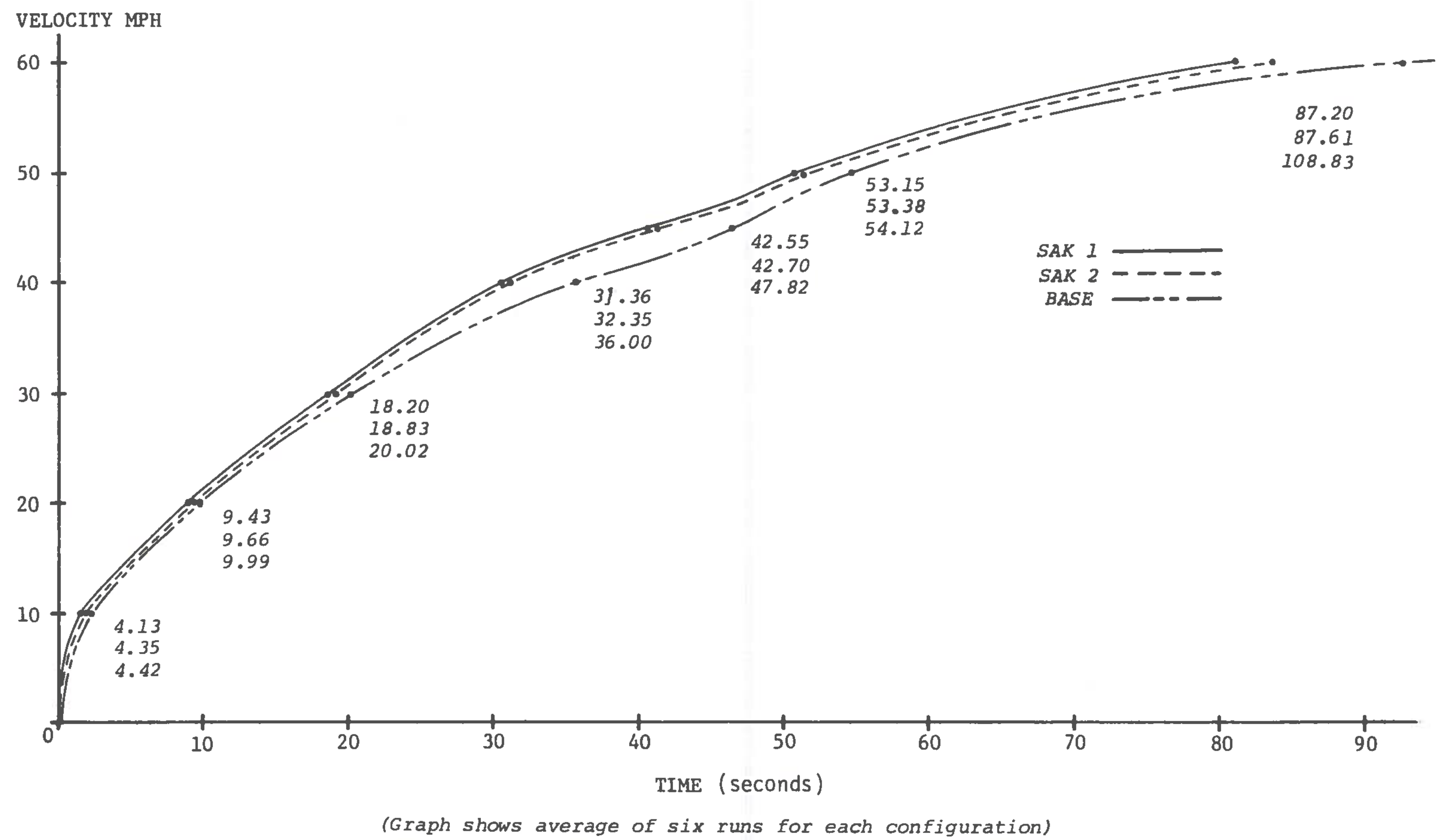

Figure 9.1-1 Flxible Bus Acceleration Performance

acceleration graph, the installation of either kit made no extreme change in the acceleration times.

9.2 DYNAMOMETER TESTS

Dynamometer tests were also used to compare the baseline bus with the two sound attenuation kits. Tests included monitoring horsepower, "road speed," fuel flow, exhaust back pressure, temperatures, and engine rpm. From these tests it was possible to compare accurately one configuration with another. In testing for net horsepower, and horsepower delivered to the wheels, the baseline coach originally tested at 120 hp and the SAK coaches tested at 115 and 112 hp respectively. At first glance, this looks to be approximately a 5% loss in power. Upon a further investigation of the tests, however, the baseline coach was tested with the engine radiator fan running in the automatic mode and only rotating at 1000 rpm, whereas the SAK #1 coach had a fan speed of 1200 rpm and the SAK #2 coach had a fan speed of 1400 rpm.

Tests made on the coaches with the fan inoperable showed a net horsepower of 120 for the baseline and 120 and 118 for SAK #1 and #2 respectively. With the fan in the full ON position, hp readings were:

Baseline	114 hp
SAK #1	115 hp
SAK #2	105 hp

The 10 hp drop between SAK #1 and #2 was assumed to be due to the redesigned shroud causing the fan to pull more air, thus doing more work and therefore, the resulting loss of net horsepower.

See Appendix G for the results of the dynamometer tests.

9.3 ENGINE BACK PRESSURE

During the engine dynamometer testing, the engine back pressures were also monitored, using a "U" tube mamometer. To obtain accurate readings, extreme care was taken in the procedures used to obtain the readings. The pressure tap was located as close as possible to the manifold flange in the neutral flow plane, approximately one pipe diameter away from the first bend. The pressure tap was a 1/8-inch pipe coupling welded to the exhaust tubing with a 1/8-inch hole drilled through the tubing. From the pipe coupling, a 3-foot piece of 1/8-inch copper tubing and a 12-foot piece of plastic tubing were used to connect the manometer. The long, small-diameter tubing was used to prevent any standing waves from forming in the line. Results of the readings were recorded on individual test sheets and then transformed to the Muffler Design Option graph (Figure 9.3.1). This graph plotted the exhaust back pressures for each muffler subsystem. The muffler cost and dB(A) readings were added so that the optimum muffler subsystem could be selected. As can be seen from the graph, the normal trend was that with increased attenuation, there was an associated increase in back pressure. The graph also shows three major groupings. The first group are those that were above the engine manufacturer's allowable limits. The second group are those that had a very low back pressure level but a high dB(A) reading. The third group consisted of three muffler systems. These three muffler systems

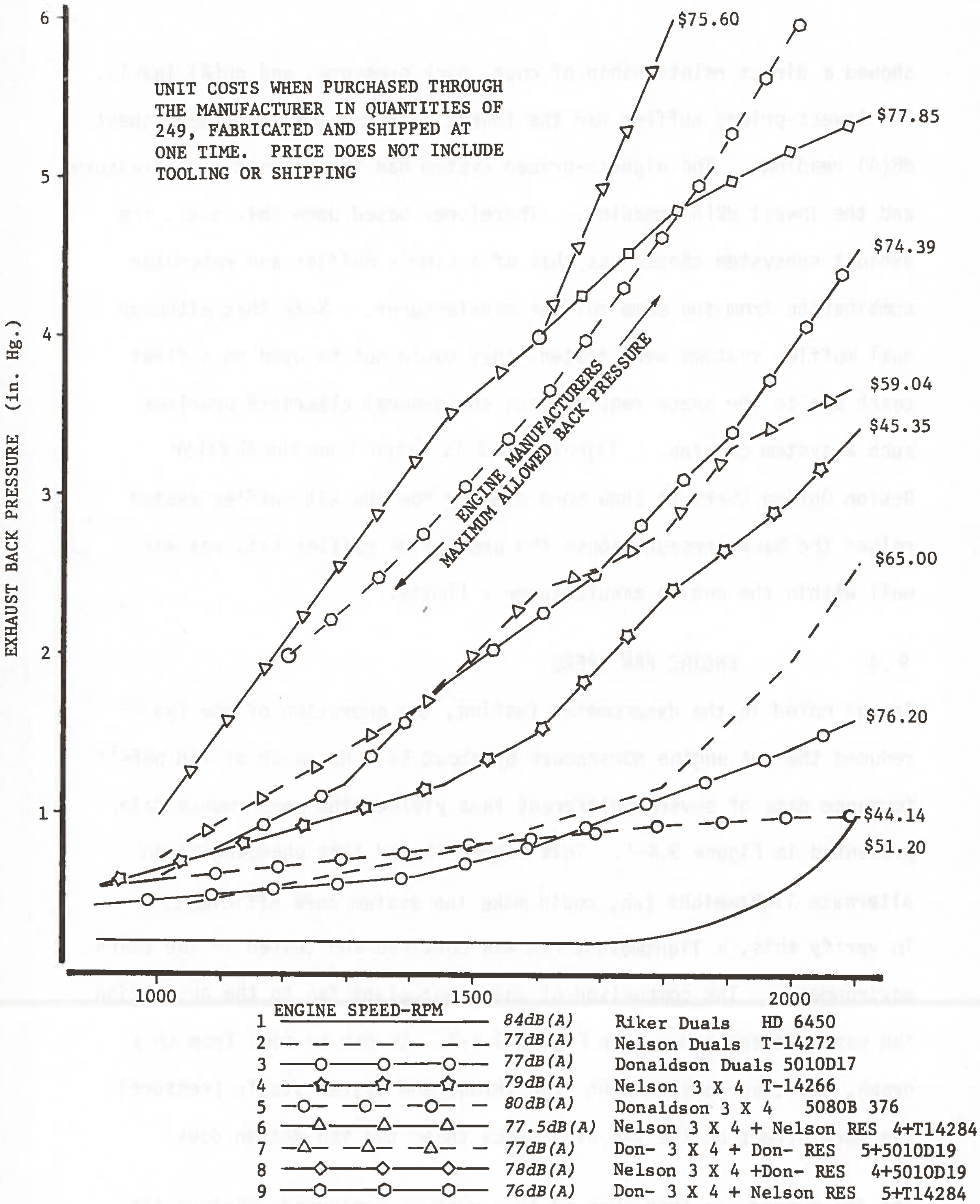

Figure 9.3-1. Muffler Design Options

showed a direct relationship of cost, back pressure, and dB(A) levels. The lowest-priced muffler had the lowest back pressure and the highest dB(A) reading. The highest-priced system had the highest back pressure and the lowest dB(A) reading. Therefore, based upon this data, the exhaust subsystem chosen was that of a single muffler and resonator combination from the same muffler manufacturer. Note that although dual muffler systems were tested, they could not be used on a fleet coach due to the space requirements and general clearance problems such a system creates. Figure 9.3-2 is taken from the Muffler Design Option Chart to show more clearly how the kit muffler system raised the back pressure above the production muffler kit, yet was well within the engine manufacturer's limits.

9.4 ENGINE FAN SPEED

As was noted in the dynamometer testing, the operation of the fan reduced the net engine horsepower by about 5%. Research of fan performance data of several different fans yielded the performance data presented in Figure 9.4-1. This figure showed that changing to an alternate lightweight fan, could make the system more efficient. To verify this, a lightweight fan was obtained and tested in the coach environment. The comparison of the lightweight fan to the production fan was made and appears as Figure 9.4-2. As can be seen from this graph, the coach environment (fan shroud and system static pressure) has more effect on the fan efficiency than the fan design does.

The fan shroud was then changed to a venturi contoured, minimum tip clearance style. Test data from this configuration appears as

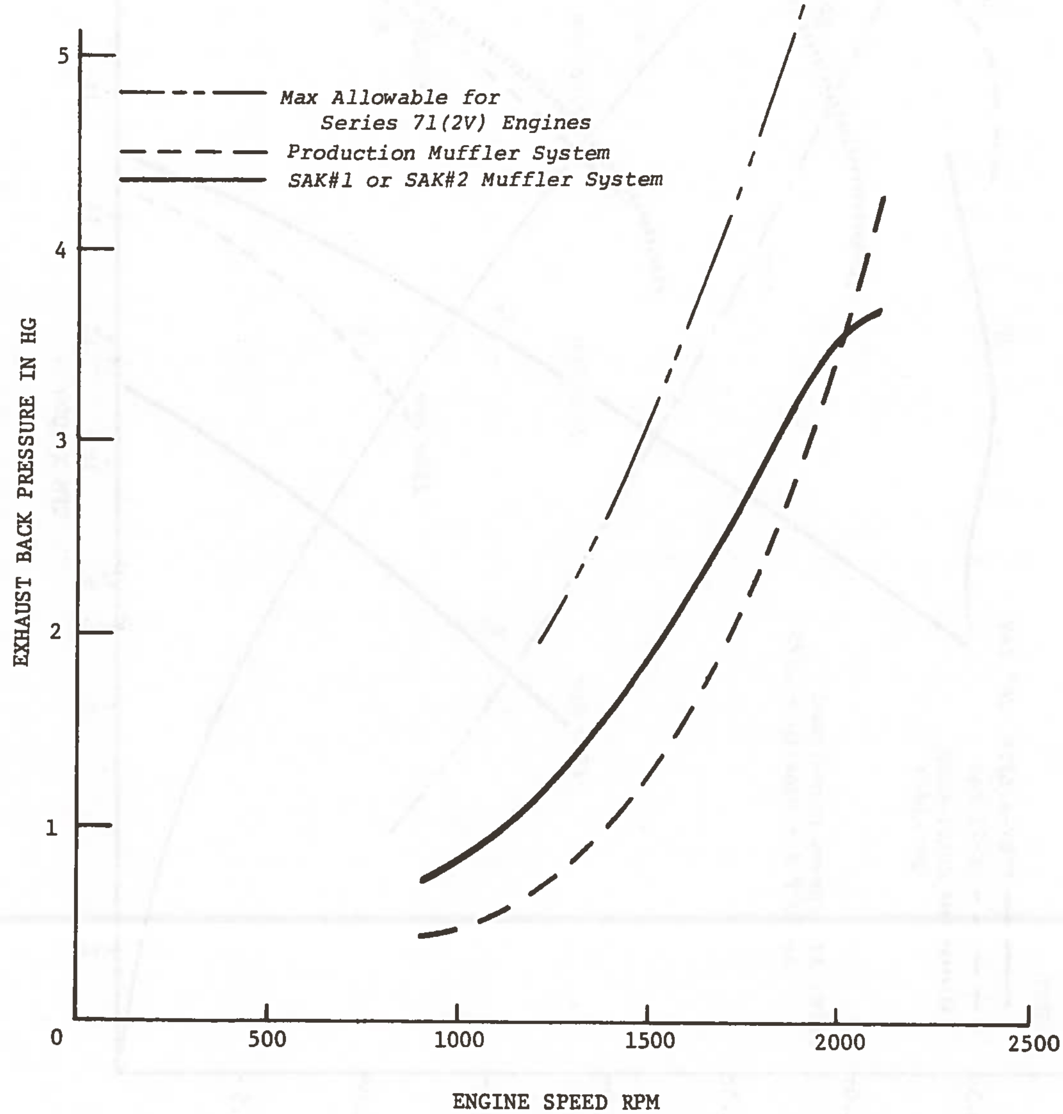

Figure 9.3-2. Full Load Exhaust Backpressure Vs. Engine Speed

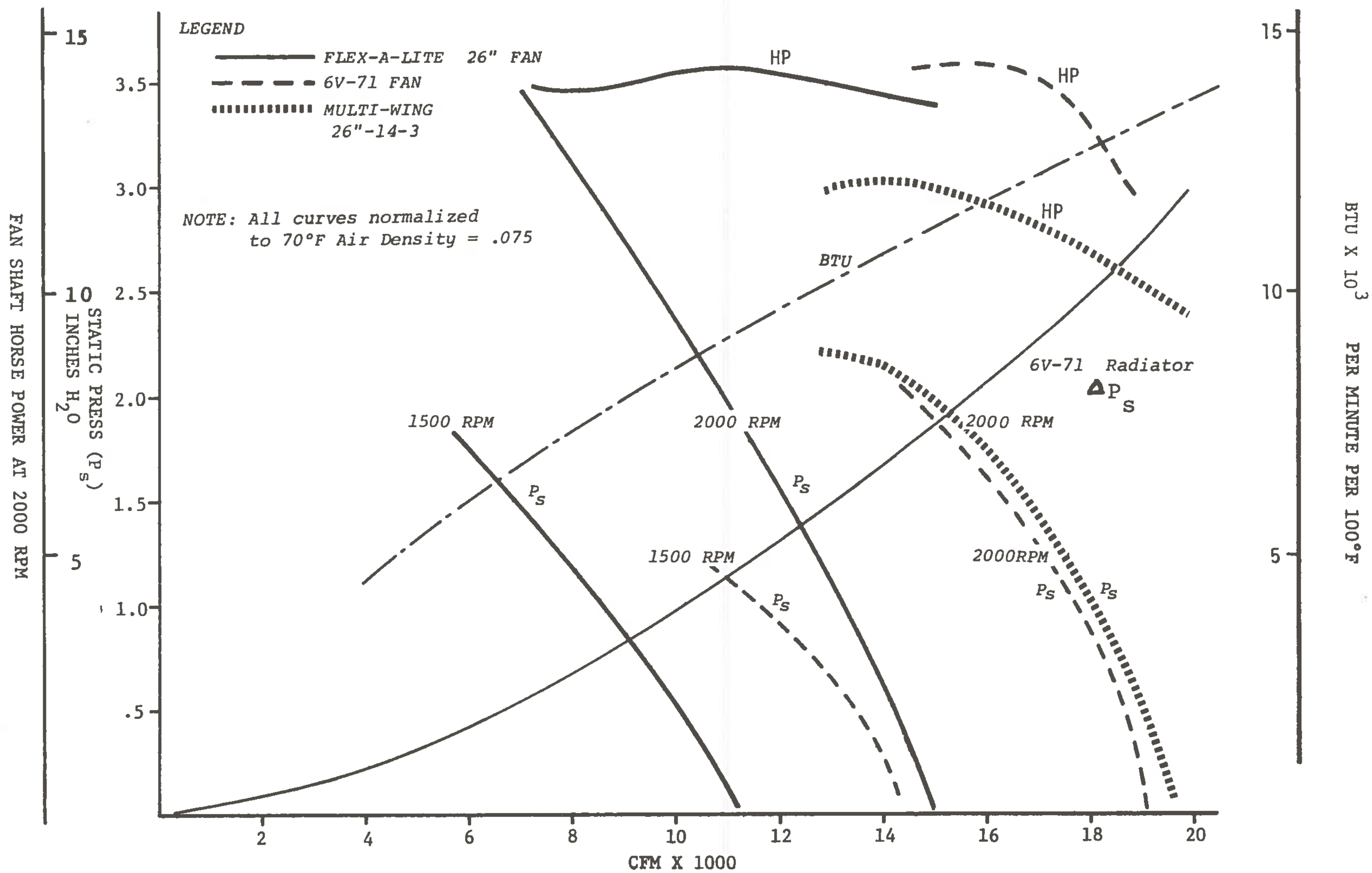

Figure 9.4-1. Radiator/Fan Performance Data

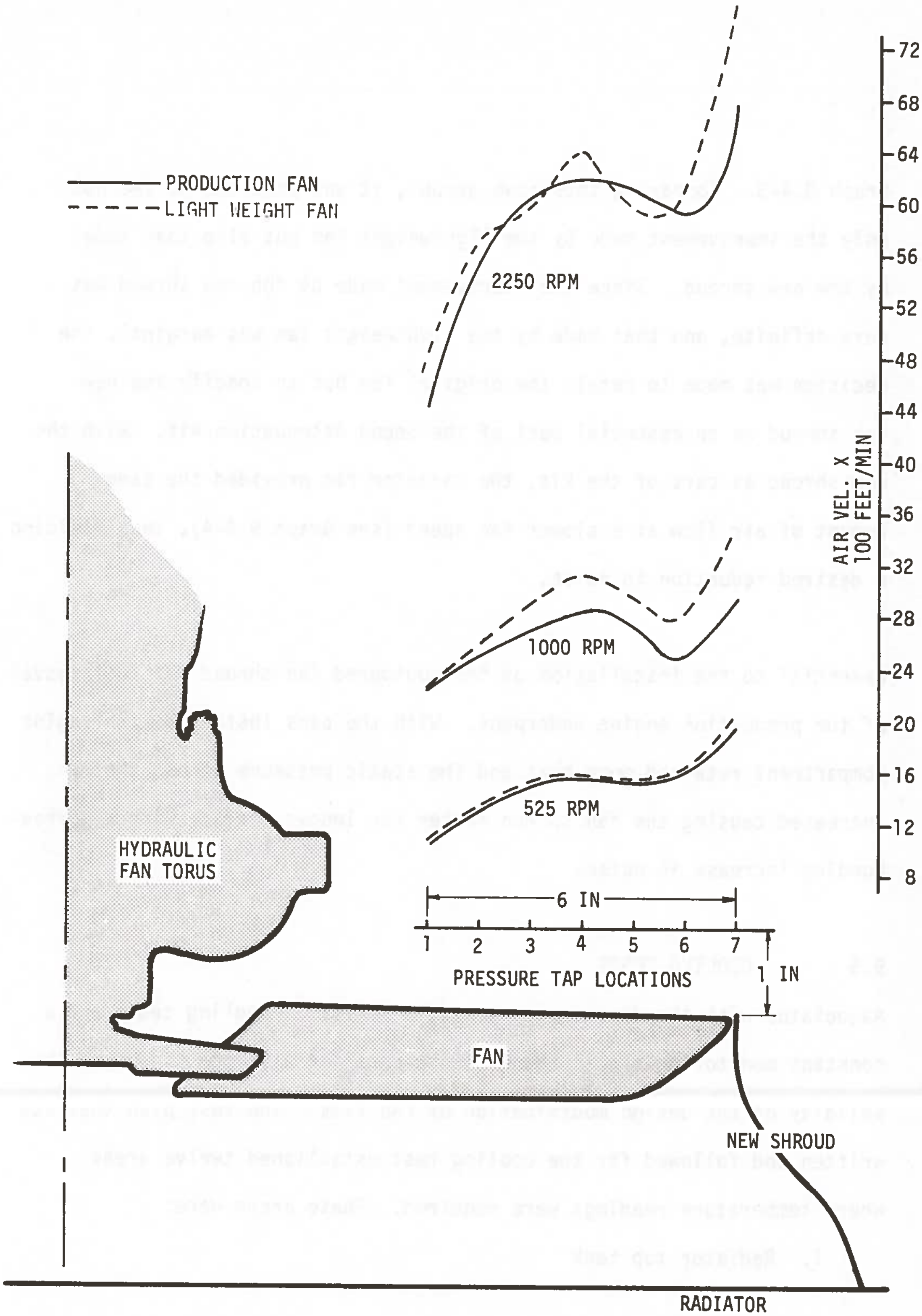

Figure 9.4-2. Air Flow at RPM Configuration
(New Shroud)

Graph 9.4-3. Comparing these two graphs, it was possible to see not only the improvement made by the lightweight fan but also that made by the new shroud. Since the improvement made by the new shroud was very definite, and that made by the lightweight fan was marginal, the decision was made to retain the original fan but to specify the new fan shroud as an essential part of the Sound Attenuation Kit. With the new shroud as part of the kit, the radiator fan provided the same amount of air flow at a slower fan speed (see Graph 9.4-4), thus yielding a desired reduction in noise.

Essential to the installation of the contoured fan shroud was the removal of the production engine underpans. With the pans installed, the engine compartment retained more heat and the static pressure across the fan increased causing the fan to run faster for longer periods with a corresponding increase in noise.

9.5 COOLING TESTS

Associated with the dynamometer tests, a series of cooling tests and a constant monitoring of the thermocouple recorder was made to assure the validity of the design modification of the kits. The test plan that was written and followed for the cooling test established twelve areas where temperature readings were required. These areas were:

1. Radiator top tank

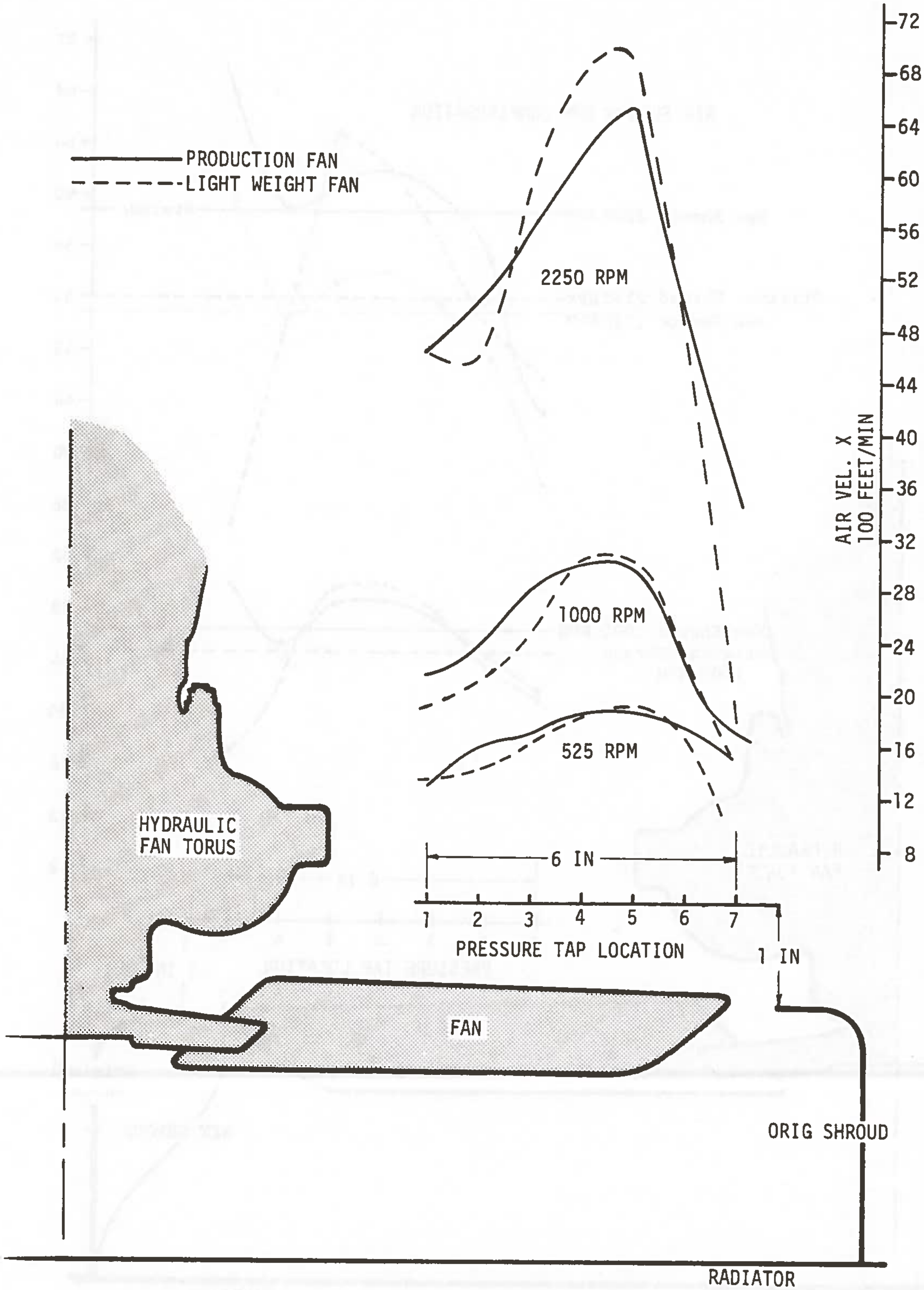

Figure 9.4-3. Air Flow at RPM Configuration (Original Shroud)

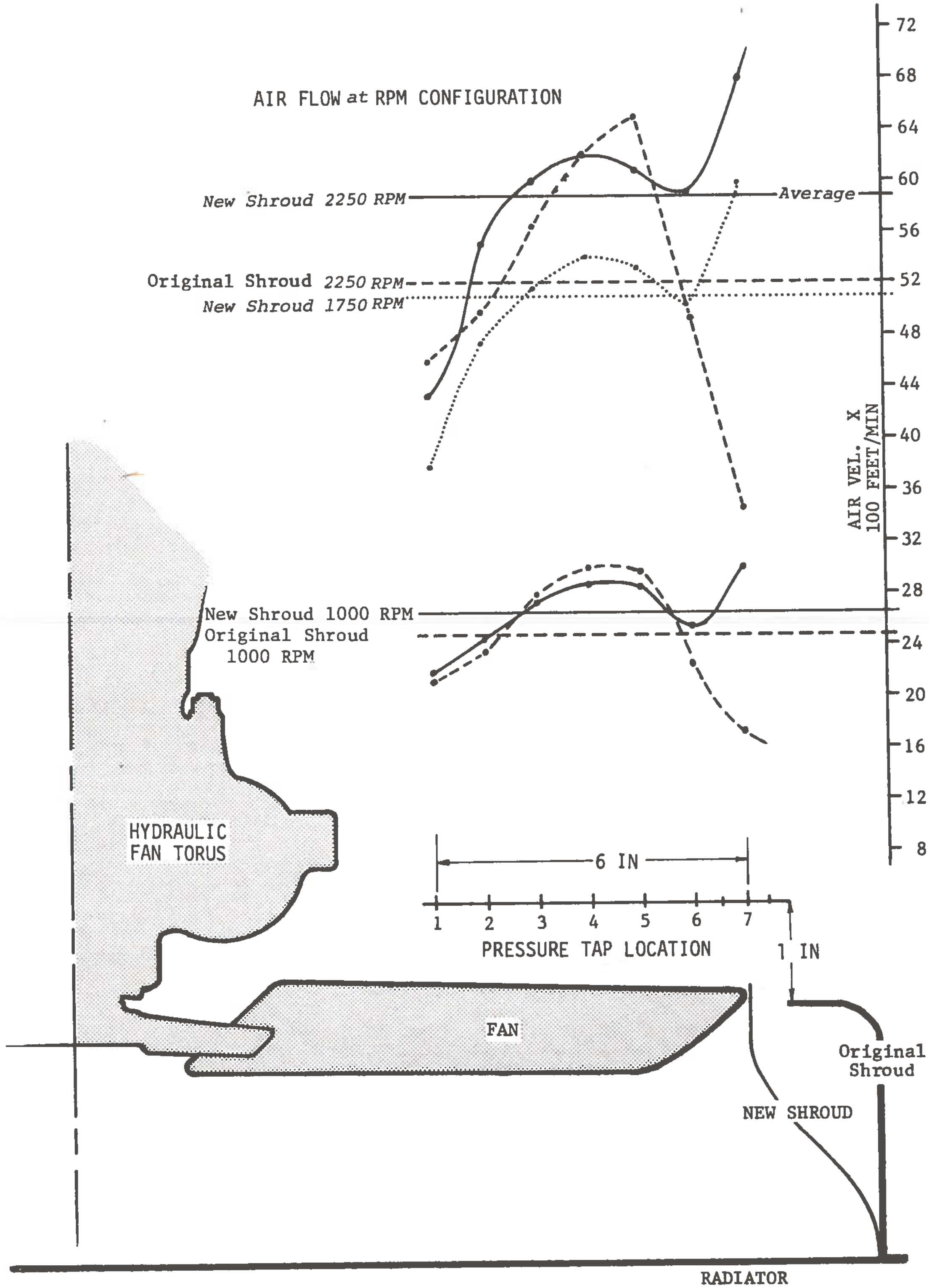

Figure 9.4-4. Air Flow at RPM Configuration
(Original and New Shroud)

2. Radiator bottom tank
3. Air leaving the radiator
4. Air entering the radiator
5. Transmission oil from the oil cooler tank
6. Transmission oil to the oil cooler tank
7. Engine air intake at resonator
8. Engine compartment aft center
9. Engine compartment bottom forward
10. Engine compartment top forward
11. Alternator oil at alternator
12. Engine oil sump at drain plug

While the vehicle was on the dyno, the recorder was operating and a complete test record was made. This provided good temperature profiles under identical power settings and ambient weather conditions. Figure 9.5-1 is a comparison of the three dynamometer tests. Only thermocouples #1, #2, and #9 were plotted for ease of interpretation. As can be seen from the graph, the top tank temperature, thermocouple #1 did not vary from the baseline profile by more than 5° F for either SAK #1 or SAK #2.

In comparing the differences in top tank and bottom tank temperature, the baseline profile yielded about a 12° F differential. This 12° F differential is in line with the design parameters of the system. As can be seen from the graph, the installation of the SAK #1 and SAK #2 did not change this 12° F temperature differential. When the fan was

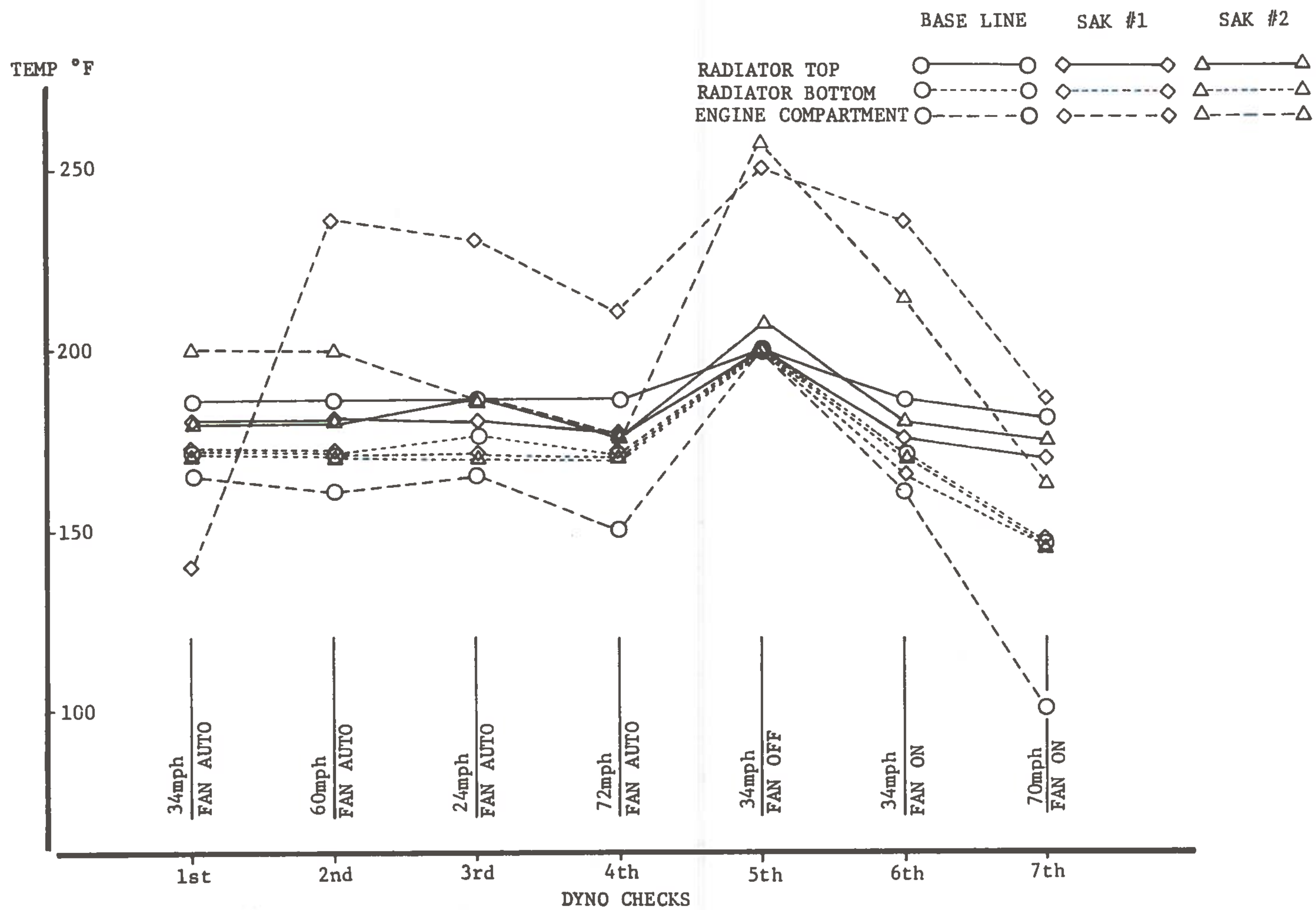

Figure 9.5-1. Dynamometer Checks

locked on during the SAK #2 test, the temperature differential rose about 30°. This increase in cooling verified the previous air flow tests, showing that with the SAK #2 radiator shroud, there was more air flow at any given rpm setting.

The third set of lines on the graph are those of thermocouple #9. The baseline profile of this thermocouple shows that a compartment temperature of 160° is about normal. When the first kit was fitted with the underpan installed, the compartment temperature rose to 230°. This extreme temperature environment could not be tolerated in a fleet operation, so different means of reducing it were considered. Basically, the SAK #1 compartment was a closed metal container with acoustic foam on all flat surfaces. This configuration retained not only the noise of the engine but also the heat generated from it. The compartment with the underpans also restricted the radiator air flow out of the compartment, thus reducing the cooling capacity of the system. The engine underpans were removed for the SAK #1 dynamometer test which did not increase noise levels but lowered the engine compartment temperature to about 190°. Although 190° is higher than the baseline temperature, it is low enough to be considered satisfactory for a fleet operation. Another benefit derived from removing the engine underpan was the increased air flow through the radiator, resulting in a slower fan speed and less noise.

Therefore, from the cooling data derived from the dynamometer tests, two conclusions were made. The first conclusion was that the SAK #1 and #2 kits did not adversely affect the cooling capacity of the coach. The second conclusion was that the acoustic insulation in the compartment also retains the heat generated by the engine, and to help reduce the heat build-up, the engine underpans must be removed.

The control of the fan speed was very important in order to determine exactly how it affected the overall performance of the coach. In order to have the control necessary for all of the tests involved with the fan, the fan system was modified as shown in Figure 9.5-2. As can be seen from the schematic, the fan control oil return line was modified ahead of the vernatherm. Basically the change consisted of installing an oil bypass line and two valves. Also installed was a fan speed tachometer and recorder. To keep the fan speed at engine speed, both valves were closed, thus retaining all of the oil in the toros as per the top sketch. To turn the fan off, the oil bypass valve was opened and the oil returned to the engine sump as per the center sketch. To allow the fan to operate automatically as the baseline coach, the bypass valve was closed and the valve in series with the vernatherm was opened. This allowed the vernatherm to operate according to the engine cooling requirement and thus the fan operated only when required.

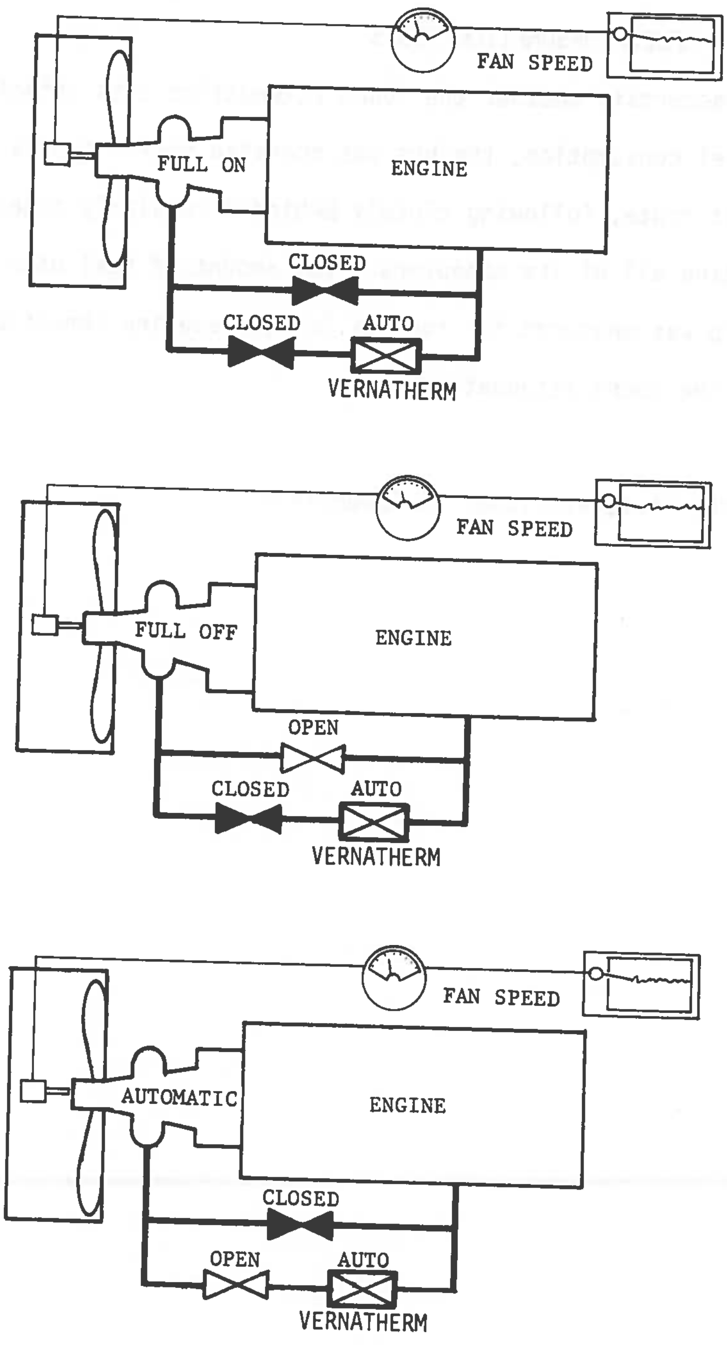

Figure 9.5-2. Fan Control Schematic

9.6 FUEL CONSUMPTION TESTS

In order to ascertain whether the sound attenuation kits affect the vehicle's fuel consumption, the bus was operated over a typical San Diego Transit route, following closely behind a regularly scheduled bus and duplicating all of its maneuvers. The amount of fuel used for the complete trip was measured for the bus in its baseline condition and when fitted with the sound attenuation kits.

Details of the route are shown in Appendix H.

10/ COST ANALYSIS

A cost analysis for the Sound Attenuation Kit must be considered in two different manners, depending upon the time of installation.

10.1 RETROFITTING AN OLD COACH IN THE FLEET

The first cost analysis is that of retrofitting an old coach in the fleet. Assumptions made for this analysis are that the retrofit is to be done in the fleet service area at a scheduled lubrication/ maintenance interval by a skilled mechanic. Labor costs are not shown but estimated times for task performance are shown. This allows the many different fleets to apply their own internal labor rates. The mechanic skill level was 3-M service mechanic with two years of experience. Material dollar costs are in 1974 spares cost dollars, FOB Flxible. (See Table 10-1)

10.2 INSTALLING SAK ON A NEW BUS

The second cost analysis is that of fitting the SAK on a new bus at the factory during the coach build up. (See Table 10-2)

TABLE 10-1

COST ANALYSIS TO RETROFIT AN OLD COACH IN THE FLEET

SAK #1 FOR 80 dB(A)

Task	Added Time	Cost
Preventive Maintenance	30 minutes	--
Exhaust Installation	30 minutes	$194*
Rocker Arm Covers	10 minutes	90
Acoustic Foam Installation	60 minutes	103
TOTAL	2 hours 10 minutes	$387

* This includes the cost of replacing mufflers which are needed even if the SAK is not installed.

SAK #2 FOR 77 dB(A)

Preventive Maintenance	30 minutes	--
Exhaust Installation	30 minutes	$194
Rocker Arm Covers	10 minutes	90
Acoustic Foam Installation	60 minutes	103
Fan Shroud	40 minutes	135
Engine Enclosure	20 minutes	88
TOTAL	3 hours 10 minutes	$610

TABLE 10-2

COST ANALYSIS TO FIT SAK ON NEW BUS AT FACTORY

SAK #1

Task	Added Time	Cost
Preventive Maintenance	--	--
Exhaust Installation	10 minutes	$ 67
Rocker Arm Covers	--	90
Acoustic Foam Installation	60 minutes	130
TOTAL	1 hour 10 minutes	$260

SAK #2

Preventive Maintenance	--	--
Exhaust Installation	10 minutes	$ 67
Rocker Arm Covers	--	90
Acoustic Foam Installation	60 minutes	103
Fan Shroud	--	135
Engine Enclosure	20 minutes	88
TOTAL	1 hour 30 minutes	$483

NOTE: These cost estimates do not include any fuel savings which may be brought about by the increased efficiency of the cooling system nor do they include any increased fuel costs due to the increased weight of the additional items of the kit. Both of these items have such an insignificant effect on the bus operation that a fleet operator could not measure it effectively.

11/ ACOUSTIC TEST RESULTS

A summary of the test results is given by the tables below, which show weighted sound level values for various configurations and modes of operation of the bus:

- Table 8-1 - Details of Configurations Tested
- Table 11-1 - Exterior Noise - SAE J366a Acceleration Tests
- Table 11-2 - Exterior Noise - Constant Speed Passbys
- Table 11-3 - Exterior Noise - Stationary Bus, Constant Engine Speeds
- Table 11-4 - Exterior Noise - Stationary Bus, Run-Up Tests and a Comparison with Corresponding SAE J366a Acceleration Tests
- Table 11-5 - Exterior Noise - Curbside Pullaway Tests
- Table 11-6 - Interior Noise - Wide-Open Throttle Through the Shift Point
- Table 11-7 - Interior Noise - Constant Speed Runs
- Table 11-8 - Interior Noise - Stationary Bus, Constant Engine Speeds

Tables and figures showing octave and one-third octave band spectra can be found in Appendix F to this report.

Engine speeds of 75%, 85%, and 95% correspond to road speeds of 22, 25 and 28 mph respectively with the bus moving at constant speed and the transmission in the converter stage.

TABLE 11-1 EXTERIOR NOISE - SAE J366a ACCELERATION TESTS

VEHICLE CONFIGURATION	SAE ACCELERATIONS Sound Level dB(A)	
	Left	Right
1 Baseline 1	94.5	80.0
1st Stage Capsule	83.0	68.5
2nd Stage Capsule	80.5	75.0
2 3rd Stage Capsule	79.0	73.5
3 *	75.0	74.0
3	74.5	73.5
3a	77.0	74.0
3b	77.5	75.0
3c	78.5	75.0
4	77.0	74.0
5	77.0	74.5
5a	-	-
5b	-	75.5
6	77.5	75.0
7a	76.5	73.0
7b	76.5	74.0
7c	79.5	76.0
7d	79.5	75.0
7e	77.0	73.0
7f	77.0	73.5
7g	77.0	74.0
8a	76.0	75.0
8b	78.0	72.0
9a	77.0	75.0
9b	80.0	76.0
10a	84.0	83.5
10b	84.0	83.5
11a	76.5	74.5
11b	-	-
12a	79.0	78.0
12b	77.5	76.0

VEHICLE CONFIGURATION	SAE ACCELERATION Sound Level dB(A)	
	Left	Right
13	76.0	74.0
14	77.0	73.0
14a	76.5	72.0
14b	76.0	72.0
14c	75.5	72.0
14c-1	76.5	73.5
14d	78.0	77.0
14e	78.0	78.0
15	76.0	72.0
16	77.0	73.5
16a	77.0	73.5
17	76.0	73.0
18	80.0	73.5
18a	76.0	-
18b	77.0	-
18c	79.5	-
19	80.0	78.0
19a	77.5	-
19b	77.0	-
19c	77.0	-
19d Fan On	80.0	77.0
19d Fan Off	77.5	74.0
19e	79.5	77.5
19f	80.0	77.5
19g	81.0	78.0
19h	78.0	74.0
Baseline 2	82.5	78.0
Baseline 2 Old Tail Pipe	89.5	81.0
SAK 1 Fan On /1	80.0	76.5
SAK 1 Fan Off /2	77.5	73.5
SAK 1 Fan Off /3	77.5	74.5
SAK 2 Fan On	77.5	75.5

Notes: /1 **Full Width Underpan Fitted**
/2 No Underpan - This is the final kit configuration
/3 Vertical Roof Level Tail Pipe

TABLE 11-2
EXTERIOR NOISE - CONSTANT SPEED PASSBYS

Vehicle Configuration	Constant Speed Passbys Sound Level in dB(A) Left			Right		
ENGINE SPEED (RPM)	1600 75% 22 mph	1825 85% 25 mph	2050 95% 28 mph	1600 75% 22mph	1825 85% 25 mph	2050 95% 28 mph
1 - Baseline 1	75	79	87	72	72	76
1st Stage Capsule	70	72	74	67	70	72
2nd Stage Capsule	70	70	75	69	69	71
2 - 3rd Stage Capsule	69	72	74	69	70	72
3	66	69	73	65	66	70
4	71	72	75	65	67	71
5	71	73	75	68	70	72
6	72	73	75	68	69	71
7a	70	72	75	66	68	70
7b	71	72	75	66	68	72
7c	72	72	78	67	71	74
7d	72	73	76	69	70	73
7e	70	71	74	65	66	70
7f	70	72	74	66	67	71
7g	70	71	72	66	67	71
8b	67	70	72	64	67	70
9a	70	71	71	68	69	72
9b	70	73	77	67	70	74
11b	71	72	74	68	70	72
12a	71	72	74	69	73	75
12b	71	73	76	69	72	74
14	72	73	75	69	71	72
14c	71	72	76	67	69	70
4d	70	72	76	72	73	76
5	69	71	74	-	67	69
7	71	73	73	68	70	72
8	74	76	79	69	71	74
9	75	76	79	72	74	77
9f	74	75	76	70	72	75
9g	75	75	78	72	74	76
9h	72	72	75	70	70	71
aseline 2	76	77	80	72	74	76
AK 1 - Fan On /1	74	77	78	71	73	75
AK 1 - Fan Off /2	71	73	75	69	70	72
AK 2 - Fan On	75	75	78	72	72	75

TABLE 11-3
EXTERIOR NOISE - STATIONARY BUS, CONSTANT ENGINE SPEEDS

Vehicle Configuration	Stationary Bus - Constant Engine Speeds Sound Level in dB(A)					
	Left			Right		
	1600 75%	1825 85%	2050 95%	1600 75%	1825 85%	2050 95%
1 Baseline 1	71	71	75	71	72	75
2 3rd Stage Capsule	67	69	71	64	66	67
3	65	66	68	63	64	65
3a	-	-	70	-	-	-
3b	-	-	69	-	-	-
3c	-	-	71	-	-	-
4	68	70	72	62	64	66
5	68	70	72	64	65	68
5a	67	69	71	-	-	-
5b	-	-	-	66	69	70
7b	67	70	72	63	65	67
9a	68	70	72	64	66	68
9b	70	74	78	66	68	72
11b	67	68	71	64	67	68
14	69	70	72	66	68	70
14c Fan On	74	77	79	69	71	72
14c Fan Off	69	71	73	67	67	69
14d	68	71	72	66	68	70
15	67	69	71	64	64	66
17	70	72	74	66	68	71
18	74	77	80	68	71	74
19	73	76	79	71	73	76
19d Fan On	-	-	79	-	-	-
19d Fan Off	-	-	73	-	-	-
19e Fan On	-	-	77	-	-	-
19e Fan Off	-	-	74	-	-	-
19f	71	73	75	66	68	72
19g	72	75	76	69	70	72
19h	72	73	74	67	68	69
Baseline 2 Fan On	75	78	81	70	73	77
Baseline 2 Fan Off	-	-	76	-	-	-
SAK 1 Fan On /1	73	75	79	68	70	73
SAK 1 Fan Off /1	70	71	73	65	67	69
SAK 2 Fan On	72	73	75	68	69	71

NOTE: /1 Same as Table 1

TABLE 11-4
EXTERIOR NOISE - STATIONARY RUNUP TESTS AND A
COMPARISON WITH CORRESPONDING SAE ACCELERATION TESTS

Vehicle Condition	Radiator Cooling Fan	Sound Level in dB(A)			
		Stationary Runup		SAE Acceleration	
		Left	Right	Left	Right
14c	Off	74.0	71.0	75.5	72.0
17	Off	75.0	73.0	76.0	73.0
2nd Baseline	On	85.0	79.0	82.5	78.0
Kit No. 1	On	81.5	76.0	80.0	76.5
Kit No. 1	Off	76.0	72.5	77.5	73.5
Kit No. 2	Auto	77.5	74.0	77.5	75.5

TABLE 11-5
EXTERIOR NOISE - CURBSIDE PULLAWAY TESTS

Vehicle Condition	Radiator Cooling Fan	Sound Level in dB(A) Curbside Pullaway
14c	Off	86.0
14c	On	87.0
17	Off	89.5
2nd Baseline	On	91.5
Kit No. 1	On	90.0
Kit No. 1	Off	90.0
Kit No. 2	Auto	91.0

TABLE 11-6

INTERIOR NOISE - WIDE OPEN THROTTLE THROUGH SHIFT POINT

Vehicle Condition	Sound Level in dB(A)		
	Center of Rear Seat	Mid Coach	Driver's Ear
1st Baseline (Bus Empty)	85	80	76
2nd Baseline	84	78	72
Kit No. 1	83	78	72
Kit No. 2	84	79	75

TABLE 11-7

INTERIOR NOISE - CONSTANT SPEED RUNS

Vehicle Condition	Sound Level in dB(A)								
	Center of Rear Seat			Mid Coach			Driver's Ear		
ENGINE SPEED (RPM)	1600 75%	1825 85%	2050 95%	1600 75%	1825 85%	2050 95%	1600 75%	1825 85%	2050 95%
1st Baseline	79	80	82	74	75	77	70	71	73
2nd Baseline	81	83	84	74	77	78	70	71	73
Kit No. 1	81	82	83	74	77	78	71	71	73
Kit No. 2	81	82	84	75	77	79	72	72	73

TABLE 11-8

INTERIOR NOISE - STATIONARY BUS, CONSTANT ENGINE SPEEDS

Vehicle Condition	Sound Level in dB(A)								
	Center of Rear Seat			Mid Coach			Driver's Ear		
ENGINE SPEED (RPM)	1600 75%	1825 85%	2050 95%	1600 75%	1825 85%	2050 95%	1600 75%	1825 85%	2050 95%
1st Baseline	78	79	81	-	-	-	69	71	73
2nd Baseline	81	83	84	73	74	76	69	69	71
Kit No. 1	80	81	83	74	76	77	69	70	72
Kit No. 2	80	81	83	74	75	77	70	70	73

12/ CONCLUSIONS AND DISCUSSIONS OF RESULTS

The program has demonstrated that a useful amount of noise reduction is obtainable with relatively minor changes to the bus. These changes include improving the quality of the exhaust system, increasing the efficiency of the radiator cooling fan, and adding vibration-damped valve rocker arm covers to the engine and sound absorbing materials to the inside of the engine compartment. The noise reduction is achieved without significantly altering the performance or maintainability of the vehicle.

The program also demonstrated the importance of vehicle maintenance, as indicated by the excessive noise levels due to a defective tail pipe and a worn transmission which subsequently failed.

On the baseline vehicle, it was established that the major noise sources were engine mechanical noise, exhaust system, and radiator cooling fan. Minor sources were engine air intake noise, transmission, and the air compressor. Aerodynamic and tire noise was minimized because of the low road speeds involved.

Source magnitude calculations based on the SAE J366a acceleration pass-bys show that the contributed noise levels were as follows:

Engine Mechanical Noise	79 dB(A)
Exhaust System	79 dB(A)
Radiator Cooling Fan	77 dB(A)
All Other Sources	65 dB(A)
Total Baseline Noise	83 dB(A)

The installation of Sound Attenuation Kit #1 reduced engine mechanical noise by 3dB(A) due to the damped rocker arm covers and the sound absorbent material. The new exhaust system dropped to 65 dB(A) but the cooling fan noise remained unchanged.

Engine Mechanical Noise	76 dB(A)
Exhaust System	65 dB(A)
Radiator Cooling Fan	77 dB(A)
All Other Sources	65 dB(A)
Total Sound Attenuation Kit #1	80 dB(A)

Sound Attenuation Kit #2 achieved a further 1 dB(A) reduction in engine mechanical noise due to the vertical partition, and fan noise was reduced because the contoured fan shroud increased the efficiency of the fan and lowered its running speed. During the dynamometer tests, adequate cooling was obtained with a fan speed of 1500 rpm, which lowers the contributed noise level to 71 dB(A).

Engine Mechanical Noise	75 dB(A)
Exhaust System	65 dB(A)
Radiator Cooling Fan	71 dB(A)
All Other Sources	65 dB(A)
Total Sound Attenuation Kit #2	77 dB(A)

It must be emphasized that the noise levels measured for the two kits represent normal average operating conditions. However, on a cold day when the cooling fan would be shut off, SAK #1 would produce only 77 dB(A) and conversely, on a very hot day with a full load, SAK #2 could produce 79 dB(A) because there is nothing to stop the fan running at the full 2100 rpm if it is required.

The two quietest configurations tested were condition 3 which had full engine encapsulation (74.5 dB(A)), and condition 8a which had the standard radiator grille replaced by a forward-facing air scoop (73 dB(A)). Neither configuration proved practical because of cooling problems. However, the principles may have applications on future vehicles if noise levels below 75 dB(A) become mandatory. Solutions to engine capsule cooling problems have been successfully demonstrated and mounting the radiator cooling fan other than in the side of the vehicle has been studied. It is estimated that the "ultimate" kit from the test vehicle would have resulted in a specially-cooled engine capsule and a relocated, redesigned radiator cooling system. The SAE J366a passby level was estimated to be 71 dB(A). Such a kit would be very expensive and would result in greatly-increased maintenance problems.

The location of the exhaust tail pipe was shown to be significant before the exhaust system was improved. The vertical, roof-level tail pipe yielded lower noise levels than did the standard configuration, due to the change in directivity pattern; thus some of the so-called EIP's (Environmental Improvement Packages) could be beneficial to current buses. However, once the exhaust system was improved and its noise level contribution dropped, the position of the tail pipe ceased to have any effect.

Because of the reduction in exhaust noise and the fact that the engine mechanical noise responded to treatment such as the damped rocker arm covers and sound absorption in the engine compartment, the radiator cooling fan became the prime noise source. A lighter, more expensive and supposedly more efficient fan was tested but showed very little improvement over the standard fan. There was no space available in which to install a larger fan, thus the only practical solution was to increase the efficiency of the present fan and enable it to run slower or less often. The contoured shroud and tunnel, with its improved air flow pattern and fan tip clearance, achieved this goal. It should be pointed out, however, that the shroud itself does not reduce the noise level, it merely allows the fan to run slower for a given air volume flow requirement.

The improved efficiency of the fan rendered it more susceptible to back pressure and surprisingly, an essential part of the sound attenuation kit is the removal of all undertrays in order to minimize restrictions to the air flow. This applies even to SAK #1 where the contoured fan shroud is not fitted. The undertrays are very poor noise shields unless they are full-width and tightly sealed. Removal of the undertrays may cause a 1 dB(A) increase in engine noise but can result in a 6 dB(A) or more decrease in fan noise.

Although far field noise was reduced by the sound attenuation kits, the curbside pullaway noise remained virtually unchanged. The reason for this is not apparent and time did not permit investigation of the phenomenon. The correlation of near and far field noise levels generated by buses is worthy of further investigation.

The vehicle interior noise levels were not affected by the installation of either sound attenuation kit. As can be seen from Figures F.5-1 through F.5-3, the bus interior exhibits very strong acoustical modes in the one-third octave bands containing the crankshaft fundamental frequency and its second and third harmonics. The sound pressure levels in these bands do not indicate a decrease as one passes from the rear to the front of the bus, as in the case with the higher frequencies. The lowest characteristic frequency of bus interior resonance is approximately 32 Hz, which is strongly excited as the engine comes into the test speed range of 75% to 95% of rated speed and standing waves form along the length of the vehicle.

Away from the low frequency engine, the interior noise exhibits a typically steeply falling spectrum (approximately 10 dB per octave), with overall noise levels being in the order of 10 dB(A) lower at the front of the bus than at the rear. It was suspected that the interior noise is due in most part to the engine compartment noise entering the body structure and being reradiated, effectively bypassing the barrier of the rear bulkhead. This was shown experimentally when the rear of the bus was totally sealed off with a heavy plywood partition and the resulting compartment was filled with sound absorbent material. With the microphone placed at the mid-coach position, measurements were made with and without the partition. As is shown in Figure F.4-10 there is only 1 dB(A) difference between the readings indicating almost complete flanking of the barrier. Plans to increase the sound transmission loss of the rear seat area were abandoned.

APPENDIX A

TEST PLAN EVALUATION OF SOUND ATTENUATION KIT FLXIBLE BUS

1.0 INTRODUCTION

1.1 OBJECTIVE

The objective of the tests is to develop a sound attenuation retrofit kit for a Rohr Flxible bus in accordance with Contract No. TMP-0134-WB.

1.2 RESPONSIBILITY FOR TESTS

The tests will be conducted by the Rohr Industries Highway Transportation Engineering Department.

1.3 TEST ARTICLE

The test article will consist of a factory reconditioned Flxible bus powered by a Detroit Diesel Model 6V-71 engine and an Allison 3 speed automatic transmission. At the present time, nearly 3000 of these vehicles are in operation.

2.0 TEST SET-UP

2.1 DESCRIPTION

All measurements will be carried out as specified in the reference contract and as described below in this document.

2.2 TEST CONDITIONS

All noise level measurements will be carried out under ambient climatic conditions but within the following restraints:

a. Measurements shall be made only when the wind velocity is below 12 MPH.

b. The ambient sound level (including wind effects) coming from sources other than the source being measured, shall be at least 10 dB lower than measured source. Under some circumstances where this is not possible, accepted acoustical level difference subtraction techniques may be employed to obtain required source levels.

c. In the event of rain and other precipitation, testing shall be postponed until the pavement in the area is completely dry.

2.3 TEST EQUIPMENT, INSTRUMENTATION, AND PERSONNEL

The following equipment, instrumentation, and test personnel will be required to perform the exterior airborne noise tests.

a. Precision Sound Level Meter which meets the ANSI S1.4-1971 and IEC 179 requirements for type 1 meters.

b. Calibrated Wind Screen for the microphone.

c. Adjustable Tripod which will support the sound level meter at various heights and orientations.

d. Portable Tape Recorder which when used in conjunction with the sound level meter, will meet the overall system frequency response specified in SAE J184.

e. Portable calibrator for the sound level meter - tape recorder system.

f. Audio Frequency Spectrometer with octave and one-third octave frequency band analysis capability.

g. Acoustic Test personnel will consist of one qualified acoustical engineer and one technician.

In all cases, instrument practices will be as prescribed by the manufacturer, and procedures laid down in SAE J366a latest revision will be followed.

2.4 TEST SITE

The test site will be laid out in strict accordance with Section 3 and Figure 1 of SAE J366a latest revision (See Figure A-1).

3.0 PROCEDURES

The driver will perform a number of dry runs in order to establish his ability to operate the vehicle within the constraints of the SAE test procedures and at the various conditions dexcribed below:

3.1 EXTERIOR NOISE TESTS DESCRIPTION

The vehicle will be operated at the following conditions:

a. In accordance with the Society of Automotive Engineers recommended practice J366a current revision.

b. Constant speed drive by at less than 35 MPH with an engine revolution rate of 80% of governed speed.

c. Constant speed drive by at less than 35 MPH with an engine revolution rate of 90% of governed speed.

d. Constant speed drive by at less than 35 MPH with an engine revolution rate of 100% of governed speed.

e. Constant speed drive by, coasting at a speed equal to that achieved under condition (d).

f. Stationary with the engine at a revolution rate of 80% of governed speed.

g. Stationary with the engine at a revolution rate of 90% of governed speed.

h. Stationary with the engine at a revolution rate of 100% of governed speed.

The sound level meter will be mounted on its tripod and fitted with its wind screen. The tripod will be placed at the measurement position shown in Figure 1 so that the microphone is 50 feet from the centerline of the vehicle path. The microphone will be oriented in accordance with the manufacturer's instructions and the sound level meter controls will be set to the C-weighted network and fast meter response.

The test bus will drive past the microphone in both directions and at the operating conditions (a) through (e) or parked on the microphone point so that the center of the cooling fan is on the axis of the microphone for conditions (f) through (h). Measurements will be made until two highest readings which differ by no more than 2 dB have been obtained for each operating condition in each direction. It is recommended that no less than three runs be made at each operating condition and in each direction for conditions (a) through (e) and that at least one minute of recording be made for conditions (f) through (h).

The acoustical engineer will take up a position with respect to the sound level meter as recommended by the manufacturer. Because bystanders have an appreciable influence on meter response when they are in the vicinity of the vehicle or the microphone, not more than one person, other than the acoustical engineer reading the meter, shall be within 50 feet of the vehicle path or instrument and that person should be the acoustical technician who shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

All information shall be recorded on magnetic tape. Any reading may be discounted if:

a. The wind speed is in excess of 12 MPH when the vehicle is in the test zone.

b. Any extraneous noise, such as airplanes, other vehicles, conversations, etc., interfere with the recording.

3.2 INTERIOR NOISE TESTS DESCRIPTION

The vehicle will be operated at the same conditions listed in Section 3.1 above.

The sound level meter will be placed at the following locations:

a. Center of rear seat equivalent to right ear of patron.

b. Mid-coach left window seat, right ear of patron.

c. At operator's location in accordance with SAE J336, Paragraph 4.1.

The meter may either be hand held or tripod-mounted with the microphone oriented vertically. The controls will be set to the C-weighted network and fast meter response. The number of test runs will be similar to those recommended in Section 3.1 above.

3.3 GENERAL PROCEDURES

The sound level meter tape recorder system will be calibrated end to end using the portable calibrator, the calibration signal being recorded on magnetic tape. A calibration will be performed both at the start and the end of the tests. If delays should occur in the middle of a series of runs necessitating postponement of the remainder until another day, calibrations will be performed at least at the beginning and end of each working day.

Readings may be taken in real time by the acoustical engineer who will note the highest value shown by the sound level meter when set to the A-weighted network, fast meter response.

The acoustical engineer will keep a careful log of the measurement runs noting the bus operating condition, the microphone location, instrumentation control settings, the real time sound level, the date and time and any other data considered relevent. He will also, when possible, identify any tape recordings made in a clear, concise manner by a voice commentary before or after the measurement run. There will be no talking or other extraneous noises during acquisition of data.

It is intended as far as possible to comply with the highly specific instructions contained in the Statement of Work of the referenced contract document. However, because of the "cut and try" nature of the initial sound suppression efforts with its attendant uncertainties, some deviations from the test plan and procedures may become necessary. These, if any, will be carefully explained and documented.

4.0 INITIAL TESTING

The completely unmodified bus will be instrumented with tachometer, thermocouples and any additional equipment necessary to carry out the performance tests.

A complete series of acoustic measurements will be carried out according to Sections 3.1, 3.2 and 3.3 in order to establish the noise levels generated by the present day bus.

Using these noise levels as a baseline, it will be possible to determine the effect of the various sound attenuating components, the total effect of the complete kit and also the accuracy of the method when the vehicle is reduced to its original condition at the end of the program and retested.

5.0 IDENTIFICATION OF NOISE SOURCES

There will be little equipment modification. Source noise control procedures will be carried out using as a guideline the draft report 74-2, "Noise Control Handbook" for diesel powered vehicles, Part 1 - Procedures for Noise Control, prepared for the Department of Transportation, Transportation Systems Center.

In order to determine the lowest noise level obtainable from the bus, the following sound reduction measures will be taken:

a. Engine and transmission will be completely enclosed in lead sheet and sound absorbing material.

b. The air intake system will be completely wrapped and air ducted in through an extension pipe.

c. The exhaust system will be completely wrapped in asbestos and lead and the exhaust pipe extended for vertical operation.

d. All fans, blowers and pumps will be switched off where possible.

When the vehicle is fully treated, measurements of coast-by noise will be made to establish tire, chasis and aerodynamic contribution.

Each separate source will then be ascertained by operating it alone. This will either be done by running a component separately on by uncovering one particular source while leaving all others covered or switched off. In this way it is hoped to obtain the magnitudes of the following sources;

a. Chassis, tire and aerodynamic contributions.

b. Air intake.

c. Engine exhaust.

d. Engine cooling fan.

e. Transmission.

f. Auxiliary equipment.

From these data will also be obtained the effective sound insulation of the body structure between the engine compartment and the passenger area.

6.0 PRACTICAL MEASURES FOR SOUND ATTENUATION

Work carried out under Section 5.0 will identify each noise source, but the sound suppression measures used may prove totally unacceptable in terms of maintainability or vehicle operation and performance. The following steps will be taken to replace the temporary treatment.

a. The Detroit Diesel Engine will be fitted with isolated rocker covers and noise shields designed by the manufacturer.

b. If necessary and practical, an acoustical enclosure will be designed for the transmission.

c. The air intake will be fitted with an optimized silencer.

d. The exhaust muffler will be optimized and exhausted vertically.

e. The cooling fan will be replaced with a more efficient shrouded unit.

f. The engine compartment will be modified to include sound absorbent and vibration damping materials, a full width undertray will be fitted and alternative designs of grille investigated. All potential acoustic leaks in this area will be eliminated.

g. The rear seat will be removed and acoustical barrier and absorbent materials installed to optimize the structure between machinery and passengers.

All of these measures may be evaluated separately by the methods employed in Section 5.0.

7.0 FINAL TESTING

When all measures laid down in Section 5.0 have been completed, the bus will be retested as in Sections 3.1, 3.2 and 3.3 above.

Thus, bus will then be returned as far as possible to the condition as originally received by Rohr and the baseline measurements will be rerun.

8.0 AUTHORITY FOR STOPPING TESTS

8.1 This authority shall be vested in any of the following persons or their superiors:

a. Rohr Test Conductor assigned.

b. Rohr Quality Assurance Representative assigned.

8.2 This authority shall only be exercised as a recourse under one or more of the following conditions:

a. Failure to meet intent of contract.

b. Release of a design change or other action affecting any noise source.

c. Any factor exists which prevents proper establishment of test conditions or prevents adequate determination.

d. A safety hazard exists.

9.0 DOCUMENTATION

9.1 DATA REDUCTION

Data recorded on magnetic tape will be analyzed into octave bands for rough order of magnitude evaluation and into one-third octave bands for more detailed study. Original graphic level recorder charts may be generated.

9.2 DATA RECORDING FORMS

Relevant real time data will be recorded on test data sheets, Figures A-2 and A-3.

9.3 REPORTS

Reports will be issued in accordance with the reference contract document.

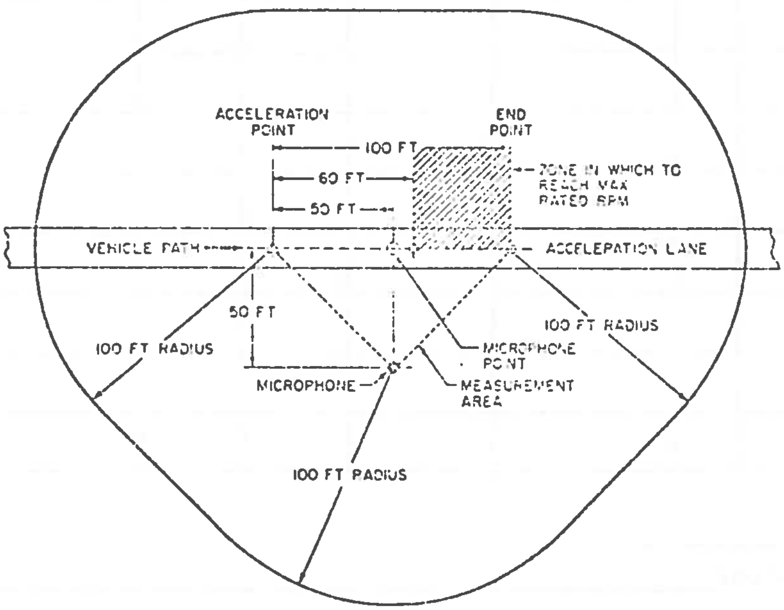

Figure A-1. Test Site Layout

EXTERIOR (COMMUNITY) NOISE LEVEL

Vehicle Operating Condition	Side of Bus (L or R)	Run No.	Sound Level Meter Attenuator Setting	Tape Recorder Gain Setting	Sound Level dB(A) Fast	Wind Speed MPH	Wind Direction	Time	Date

Prepared By____________________

Remarks and Observations____

Figure A-2. Test Data Form - Exterior Noise Level

INTERIOR NOISE LEVELS

Vehicle Operating Condition	Microphone Location	Run No.	Sound Level Meter Attenuator Setting	Tape Recorder Gain Setting	Sound Level dB(A) Fast	Time	Date

TEST COMMENTS: ______________________________

____

____

____

____

TEST ENGINEER: ______________

DATE: ______________

Figure A-3. Test Data Form - Interior Noise Level

APPENDIX B

TEST PLAN

VEHICLE PERFORMANCE

FLXIBLE BUS

David L. Overgard

Engineer

Approved: Keith Barnes
Engineer, Senior

E. N. Kravitz, Chief
Vehicle Design

Test Plan: ATSD 1001

Project: Flxible Bus
Sound Attenuation Kit

Issued: March 1974

1.0 INTRODUCTION

1.1 OBJECTIVE

The objective of this test is to determine the performance of the Flxible Bus.

1.2 RESPONSIBILITY FOR TESTS

The vehicle performance tests will be conducted by Rohr Industries Advanced Transportation Systems Division, Engineering Department.

1.3 TEST ARTICLE

The test article will consist of Flxible Bus No. 55106 loaded to the GVWR which is defined as the vehicle wet weight plus 45 seated passengers.

2.0 TEST SET-UP

2.1 DESCRIPTION

A flat, level, straight road surface of sufficient length to safely conduct the test shall be required. Safety measures shall be taken to assure that the bus being tested will be the only vehicle on the road surface.

2.2 TEST CONDITIONS

The bus shall only be tested on a dry road surface, with the ambient temperature between $50^{o}F$ and $80^{o}F$. Wind conditions shall be from nil to light.

2.3 TEST EQUIPMENT, INSTRUMENTATION AND PERSONNEL

The following equipment, instrumentation, and personnel will be required to perform the vehicle performance test:

a. Flxible Bus No. 55106 loaded to GVWR
b. Fifth wheel, equipped with instrumentation to measure distance and velocity

c. Stop watch

d. Appropriate test personnel

3.0 TEST PROCEDURE

3.1 DESCRIPTION

a. <u>Vehicle Acceleration</u>

The bus will be accelerated from rest at maximum throttle, on level ground, with all accessories operating. A stop watch will be used to measure the time required to attain a speed of 10 mph and this value recorded on the Figure 1. Repeat six times. Then repeat the procedure for 0-20 mph, 0-30 mph, 0-40 mph, 0-50 mph, 0-60 mph, 0-70 mph.

b. <u>Top Speed</u>

The bus will be operated on level ground, at maximum throttle with all accessories operating, until a maximum speed is attained. This speed will be recorded on the Top Speed Data Sheet Figure 2. Repeat the test in the opposite direction.

c. <u>Gradeability Test</u>

The bus will be operated on a 3% grade at maximum acceleration with all accessories operating. Maximum maintained speed will be recorded on the Gradeability Test Data Sheet Figure 3. Repeat the test three times.

3.2 PASS/FAIL/REJECTION CRITERIA

The vehicle performance tests are designed to establish the pass/fail criteria for further testing and, therefore, do not have any pass/fail criteria of their own. The acceptance of the performance data, therefore, is soley dependent on the test conductor's judgment of whether or not the test was a "best effort." If the test is not a "best effort" then it must be repeated.

3.3 AUTHORITY FOR STOPPING TESTS

3.3.1

This authority shall be vested in any of the following persons or their superiors.

a. Rohr Test Conductor Assigned

b. Rohr Responsible System Design Engineer

c. Rohr Safety Engineer

3.3.2

This authority shall only be exercised as a recourse when one of the following conditions exists.

a. Failure to meet pass/fail criteria.

b. Release of a design change affecting vehicle performance.

c. Any factor exists which prevents proper establishment of test conditions or prevents adequate determination.

d. Any safety hazard exists.

4.0 DOCUMENTATION

4.1 DATA RECORDING FORMS

Test data will be recorded on Test Data Sheets, Figures B-1, B-2, and B-3.

4.2 DATA REDUCTION METHODOLOGY

No data will be reduced from this test other than specified on the Test Data Sheets.

4.3 REPORT

A concise summary report will be prepared presenting the Test Data Sheets, Figures 1, 2 and 3, any deviations from the test plan, photographs of the test set-up and the Test Verification Signature Sheet.

5.0 DEPOSITION OF THE TEST ARTICLE

Upon satisfactory completion of this test, the vehicle will be assigned for other test purposes defined by the Program Test Schedule.

ACCELERATION TEST

GVWR__________ LBS.   WET WEIGHT__________ LBS.   DIFFERENTIAL GEAR RATIO__________

ENGINE__________ HP AT__________ RPM   WIND VELOCITY__________ MPH

TRANSMISSION 1ST GEAR__________   TIRE SIZE__________

RATIO: 2ND GEAR__________   TIRE PRESSURE__________ FRONT__________ REAR

2RD GEAR__________   FRONTAL AREA__________ FT^2

VEHICLE DIRECTION__________   WIND DIRECTION__________

SPEED	TIME TO ATTAIN, SECONDS				Gear Change Speed, MPH		REMARKS
MPH	Trial 1	Trial 2	Trial 3	Average	2nd Gear	3rd Gear	
10							
20							
30							
40							
50							
60							
70							

TEST COMMENTS:__________

TEST DATA FORM
FLXIBLE PERFORMANCE TESTS

TEST ENGINEER:__________
DATE:__________

Figure B-1. Acceleration Test Data Form

TOP SPEED TEST

G.V.W.R. ______ LBS. WET WEIGHT ______ LBS. FRONTAL AREA ________ FT^2

ENGINE ______ H.P. AT ______ RPM WIND DIRECTION __________

TRANSMISSION RATIO 1ST GEAR ______

2ND GEAR ______ VEHICLE DIRECTION __________

3RD GEAR ______

DIFFERENTIAL RATIO ______ TIRE SIZE ______

WIND VELOCITY ______ MPH TIRE PRESSURE ______ FRONT ______ REAR

MAXIMUM SPEED ATTAINED, MPH

TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE

Test Comments ______________________________

Test Engineer __________

Date: __________

Figure B-2. Flxible Performance Test Data Form

GRADEABILITY TEST

GVWR ____________LBS. WET WEIGHT______________LBS.

ENGINE__________HP AT__________RPM

TRANSMISSION RATIO 1ST GEAR___________ FRONTAL AREA_________FT^2

2ND GEAR___________ GRADE__________PERCENT

3RD GEAR___________ WIND DIRECTION _______________

DIFFERENTIAL RATIO_____________________ VEHICLE DIRECTION _______________

WIND VELOCITY______________________MPH

TIRE SIZE_____________________________

TIRE PRESSURE____________FRONT____________REAR

MAXIMUM SPEED ATTAINED, MPH

Trial 1	Trial 2	Trial 3	Average

TEST COMMENTS____

TEST ENGINEER:______________________________

DATE:______________________________

Figure B-3. Gradeability Test Data Form

APPENDIX C

TEST PLAN

POWER PLANT COOLING TEST

FLXIBLE BUS

D. L. Overgard
Engineer

APPROVED: ____________,
K. R. Barnes,
Senior Engineer

____
E. N. Kravitz, Chief
Vehicle Design

TEST PLAN: ATSD-1002

PROJECT: 360

ISSUED: March 1974

1.0 INTRODUCTION

1.1 OBJECTIVE

The objective of this test is to determine the ability of the power plant equipment to operate at design temperatures while operating in urban transit use.

1.2 RESPONSIBILITY FOR TESTS

The Power Plant Cooling Test will be conducted by Rohr Industries Advanced Transportation Systems Division Engineering Department.

1.3 TEST ARTICLE

The Test Article will consist of Flxible bus No. 55106 loaded to the GVWR which is defined as vehicle wet weight plus 45 seated passengers.

2.0 TEST SET-UP

2.1 DESCRIPTION

Thermocouples will be installed in the locations indicated in Figure C-1. A switch will be used for selection of the desired thermocouple location.

2.2 TEST CONDITIONS

a. Idle test and simulated bus operations test will be conducted at Rohr Industries, Inc., Chula Vista, California.

b. The maximum governed speed test will be performed on Interstate 8 between Ocotillo Wells and Yuma where a top mph speed can be maintained.

These tests will be conducted at GVWR and all accessories operating as shown on page 5.

2.3 TEST EQUIPMENT, INSTRUMENTATION, AND PERSONNEL

The following equipment, instrumentation, and test personnel will be required to perform the power plant cooling tests.

a. Twelve thermocouples with hardware for connecting to various points on the engine and the cooling systems.

b. Temperature read-out instrumentation equipped to read and record the 12 thermocouple locations.

c. A fifth wheel equipped with instrumentation to measure distance, and velocity.

d. Appropriate test personnel.

3.0 PROCEDURE

3.1 DESCRIPTION

a. Idle

The engine will be started at ambient temperature and temperatures recorded every five minutes. Thermocouple location will be considered to have a stabilized temperature when three consecutive readings are within $1^{o}F$. Thermocouple locations 1-12 (Figure 1) will be considered. Data will be recorded on Test Data Sheet, Figure 2.

b. Simulated Bus Operations

The vehicle will accelerate at moderate acceleration to 30 mph, cruise at a steady speed, and then decelerate to a stop. The distance traveled from start to stop will be 0.3 miles. At each stop the vehicle will idle for 30 seconds before repeating the cycle. Temperature readings will be taken shortly before braking and immediately after stopping. A thermocouple location will be considered to have a stabilized temperature when three consecutive readings are within $1^{o}F$. Data will be recorded on a test data sheet, Figure C-2. All thermocouple locations will be considered for this test.

c. Maximum Governed Speed

The vehicle will maintain maximum governed speed for this test. Temperatures will be recorded every 5 minutes on a test data form, Figure 2. A thermocouple location will be considered to have a stabilized temperature when three consecutive readings are within $1^{o}F$. All thermocouple locations will be considered for this test. Before the test, ambient air temperature, humidity, and barometric pressure will be measured.

3.2 PASS/FAIL/REJECTION CRITERIA

All temperatures shall be within acceptable limits

3.3 AUTHORITY FOR STOPPING TESTS

3.3.1

This authority shall be vested in any of the following persons or their superior.

a. Rohr Test Conductor assigned

b. Rohr Quality Assurance Representative assigned.

3.3.2

This authority shall only be exercised as a recourse when one or more of the following conditions exists.

a. Failure to meet pass/rejection criteria.

b. Release of a design change affecting the engine or power train.

c. Any factor exists which prevents proper establishment of test conditions or prevents adequate determination.

d. A safety hazard exits.

4.0 DOCUMENTATION

4.1 DATA RECORDING FORMS

Test data will be recorded on test data sheets, Figure C-2.

4.2 DATA REDUCTION METHODOLOGY

No data will be reduced from this test other than specified on the test data sheets.

4.3 REPORT

A concise summary report will be prepared presenting the test data sheets, Figure 2, any deviation from the test plan, photographs of the test setup and the test verification signature sheet, Figure C-3.

5.0 DISPOSITION OF THE TEST ARTICLE

Upon satisfactory completion of this test, the Flxible bus will be assigned for other test purposes defined by the program test schedule.

	Approximate Design Operating Temperature $0^{o}F$
1. Radiator Top Tank	$200^{o}F$ Maximum
2. Radiator Bottom Tank	190^{o} - $192^{o}F$ Maximum
3. Air Leaving Radiator	ΔT 45^{o}- $60^{o}F$
4. Air Entering Radiator	Ambient-5^{o} above Ambient (Max)
5. Transmission Oil from Oil Cooler Tank	ΔT $30^{o}F$ Max.
6. Transmission Oil to Oil Cooler Tank	$300^{o}F$ (Max)
7. Engine Air Intake	$10^{o}F$ above Ambient (Max)
8. Engine Compartment - Aft Center	TBD $300^{o}F$ Max.
9. Engine Compartment - Bottom Forward	TBD $300^{o}F$ Max.
10. Engine Compartment - Top Forward	TBD $300^{o}F$ Max.
11. Alternator	$275^{o}F$ Max.
12. Engine Sump	$230^{o}F$ Maximum

Figure C-1. Thermocouples Required for Power Plant Cooling Tests

ACCESSORIES RUNNING DURING TESTS

1. All Exterior Lights
2. All Interior Lights
3. Air Conditioner
4. Destination Signs (if applicable)
5. Defroster

Engine ______ Fan ______ Dia. ______ Blades ______ Degrees ______ RPM

Transmission ______ Ambient Air Temp. ______

Differential ______ Ambient Air Press ______ Vehicle Weight Wet ______

Radiator ______ Ambient Air Humidity ______

Vehicle Weight Overload ______

Vehicle Weight Rated ______

THERMO COUPLE NO.	THERMOCOUPLE LOCATION	TEMPERATURE, ^{o}F, AT 5 MINUTE INTERVALS														
		5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

Figure C-2. Test Data Sheet - Power Plant Cooling

TEST REPORT

FLXIBLE BUS

TEST PLAN TITLE: Flxible Bus Power Plant Cooling Test

TEST PLAN NO.: ______________________________

REMARKS: ______________________________

____

____

____

____

____

____

____

DATE TESTED: ____________ TEST ENGINEER: ______________________________

WITNESSES: ROHR DESIGN REPRESENTATIVE ______________________________

SAFETY ENGINEER: ______________________________

Figure C-3. Test Report Form

APPENDIX D

SERVICE INFORMATION #402-0102-1

SOUND ATTENUATION KIT NO. 1

The service bulletin contained in Appendix D is intended as an example only. It does not imply or guarantee that the sound attenuation kit, or parts of the kit, are available from Rohr Industries or the Flxible Company.

THE **FLXIBLE** COMPANY

North Water Street, Loudonville, Ohio 44842
Phone: (419) 994-4141 Telex: 987431

a subsidiary of ROHR

Service Information

Date: January 1975 | Service Information # 402-0102-1 | Record in Section #10

SUBJECT: SOUND ATTENUATION KIT NO. 1
80 dBa SAE PASSBY RETROFIT

MODELS AFFECTED: ALL FLXIBLE TRANSIT COACHES WITH DETROIT DIESEL 6V71 TRANSVERSE ENGINE INSTALLATION

DOCUMENTS AFFECTED: MAINTENANCE MANUAL, FLXIBLE TRANSIT COACH
Section 10. Fuel System and Exhaust.
Engine and body components, not covered in detail by manual, are also affected. See "Description of Change," following.

SCOPE:

This service information describes Sound Attenuation Kit (SAK) No. 1, designed for maximum 80 dBa exterior sound level when installed on Flxible coach models affected. Kit listing and instructions for retrofit installation are included. The kit covered by this information was developed under Department of Transportation Contract No. DOT-TSC-[illegible], and has been tested in accordance with SAE Recommended Practices for sound level of heavy trucks and buses.

GENERAL DISCUSSION:

Vehicle performance changes resulting from the SAK installation are very minimal. Test data from dynamometer testing showed an increase in engine backpressure of 0.4 inches of Mercury. Fuel flow increased 1.0 pound per hour and horsepower loss measured at the wheels was less than 5 percent. Operation of the bus on a 32 mile test route yielded a fuel consumption of 4.26 miles per gallon.

In terms of this service information, the 80 dBa exterior sound level is stated as a design standard for coaches equipped with Sound Attenuation Kit No. 1. The SAK prototype coach installation established the standard in passby tests as recommended by SAE practice. Proper coach maintenance, however, is a prerequisite to attain and keep the 80 dBa level.

The following preventive maintenance tasks should be completed prior to SAK installation, and performed at regularly scheduled intervals, for proper kit performance.

1. A small amount of twist occurs in coach body, as complete rigidity of structure is not desirable. It is therefore important that body be regularly inspected for loose bolts and rivets.

2. Check all suspension and understructure fasteners. Tighten nuts and bolts as required. Refer to Flxible Maintenance Manual, Section 3 "Understructure Torque Chart."

3. Check floor board nuts and bolts. All floor board bolts are not accessible from beneath the coach, but those that are accessible should be located and tightened if necessary. Where heads of bolts are under floor covering, they cannot be kept from turning from above. If bolt turns when attempting to tighten nut, use a pair of vise-grips to hold the bolt. Tighten nuts to a snug fit, but do not overtighten. There is no specified torque.

4. Maintain recommended lubrication of coach. Refer to "Lubrication Guide" in Flxible Maintenance Manual, Section 15.

DESCRIPTION OF CHANGE:

The Sound Attenuation Kit is made to retrofit coaches equipped with standard or EIP exhaust system installation. Retrofit change to existing installation incorporates an elongated oval muffler with enlarged exhaust outlet. Sectional exhaust piping is fitted to muffler outlet and resonator is added between muffler exhaust and tail pipe. If coach is EIP-equipped, SAK resonator is in addition to existing exhaust resonator. EIP aspirator is changed to fit with enlarged exhaust piping, but tail pipe vertical stack above aspirator is not affected. Alternate procedures are noted in retrofit instructions.

The two existing rocker arm covers are removed and replaced by noiseless steel (metal-plastic-metal) formed covers, insides of which are reinforced with steel bolting and edge bands. Gaskets and bolt hardware are included with covers in kit.

Interior facings of engine access door and transmission access door (right rear side of coach) are covered with acoustic foam panels, fitted into door structural members. Sheet metal forms are installed to mount acoustic foam around engine door fixtures, and which are removable for service access to rear lights.

Replacement attaching and mounting parts required for retrofit are identified in kit listing and discussed with installation instructions which follow.

KIT LISTING:

Kit listing in this service information identifies retrofit items and Flxible standard parts required for SAK installation. Figure D-1 is a composite; illustration keyed to item numbers in kit listing. Installations are categorized and tabulated for alternate coach-equipped systems. Additional data for SAK installation on a particular coach model is available through Flxible Field Service Representative.

NOTE

Item numbers not used in illustration and kit listing are parts of Sound Attenuation Kit No. 2.

FLXIBLE

Date: January 1975 | **Service Information** #402-0102-1 | **Record in Section** #10

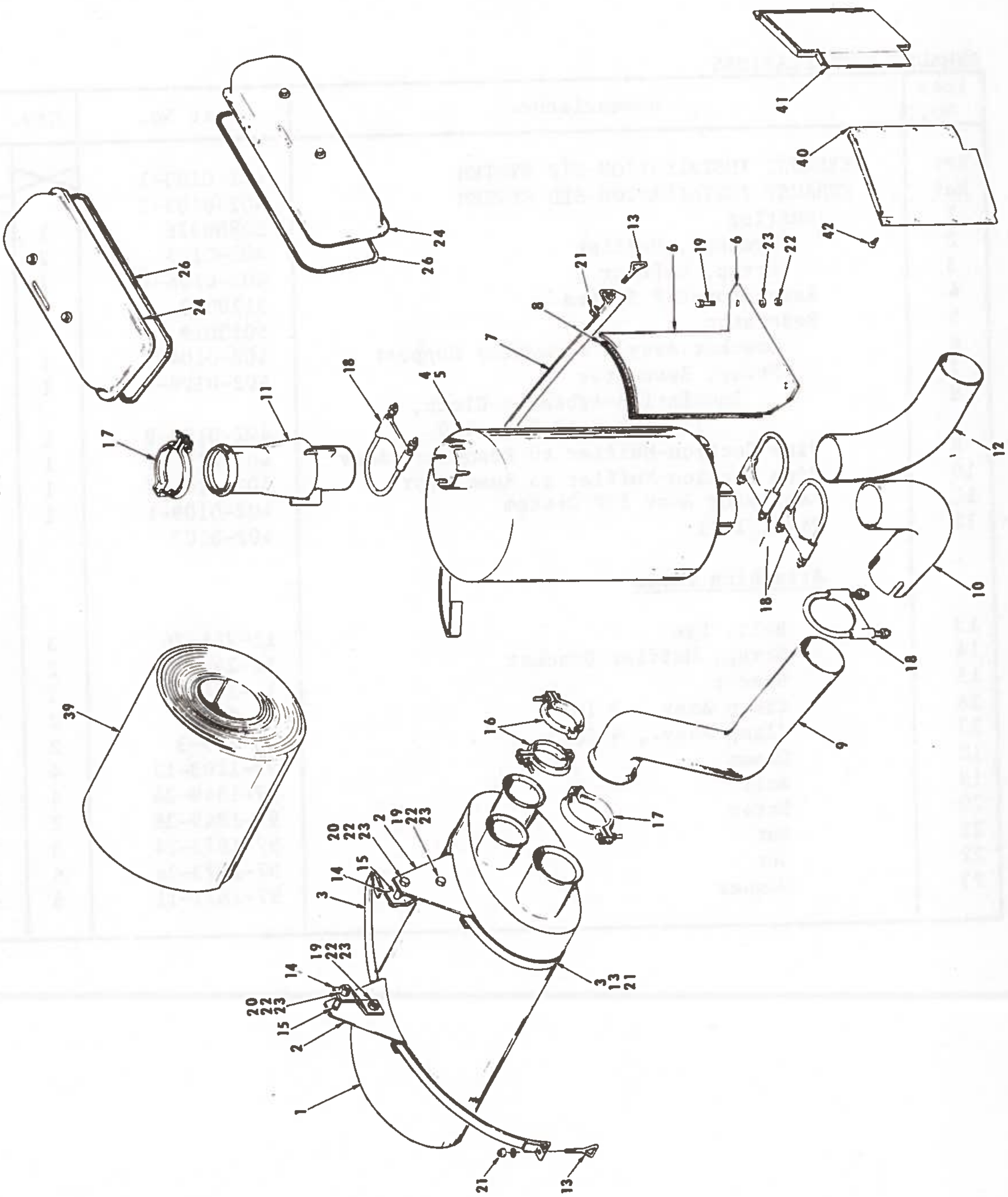

Figure D-1. Sound Attenuation Kit No. 1 - Composite Parts

FLXIBLE

Date: January 1975 **Service Information #** 402-0102-1 **Record in Section #** 10

EXHAUST INSTALLATIONS

Item No.	Nomenclature	Part No.	Qty. Rqd.	
Ref	EXHAUST INSTALLATION-EIP SYSTEM	402-0103-1	X	
Ref	EXHAUST INSTALLATION-STD SYSTEM	402-0103-3		X
1	Muffler	5080B376	1	1
2	Bracket, Muffler	402-0105	2	2
3	Strap, Muffler	402-0106-1	2	2
4	Resonator-EIP System	5120D12	1	
5	Resonator	5010D19		1
6	Bracket Assy., Resonator Support	402-0104-1	1	1
7	Strap, Resonator	402-0106-3	1	1
8	Insulation-Asbestos Cloth, 1/4 thk X 12.0 X 14.0	402-0103-9	1	1
9	Pipe Section-Muffler to Resonator Assy	402-0108-1	1	1
10	Pipe Section-Muffler to Resonator	402-0108-7	1	1
11	Aspirator Assy EIP System	402-0109-1	1	
12	Pipe, Tail	402-0107		1
	Attaching Parts			
13	Bolt, Eye	11-244-26	3	3
14	Strap, Muffler Bracket	11-244-40	2	2
15	Spacer	11-244-41	2	2
16	Clamp Assy., 3 in.	11-248-1	2	2
17	Clamp Assy., 4 in.	11-249-3	2	2
18	Clamp	97-1203-12	2	1
19	Bolt	97-1849-24	4	4
20	Screw	97-1849-28	4	4
21	Nut	97-1873-24	2	2
22	Nut	97-1873-26	3	3
23	Washer	97-1877-11	6	6

FLXIBLE

ENCLOSURE INSTALLATIONS

Item No.	Nomenclature	Part No.	Qty. Rqd.
Ref	ROCKER ARM COVERS	402-0110	
24	Cover Assy., Rocker Arm	402-0110-1	2
26	Gasket	Orig. Equip.	2

ACOUSTIC INSTALLATIONS

Item No.	Nomenclature	Part No.	Qty. Rqd.
Ref	ACOUSTIC INSTALLATION-ENGINE DOOR	402-0113-1	
39	Acoustic Foam-Approx. 32 sq. ft. (Specialty Composites Co.)	402-0113-9	1
40	Structural Form, Sheet Metal-LH	402-0113-5	1
41	Structural Form, Sheet Metal-RH	402-0113-6	1
	Attaching Parts		
42	Screw, Self-Tapping-1/4 X 1/2 in. long	Commercial	20

FLXIBLE

Date: January 1975 **Service Information #** 402-0102-1 **Record in Section #** 10

RETROFIT INSTRUCTIONS:

Use the following procedure for SAK installation on Flxible standard-equipped coach models. Alternate steps are noted for commonly used special equipment.

1. Remove existing engine underpans (Flxible P/N 16-709).

2. Remove existing muffler, the 3" tail pipe, the aft exhaust pipe from engine manifold to muffler, and associated support hardware. Leave as installed the forward exhaust pipe from engine manifold to muffler. See step (5) for reinstallation of aft manifold exhaust pipe to muffler.

NOTE

If coach is EIP-equipped, step (2) applies except for tail pipe. Instead, remove muffler exhaust pipe sections only up to and including the aspirator.

3. Remove engine oil filter assembly. See step (11) in this procedure for reinstallation.

4. Place exhaust pipe section (402-0108-1) through the bulkhead and across the engine support rail. This pipe section assembles to muffler in step (6).

NOTE

Typical SAK installations are shown in Figure D-2 for an EIP exhaust system and Figure D-2 for a standard exhaust system. Refer to Rohr Dwg. No. 402-0103 for engineering details. During installation of exhaust and tail pipes, care should be taken to properly position components in relation to each other. Incorrectly assembled parts of exhaust system can be cause of noises and damage due to improper clearance. Therefore, leave all clamp bolts temporarily loose until entire system has been inspected for adequate clearance between exhaust and engine components. After aligning pipes and checking entire system for clearances, tighten all clamps and bolts.

5. Install existing exhaust pipe (removed by step 2) from aft manifold on engine to location of muffler.

6. Install muffler brackets (402-0105). Install SAK muffler (5080B376), using two straps (402-0106-2). Install the two existing 3" exhaust pipes from engine manifolds to muffler inlets. Tighten the 3" clamp assemblies (11-248-1) at this time to ensure proper location of muffler. Position 4" exhaust pipe section (402-0108-1, see step 4) at muffler outlet and finger tighten the 4" clamp assembly (11-249-3).

7. Position 4" exhaust pipe section (402-0108-7) from mating pipe section (402-0108-1) to resonator location.

8. Place resonator (5010D19) in position behind radiator and in front of engine. Install resonator support bracket (402-0109-1) on aft engine cradle mount "Z"-member. Refer to Rohr Dwg. No. 402-0103 for location and drill callouts, and for use of attaching parts furnished in kit.

NOTE

If EIP coach, use resonator (5120D12) and install aspirator (402-0109-1).

9. Install resonator with asbestos cloth insulation (402-0103-9) on bracket, using strap (402-0106-3). Fit exhaust pipe section (402-0108-7) and tail pipe (402-0107) to resonator ports, using clamps (97-1203-12).

NOTE

If EIP coach, fit exhaust pipe section and aspirator to resonator ports; then fit aspirator to existing vertical stack tail pipe.

10. Inspect entire exhaust system for adequate clearances (see NOTE following step 4). Tighten all bolts and clamps. Visually examine all joints for tightness.

11. Install oil filter assembly (removed by step 3).

NOTE

New filter element and gasket is recommended at this time. Refer to FLXIBLE MAINTENANCE MANUAL Section 12 for replacement instructions.

12. Remove the two existing rocker arm covers and gaskets. Install SAK rocker arm covers (402-0110-1) with gaskets furnished in kit. Figures D-2 and D-3, following, are typical SAK installations.

NOTE

For improved sound attenuation, it is recommended that engine underpans removed by step (1) should not be reinstalled on coach.

13. Steam clean and degrease the aft engine access door and transmission access (right rear side) door.

14. Install sheet metal forms (402-0113-5 & 6) for acoustic foam installation on engine access door.

15. Install acoustic foam on interior facings of engine access door and transmission access door. Refer to Dwg. No. 402-0113 for engineering details and for manufacturer's instructions. See Figure D-4, following, for typical completed acoustic installation.

NOTE

Remaining foam sheet or scraps may be installed at other locations within engine compartment to improve sound attenuation.

16. Start engine and check entire exhaust system for leaks. Inspect around rocker arm covers for oil leakage. Check engine access and transmission access doors for straightness and sealing.

NOTE

AFTER SATISFACTORY CHECKOUT - COACH MAY BE RETURNED TO SERVICE.

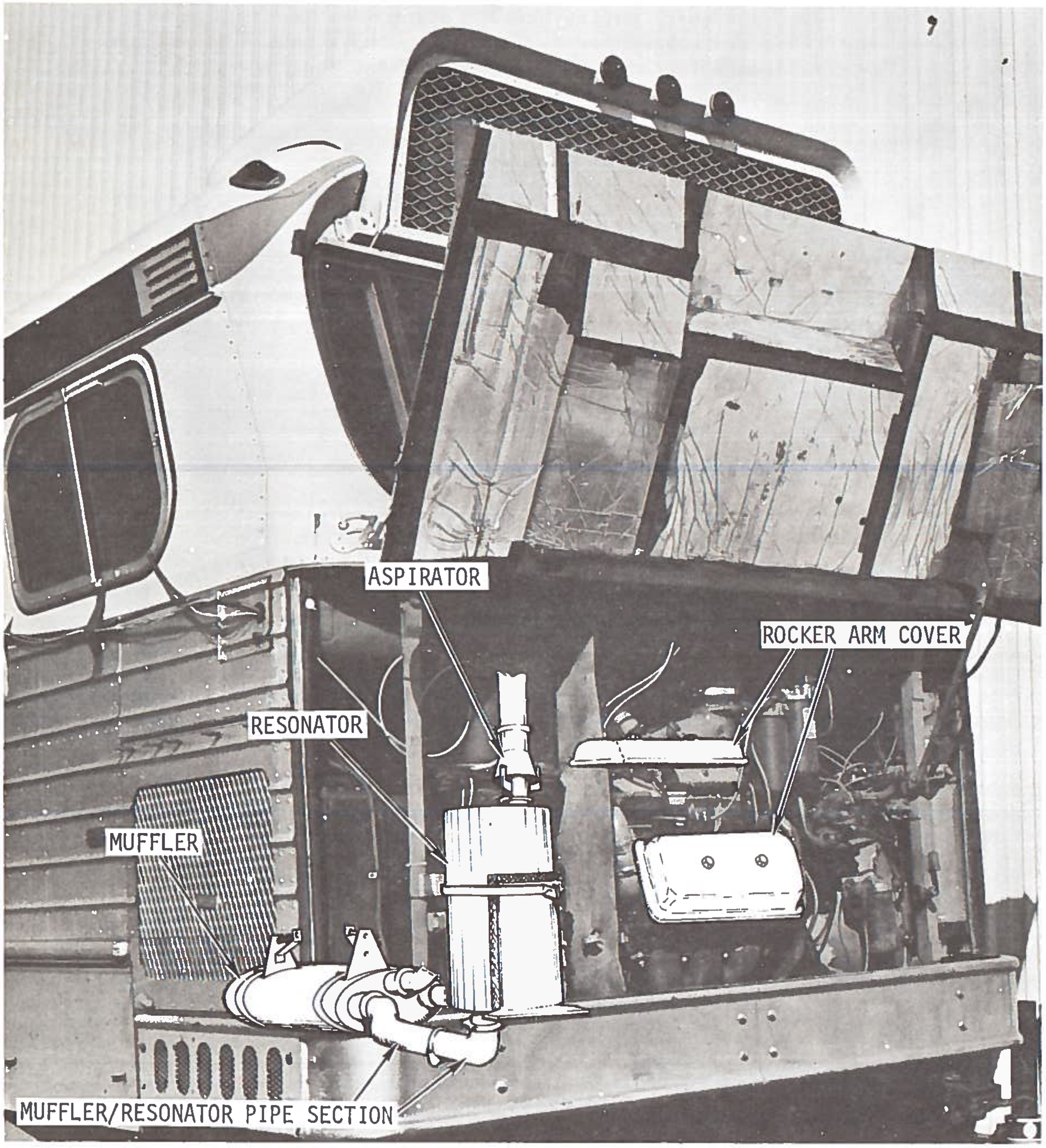

Figure D-2. SAK Installation - Coach Equipped with EIP Exhaust System

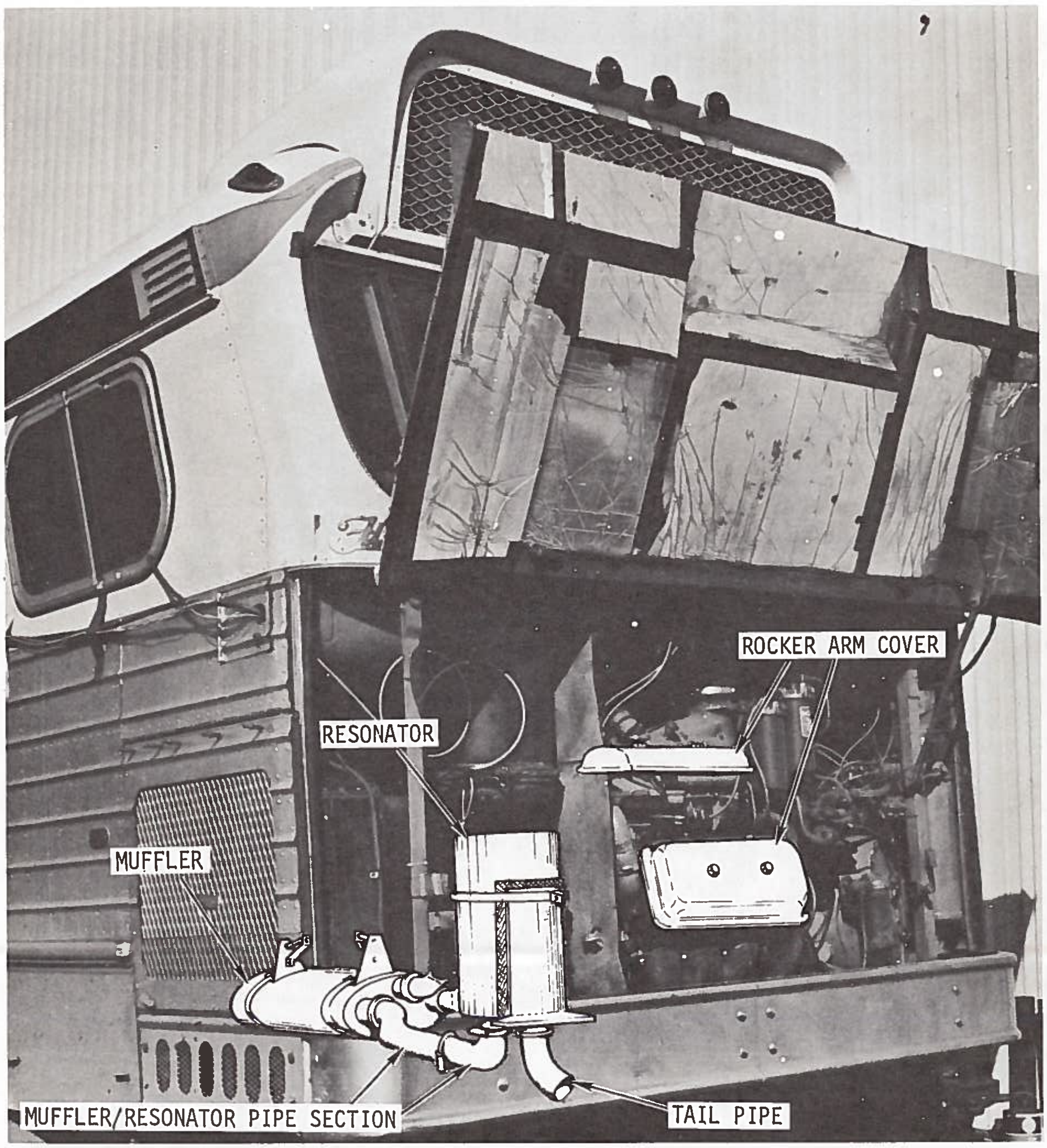

Figure D-3. SAK Installation - Coach Equipped with Standard Exhaust System

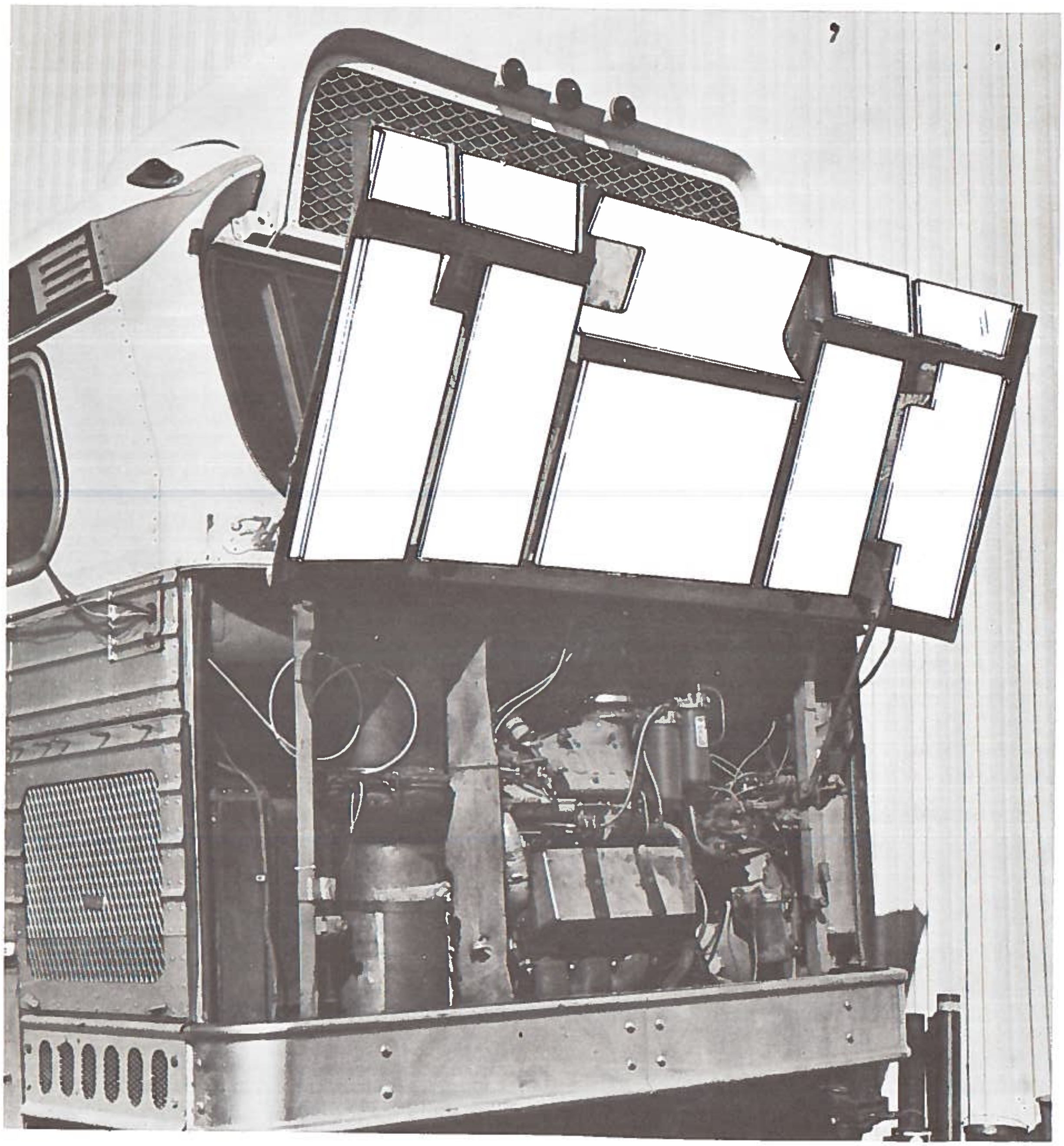

Figure D-4. SAK Acoustic Installation - Typical Engine Access Door Interior

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Date: January 1975 **Service Information # 402-0102-1** **Record in Section # 10**

REFERENCE DOCUMENTS:

Rohr Industries, Inc.

Drawings

402-0101	Sound Attenuation Kit - Final Report
402-0103	Installation - Exhaust System
402-0104	Bracket Assembly - Resonator Support
402-0105	Bracket - Muffler
402-0106	Strap Assembly - Muffler and Resonator
402-0107	Tail Pipe, Exhaust
402-0108	Pipe Assembly - Muffler to Resonator
402-0109	Aspirator Assembly - EIP System
402-0110	Rocker Arm Cover
402-0113	Acoustic Foam Installation (with Structural Forms)

Copies of Rohr Industries documents may be obtained through Flxible Field Service Representative.

Society of Automotive Engineers

SAE Recommended Practice

SAE J336	Sound Level for Truck Cab Interior
SAE J366a	Exterior Sound Level for Heavy Trucks and Buses

SAE Standard

SAE J672a	Exterior Loudness Evaluation of Heavy Trucks and Buses

Copies of SAE documents may be obtained from American National Standards Institute, Inc., 1430 Broadway, New York City, New York 10018.

NOTE:

1. Sound Attenuation Kit No. 2 - 77 dBa SAE Passby Retrofit is documented by Flxible Service Information No. 402-0102-2, and may be obtained through Flxible Field Service Representative.

APPENDIX E

SERVICE INFORMATION #402-0102-2

SOUND ATTENUATION KIT NO. 2

The service bulletin contained in Appendix E is intended as an example only. It does not imply or guarantee that the sound attenuation kit, or parts of the kit, are available from Rohr Industries, or The Flxible Company.

THE FLXIBLE COMPANY

Service Information

North Water Street, Loudonville, Ohio 44842
Phone: (419) 994-4141 Telex: 987431

a subsidiary of

Date: January 1975 | Service Information # 402-0102-2 | Record in Section # 10

SUBJECT: SOUND ATTENUATION KIT NO. 2
77dBa SAE PASSBY RETROFIT

MODELS AFFECTED: ALL FLXIBLE TRANSIT COACHES WITH DETROIT DIESEL 6V71 TRANSVERSE ENGINE INSTALLATION

DOCUMENTS AFFECTED: MAINTENANCE MANUAL, FLXIBLE TRANSIT COACH
Section 10. Fuel System and Exhaust.
Engine and body components, not covered in detail by manual, are also affected. See "Description of Change," following.

SCOPE:

This service information describes Sound Attenuation Kit (SAK) No. 2, designed for maximum 77 dBa exterior sound level when installed on Flxible coach models affected. Kit listing and instructions for retrofit installation are included. The kit covered by this information was developed under Department of Transportation Contract No. DOT-[illegible]-714, and has been tested in accordance with SAE Recommended Practice for sound level of heavy trucks and buses.

GENERAL DISCUSSION:

Vehicle performance changes resulting from the SAK installation are very minimal. Test data from dynamometer testing showed an increase in engine backpressure of 0.4 inches of Mercury. Fuel flow increased 1.0 pound per hour and horsepower loss measured at the wheels was less than 5 percent. Operation of the bus on a 32 mile test route yielded a fuel consumption of 4.26 miles per gallon.

In terms of this service information, the 77 dBa exterior sound level is stated as a design standard for coaches equipped with Sound Attenuation Kit No. 2. The SAK prototype coach installation established the standard in passby tests as recommended by SAE practice. Proper coach maintenance, however, is a prerequisite to attain and keep the 77 dBa level.

The following preventive maintenance tasks should be completed prior to SAK installation, and performed at regularly scheduled intervals, for proper kit performance.

1. A small amount of twist occurs in coach body, as complete rigidity of structure is not desirable. It is therefore important that body be regularly inspected for loose bolts and rivets.

2. Check all suspension and understructure fasteners. Tighten nuts and bolts as required. Refer to Flxible Maintenance Manual, Section 3 "Understructure Torque Chart."

3. Check floor board nuts and bolts. All floor board bolts are not accessible from beneath the coach, but those that are accessible should be located and tightened if necessary. Where heads of bolts are under floor covering, they cannot be kept from turning from above. If bolt turns when attempting to tighten nut, use a pair of vise-grips to hold the bolt. Tighten nuts to a snug fit, but do not overtighten. There is no specified torque.

4. Maintain recommended lubrication of coach. Refer to "Lubrication Guide" in Flxible Maintenance Manual, Section 15.

DESCRIPTION OF CHANGE:

The Sound Attenuation Kit is made to retrofit coaches equipped with standard or EIP exhaust system installation. Retrofit change to existing installation incorporates an elongated oval muffler with enlarged exhaust outlet. Sectional exhaust piping is fitted to muffler outlet and resonator is added between muffler exhaust and tail pipe. If coach is EIP-equipped, SAK resonator is in addition to existing exhaust resonator. EIP aspirator is changed to fit with enlarged exhaust piping, but tail pipe vertical stack above aspirator is not affected. Alternate procedures are noted in retrofit instructions.

The existing fan shroud is removed and replaced by a venturi-shaped shroud with minimum tip clearance. The SAK shroud allows more air flow through the radiator core for engine cooling. With the improved shroud installed, the cooling system gains efficiency and the fan can operate at reduced speed. Exterior sound is thereby abated.

A vertical partition is installed in the rear compartment between the engine and the air induction resonator. The partition serves as a barrier to engine noise. A cutout is provided where required for air induction ducting.

The two existing rocker arm covers are removed and replaced by noiseless steel (metal-plastic-metal) formed covers, insides of which are reinforced with steel bolting and edge bands. The aft facing cover mounts an engine oil filler spout. The existing oil filler assembly on the cylinder block is removed and the port is capped prior to installation of the compartment vertical partition (previous discussion), which obstructs access to the cylinder block location. Gaskets and bolt hardware are included with rocker arm covers in kit.

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Interior facings of engine access door and transmission access door (right rear side of coach) are covered with acoustic foam panels, fitted into door structural members. Sheet metal forms are installed to mount acoustic foam around engine door fixtures, and which are removable for service access to rear lights.

Replacement attaching and mounting parts required for retrofit are identified and illustrated in kit listing and discussed with installation instructions which follow.

KIT LISTING:

Kit listing in this service information identifies retrofit items and Flxible standard parts required for SAK installation. Figure E-1 is a composite illustration keyed to item numbers in kit listing. Installations are categorized and tabulated for alternate coach-equipped systems. Additional data for SAK installation on a particular coach model is available through Flxible Field Service Representative.

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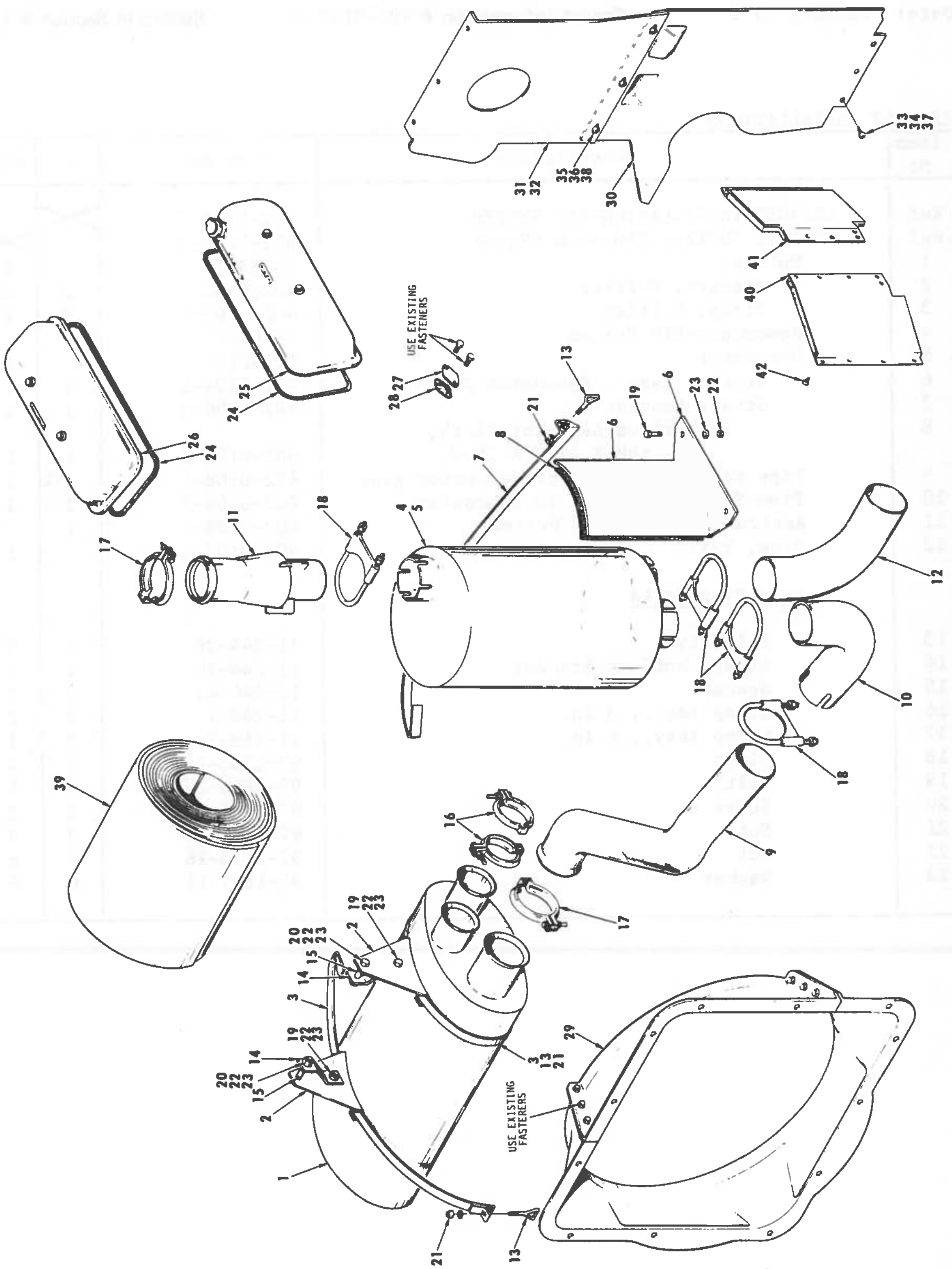

Figure E-1. Sound Attenuation Kit No. 2 - Composite Parts

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EXHAUST INSTALLATIONS

Item No.	Nomenclature	Part No.	Qty.	Rqd.
Ref	EXHAUST INSTALLATION-EIP SYSTEM	402-0103-1	X	
Ref	EXHAUST INSTALLATION-STD SYSTEM	402-0103-3		X
1	Muffler	5080B376	1	1
2	Bracket, Muffler	402-0105	2	2
3	Strap, Muffler	402-0106-1	2	2
4	Resonator-EIP System	5120D12	1	
5	Resonator	5010D19		1
6	Bracket Assy., Resonator Support	402-0104-1	1	1
7	Strap, Resonator	402-0106-3	1	1
8	Insulation-Asbestor Cloth, 1/4 thk X 12.0 X 14.0	402-0103-9	1	1
9	Pipe Section-Muffler to Resonator Assy	402-0108-1	1	1
10	Pipe Section-Muffler to Resonator	402-0108-7	1	1
11	Aspirator Assy - EIP System	402-0109-1	1	
12	Pipe, Tail	402-0107		1
	<u>Attaching Parts</u>			
13	Bolt, Eye	11-244-26	3	3
14	Strap, Muffler Bracket	11-244-40	2	2
15	Spacer	11-244-41	2	2
16	Clamp Assy., 3 in.	11-248-1	2	2
17	Clamp Assy., 4 in.	11-249-3	2	1
18	Clamp	97-1203-12	4	4
19	Bolt	97-1849-24	4	4
20	Screw	97-1849-28	2	2
21	Nut	97-1873-24	3	3
22	Nut	97-1873-26	6	6
23	Washer	97-1877-11	6	6

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ENCLOSURE INSTALLATIONS

Item No.	Nomenclature	Part No.	Qty. Rqd.	
Ref	ROCKER ARM COVERS	402-0110		
24	Cover Assembly, Rocker Arm	402-0110-1	1	
25	Cover Assembly, Rocker Arm-with oil filler spout	402-0110-2	1	
26	Gasket	Orig. Equip.	2	
Ref	OIL PORT COVER			
27	Plate	402-0115-3	1	
28	Gasket	402-0115-5	1	
Ref	FAN ENCLOSURE			
29	Shroud Assembly, Fan	402-0111	1	
Ref	ENGINE ENCLOSURE	402-0114		
Ref	Vertical Partition-EIP System	402-0114-1		
Ref	Vertical Partition-Std. System	402-0114-3		
30	Panel, Lower	402-0114-5	1	1
31	Panel, Upper	402-0114-7	1	
32	Panel, Upper-with cutout	402-0114-9		1
	<u>Attaching Parts</u>			
33	Screw, Self-Tapping-No. 10, 24 TDS X .50 in. long	Commercial	6	6
34	Washer-No. 10	Commercial	6	6
35	Bolt-1/4-20 X 1/2 in. long	Commercial	3	3
36	Nut-1/4-20	Commercial	3	3
37	Washer-1/4 in.	Commercial	6	6
38	Washer, Lock	Commercial	3	3

ACOUSTIC INSTALLATIONS

Item No.	Nomenclature	Part No.	Qty. Rqd.	
Ref	ACOUSTIC INSTALLATION-ENGINE DOORS	402-0113-1		
39	Acoustic Foam-Approx. 32 sq. ft. (Specialty Composites Co.)	402-0113-9	1	
40	Structural Form, Sheet Metal-LH	402-0113-5	1	
41	Structural Form, Sheet Metal-RH	402-0113-6	1	
	<u>Attaching Parts</u>			
42	Screw, Self-Tapping-1/4 X 1/2 in. long	Commercial	20	

FLXIBLE

Date: January 1975 **Service Information #** 402-0102-2 **Record in Section #** 10

RETROFIT INSTRUCTIONS:

Use the following procedure for SAK installation on Flxible standard-equipped coach models. Alternate steps are noted for commonly used special equipment.

1. Remove existing engine underpans (Flxible P/N 16-709).
2. Remove existing muffler, the 3" tail pipe, the aft exhaust pipe from engine manifold to muffler, and associated support hardware. Leave as installed the forward exhaust pipe from engine manifold to muffler. See step (9) for reinstallation of aft manifold exhaust pipe to muffler.

NOTE

If coach is EIP-equipped, step (2) applies except for tail pipe. Instead, remove muffler exhaust pipe sections only up to and including the aspirator.

3. Remove engine oil filter assembly. See step (15) in this procedure for reinstallation.
4. Remove existing fan and shroud. Install SAK shroud (402-0111); use attaching hardware removed from existing shroud. Reinstall existing fan.
5. Remove engine oil filler assembly (9-1111-2001), and oil drip shield (9-1159-2) along with clip, from cylinder block. Cap the oil filler port with gasket (402-0115-5) and plate (402-0115-3), using the two bolts removed with oil filler assembly. Leave as installed the oil filler mounting bracket with attaching hardware, and the engine oil level dip stick and guide tube. Installation of engine enclosure vertical partition (step 7, following) does not obstruct access to dip stick. Installation of rocker arm cover on aft cylinder head (step 16, following) provides accessible oil filler spout.
6. Remove air induction resonator along with inlet and outlet rubber tubes, the rubber elbow, and clamp hardware. See step (7) for reinstallation.

NOTE

If coach is EIP-equipped, step 6 is not applicable.

7. Install engine enclosure vertical partition (402-0114-3), using lower panel (402-0114-5) and upper panel (402-0114-9) with attaching hardware as shown on Dwg. No. 402-0114. Reinstall the resonator and induction ducting removed by step (6). Elbow ducting installs through cutout in vertical partition upper panel (402-0114-9).

NOTE

If coach is EIP-equipped, install engine enclosure vertical partition (402-0114-1), using lower panel (402-0114-5) and upper panel (402-0114-7) with attaching hardware as shown on Dwg. No. 402-0114.

8. Place exhaust pipe section (402-0108-1) through the bulkhead and across the engine support rail. This pipe section assembles to muffler in step (10).

NOTE

Typical SAK installations are shown in Figure E-2 for an EIP exhaust system and Figure E-3 for a standard exhaust system. Refer to Rohr Dwg. No. 402-0103 for engineering details. During installation of exhaust and tail pipes, care should be taken to properly position components in relation to each other. Incorrectly assembled parts of exhaust system can be cause of noises and damage due to improper clearance. Therefore, leave all clamp bolts temporarily loose until entire system has been inspected for adequate clearance between exhaust and engine components. After aligning pipes and checking entire system for clearances, tighten all clamp and bolts.

9. Install existing exhaust pipe (removed by step 2) from aft manifold on engine to location of muffler.

10. Install muffler brackets (402-0105). Install SAK muffler (5080B376), using two straps (402-0106-2). Install the two existing 3" exhaust pipes from engine manifolds to muffler inlets. Tighten the 3" clamp assemblies (11-248-1) at this time to ensure proper location of muffler. Position 4" exhaust pipe section (402-0108-1, see step 8) at muffler outlet and finger tighten the 4" clamp assembly (11-249-3).

11. Position 4" exhaust pipe section (402-0108-7) from mating pipe section (402-0108-1) to resonator location.

12. Place resonator (5010D19) in position behind radiator and in front of engine. Install resonator support bracket (402-0109-1) on aft engine cradle mount "Z"-member. Refer to Rohr Dwg. No. 402-0103 for location and drill callouts, and for use of attaching parts furnished in kit.

NOTE

If EIP coach, use resonator (5120D12) and install aspirator (402-0109-1).

13. Install resonator with asbestos cloth insulation (402-0103-9) on bracket, using strap (402-0106-3). Fit exhaust pipe section (402-0108-3) and tail pipe (402-0107) to resonator ports using clamps (97-1203-12).

NOTE

If EIP coach, fit exhaust pipe section and aspirator to resonator ports; then fit aspirator to existing vertical stack tail pipe.

14. Inspect entire exhaust system for adequate clearances (see NOTE following step 8). Tighten all bolts and clamps. Visually examine all joints for tightness.

15. Install oil filter assembly (removed by step 3).

NOTE

New filter element and gasket is recommended at this time. Refer to FLXIBLE MAINTENANCE MANUAL Section 12 for replacement instructions.

16. Remove the two existing rocker arm covers and gaskets. Install SAK rocker arm cover (402-0110-1) on forward cylinder head. Install SAK rocker arm cover (402-0110-2), which incorporates oil filler spout, on aft cylinder head. Use gaskets furnished in kit. Figures E-2 and E-3, following, are typical SAK installations.

NOTE

For improved sound attenuation, it is recommended that engine underpans removed by step (1) should not be reinstalled on coach.

17. Steam clean and degrease the aft engine access door and transmission access (right rear side) door.

18. Install sheet metal forms (402-0113-5 & 6) for acoustic foam installation on engine access door.

19. Install acoustic foam on interior facings of engine access door and transmission access door. Refer to Dwg. No. 402-0113 for engineering details and for manufacturer's instructions. See Figure E-4, following, for typical completed acoustic installation.

NOTE

Remaining foam sheet or scraps may be installed at other locations within engine compartment to improve sound attenuation.

20. Start engine and check entire exhaust system for leaks. Inspect around rocker arm covers, and around capped oil port on cylinder block, for oil leakage. Check engine access and transmission doors for straightness and sealing.

NOTE

AFTER SATISFACTORY CHECKOUT - COACH MAY BE RETURNED TO SERVICE

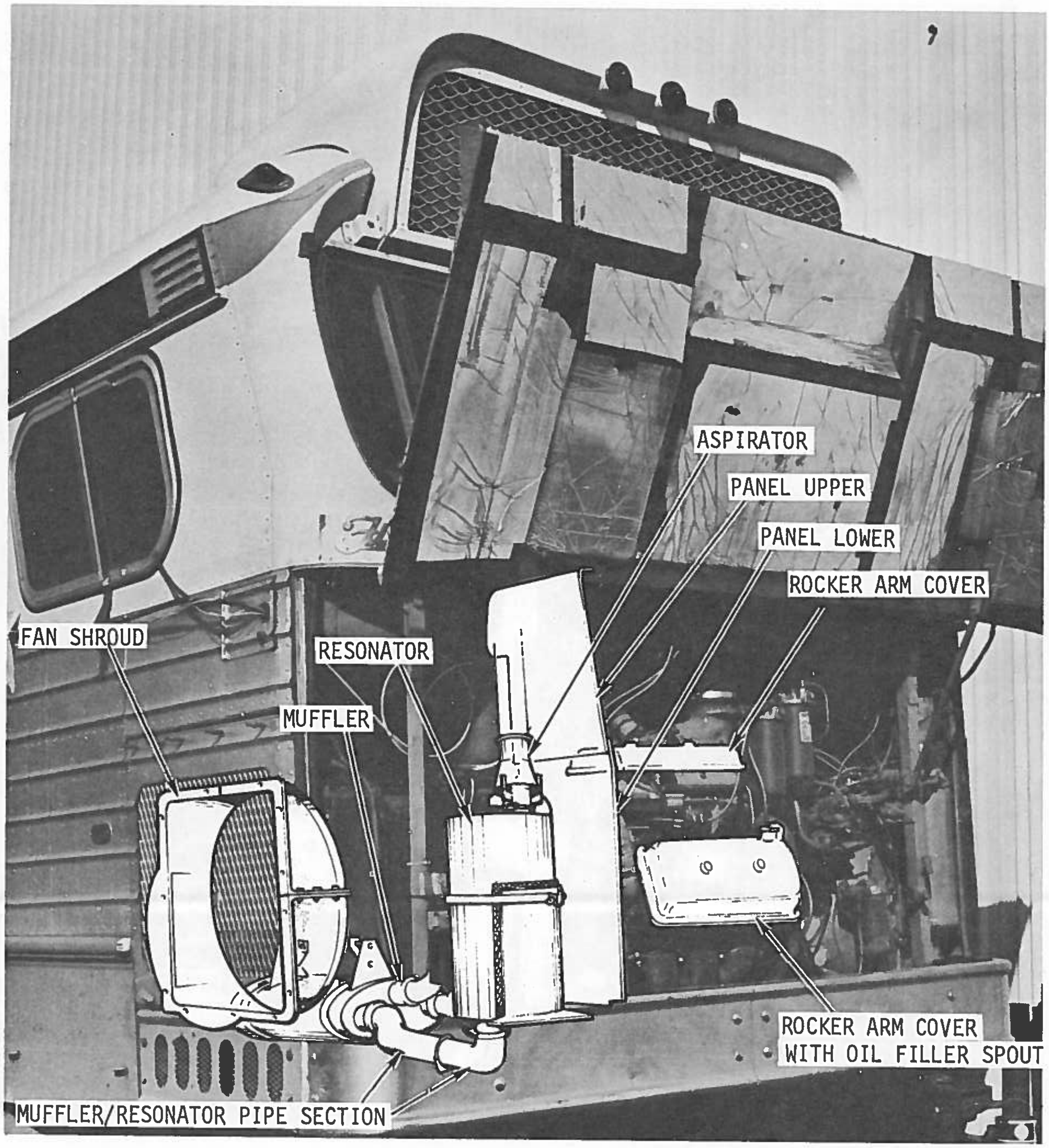

Figure E-2. SAK Installation - Coach Equipped with EIP Exhaust System

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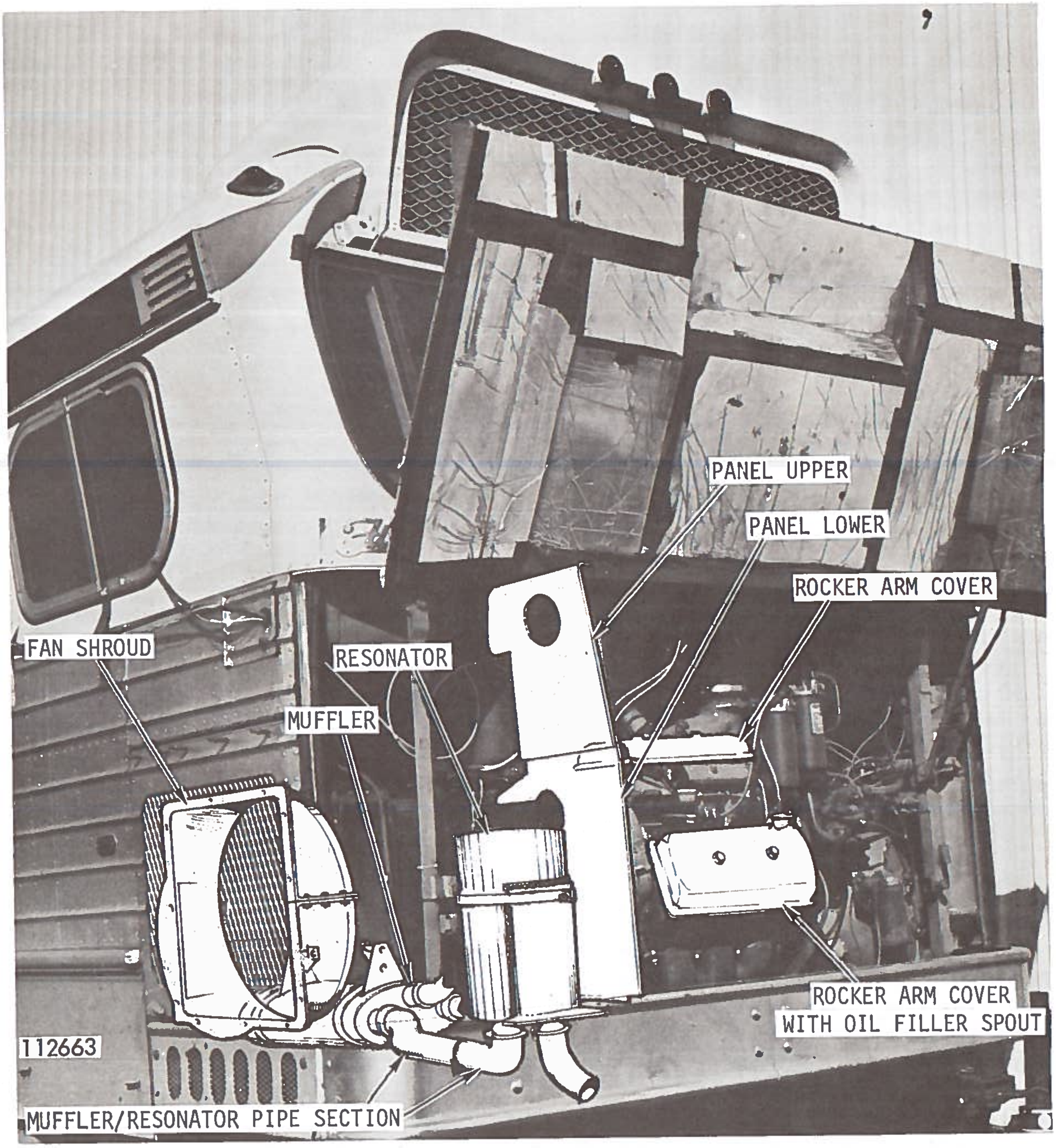

Figure E-3. SAK Installation - Coach Equipped with Standard Exhaust System

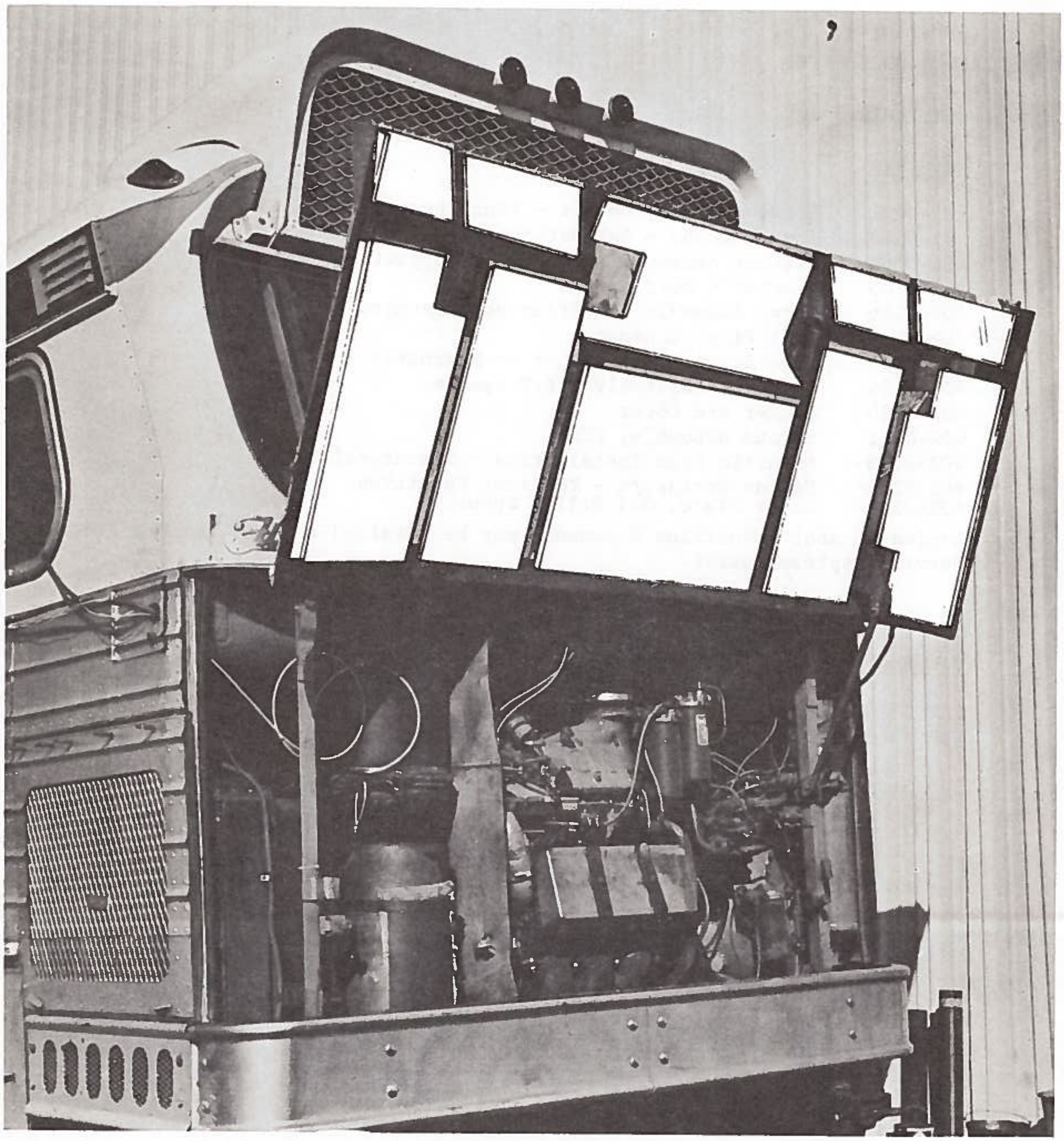

Figure E-4. SAK Acoustic Installation - Typical Engine Access Door Interior

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Date: January 1975 **Service Information #** 402-0102-2 **Record in Section #** 10

REFERENCE DOCUMENTS:

Rohr Industries, Inc.

Drawings

402-0101	Sound Attenuation Kit - Final Report
402-0103	Installation - Exhaust System
402-0104	Bracket Assembly - Resonator Support
402-0105	Bracket - Muffler
402-0106	Strap Assembly - Muffler and Resonator
402-0107	Tail Pipe, Exhaust
402-0108	Pipe Assembly - Muffler to Resonator
402-0109	Aspirator Assembly - EIP System
402-0110	Rocker Arm Cover
402-0111	Shroud Assembly, Fan
402-0113	Acoustic Foam Installation - Structural Forms
402-0114	Engine Enclosure - Vertical Partition
402-0115	Cover Plate, Oil Filler Spout

Copies of Rohr Industries documents may be obtained through Flxible Field Service Representative.

Society of Automotive Engineers

SAE Recommended Practice

SAE J336	Sound Level for Truck Cab Interior
SAE J366a	Exterior Sound Level for Heavy Trucks and Buses

SAE Standard

SAE J672a	Exterior Loudness Evaluation of Heavy Trucks and Buses

Copies of SAE documents may be obtained from American National Standards Institute, Inc., 1430 Broadway, New York City, New York 10018.

NOTE:

1. Sound Attenuation Kit No. 1 - 80 dBa SAE Passby Retrofit is documented by Flxible Service Information No. 402-0102-1, and may be obtained through Flxible Field Service Representative.

APPENDIX F

ACOUSTIC TEST DATA
OCTAVE AND ONE-THIRD OCTAVE BAND SPECTRA

Table F-1

CONDITION 1 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	65	63	62	66	63	64
63	69	70	67	65	70	66
125	70	71	71	68	73	70
250	71	73	78	65	69	73
500	70	71	77	66	68	73
1000	73	75	81	69	71	72
2000	71	75	85	66	67	71
4000	66	71	80	57	61	67
8000	62	67	75	53	58	66
dB(a)	75	79	87	72	72	76

CONDITION 2 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	70	70	70	70	69	70
63	68	75	73	70	74	=
125	71	72	74	72	74	75
250	71	76	75	68	70	71
500	64	67	72	66	67	69
1000	66	68	70	66	65	67
2000	62	64	67	62	65	65
4000	52	54	59	53	54	56
8000	44	44	49	43	43	45
dB(a)	69	72	74	69	66	72

Table F-1 (continued)

CONDITION 3 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	68	69	66	67	67	68
63	65	70	66	65	68	71
125	68	74	74	69	76	78
250	68	72	74	63	68	70
500	63	65	70	61	62	66
1000	62	64	68	62	62	65
2000	59	62	66	58	58	62
4000	48	48	57	47	46	48
8000	37	44	53	37	40	43
dB(a)	66	69	73	65	66	70

CONDITION 4 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	69	65	66	69	65	66
63	67	69	69	65	69	70
125	71	73	74	70	71	72
250	71	72	75	66	68	73
500	66	66	71	62	64	67
1000	66	66	69	62	64	66
2000	63	66	68	57	60	62
4000	54	56	59	49	52	55
8000	44	47	54	35	41	45
dB(a)	71	72	75	65	67	71

Table F-1 (continued)

CONDITION 5 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	67	68	65	67	66	67
63	69	72	69	69	72	70
125	73	72	74	70	72	71
250	71	72	75	65	70	71
500	66	67	71	63	65	68
1000	68	68	70	65	66	68
2000	66	68	69	61	64	65
4000	55	58	60	53	54	58
8000	45	49	55	42	44	48
dB(a)	71	73	75	68	70	72

CONDITION 6 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	66	65	67	67	65	66
63	68	71	69	77	72	70
125	75	76	74	75	72	73
250	75	73	74	73	72	71
500	66	67	75	63	64	70
1000	68	70	70	65	66	67
2000	64	67	69	58	63	63
4000	55	57	60	51	54	56
8000	44	47	54	38	43	45
dB(a)	72	73	75	68	69	71

Table F-1 (continued)

CONDITION 7a Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	64	64	67	66	65	65
63	68	68	66	67	70	69
125	69	73	74	70	69	70
250	70	71	75	64	68	72
500	66	67	71	62	64	68
1000	67	67	70	64	65	66
2000	66	67	69	60	62	63
4000	56	58	61	51	54	56
8000	46	48	55	41	44	46
dB(a)	70	72	75	66	68	70

CONDITION 7b Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	67	66	67	65	65	68
63	68	69	70	67	71	68
125	70	73	76	71	71	71
250	73	72	77	66	69	73
500	66	68	71	62	65	69
1000	67	67	69	63	65	67
2000	64	64	68	57	60	63
4000	54	55	58	46	49	51
8000	45	48	54	43	43	45
dB(a)	71	72	75	66	68	72

Table F-1 (continued)

CONDITION 7c Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	66	67	68	67	65	68
63	70	73	73	69	70	71
125	74	77	78	73	76	76
250	72	72	83	68	71	80
500	68	68	74	63	67	72
1000	67	67	71	64	66	68
2000	66	66	70	59	62	64
4000	56	56	64	51	54	56
8000	46	46	55	41	44	47
dB(a)	72	72	78	67	71	74

CONDITION 7d Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	65	66	65	64	64	67
63	70	70	71	72	70	71
125	77	77	79	75	77	78
250	72	73	79	69	71	78
500	68	68	73	65	66	70
1000	67	68	71	64	65	68
2000	66	68	70	59	60	64
4000	56	58	63	53	52	54
8000	46	47	55	42	43	46
dB(a)	72	73	76	69	70	70

Table F-1 (continued)

CONDITION 7e Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	71	65	69	71	63	69
63	72	68	68	68	66	66
125	71	71	73	69	68	69
250	68	71	74	65	68	72
500	66	68	70	62	63	66
1000	66	67	69	61	63	66
2000	64	65	70	58	60	61
4000	55	56	63	50	52	54
8000	45	49	56	41	45	46
dB(a)	70	71	74	65	66	70

CONDITION 7f Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	65	67	67	67	67	67
63	68	70	68	71	70	67
125	71	72	71	70	70	70
250	70	71	75	66	67	73
500	67	68	70	62	64	68
1000	66	68	69	63	63	67
2000	65	67	69	58	61	63
4000	55	58	62	50	53	56
8000	47	50	57	41	45	48
dB(a)	70	72	74	66	67	71

Table F-1 (continued)

CONDITION 7g Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	71	67	69	68	68	67
63	68	72	67	68	69	70
125	72	73	71	71	68	70
250	70	70	72	65	67	73
500	65	66	68	62	64	69
1000	65	66	68	64	64	66
2000	64	66	67	59	60	63
4000	54	55	59	52	53	56
8000	46	47	54	44	46	50
dB(a)	70	71	72	66	67	71

CONDITION 8b Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	65	66	66	66	63	64
63	71	70	69	66	68	70
125	68	73	70	66	70	69
250	67	68	73	64	66	72
500	62	66	68	61	65	68
1000	63	65	66	61	62	64
2000	62	65	67	57	59	61
4000	53	56	59	50	53	56
8000	44	47	53	42	44	47
dB(a)	67	70	72	64	67	70

Table F-1 (continued)

CONDITION 9a Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	64	66	66	67	64	66
63	73	74	69	65	71	71
125	74	71	72	70	70	71
250	67	70	75	64	68	71
500	65	67	69	64	66	69
1000	67	66	68	66	65	68
2000	65	66	68	62	61	63
4000	56	57	61	53	54	56
8000	49	53	58	43	44	46
dB(a)	70	71	73	68	69	72

CONDITION 9b Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	67	65	66	68	63	67
63	66	71	70	64	71	70
125	75	75	79	70	70	78
250	70	73	82	66	69	75
500	66	69	73	64	67	72
1000	67	69	70	64	66	68
2000	65	68	69	58	62	63
4000	54	57	61	51	55	57
8000	44	53	53	42	44	52
dB(a)	70	73	77	67	70	74

Table F-1 (continued)

CONDITION 11b Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	64	65	63	66	62	65
63	69	70	67	63	69	70
125	81	80	74	78	71	75
250	70	73	78	71	73	75
500	63	65	69	62	65	68
1000	65	67	68	64	66	67
2000	65	66	68	60	62	64
4000	52	54	58	53	55	57
8000	43	51	48	41	46	46
dB(a)	71	72	74	68	70	72

CONDITION 12a Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	69	62	65	65	62	63
63	66	68	73	67	73	70
125	69	75	74	77	75	73
250	64	74	77	72	77	77
500	66	69	72	66	70	73
1000	65	67	69	63	66	68
2000	60	65	66	57	61	64
4000	51	54	56	50	52	55
8000	40	45	47	31	40	45
dB(a)	71	72	74	69	73	75

Table F-1 (continued)

CONDITION 12b Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	64	69	70	67	73	69
63	66	68	68	67	72	71
125	74	74	74	71	68	69
250	75	77	77	72	77	77
500	66	69	73	67	70	72
1000	66	68	70	65	66	67
2000	65	67	70	61	62	64
4000	54	57	61	53	52	57
8000	44	46	57	43	43	48
dB(a)	71	73	76	69	72	74

CONDITION 14 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	65	67	71	66	67	65
63	72	70	73	70	68	69
125	71	72	75	68	69	70
250	71	72	74	68	73	73
500	67	69	69	65	69	69
1000	67	68	68	64	65	66
2000	67	68	70	62	63	64
4000	57	60	60	53	55	57
8000	52	56	56	43	46	52
dB(a)	72	73	75	69	71	72

Table F-1 (continued)

CONDITION 14c Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	63	64	69	62	64	67
63	73	71	68	70	70	69
125	70	71	71	67	70	72
250	70	71	75	68	72	72
500	65	66	72	64	67	67
1000	67	67	68	64	64	67
2000	67	68	71	62	63	64
4000	57	58	61	54	55	58
8000	47	49	51	43	45	49
dB(a)	71	72	76	67	69	70

CONDITION 14d Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	62	63	63	61	63	64
63	73	69	67	69	69	66
125	72	73	70	71	71	71
250	72	73	75	75	75	77
500	66	69	71	66	69	71
1000	65	68	71	66	68	71
2000	61	64	70	65	67	70
4000	54	57	63	56	57	62
8000	41	46	53	46	47	60
dB(a)	70	72	76	72	73	76

Table F-1 (continued)

CONDITION 15 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	63	63	53	-	63	65
63	69	65	67	-	65	66
125	70	68	70	-	65	70
250	68	70	72	-	68	69
500	63	65	68	-	68	65
1000	64	65	65	-	60	61
2000	62	65	67	-	57	59
4000	51	57	57	-	53	57
8000	42	48	48	-	42	43
dB(a)	69	71	74	-	67	69

CONDITION 17 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	63	61	63	62	63	64
63	72	70	65	69	70	70
125	68	72	72	66	68	70
250	70	72	76	68	69	72
500	67	69	70	67	67	69
1000	66	68	69	65	64	64
2000	65	65	67	61	62	63
4000	55	55	57	51	55	57
8000	47	47	50	41	46	46
dB(a)	71	73	75	68	70	72

Table F-1 (continued)

CONDITION 18 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	65	67	63	65	68
63	75	71	71	73	71	69
125	73	75	77	71	72	74
250	73	75	80	70	73	76
500	69	73	76	66	69	72
1000	68	69	72	64	66	67
2000	66	67	70	60	61	63
4000	56	61	63	50	53	55
8000	44	53	53	44	45	55
dB(a)	74	76	79	69	71	74

CONDITION 19 Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	66	66	65	65	66	65
63	76	71	71	74	71	73
125	76	78	78	75	79	77
250	72	74	82	70	74	79
500	70	72	76	69	71	75
1000	70	70	74	68	67	70
2000	67	68	71	63	63	66
4000	61	62	64	52	54	60
8000	49	53	53	41	44	52
dB(a)	75	76	79	72	74	77

Table F-1 (continued)

CONDITION 19f Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	64	64	66	69	66	64
63	70	69	70	76	75	69
125	77	73	72	75	74	72
250	71	74	75	68	73	75
500	68	71	73	66	68	72
1000	70	72	73	66	68	70
2000	67	69	70	63	64	67
4000	59	61	62	53	54	59
8000	53	56	57	45	47	55
dB(a)	74	75	76	70	72	75

CONDITION 19g Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	62	64	61	62	65
63	72	68	67	75	71	68
125	74	75	71	76	73	72
250	72	72	75	69	71	76
500	69	70	73	67	68	71
1000	69	70	73	67	68	69
2000	67	67	71	63	65	66
4000	59	59	64	54	56	59
8000	47	49	53	42	48	47
dB(a)	75	75	78	72	74	76

Table F-1 (continued)

CONDITION 19h Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	66	64	65	64	65	66
63	74	69	66	73	68	69
125	71	69	73	70	67	71
250	67	68	72	67	69	71
500	67	69	72	65	67	68
1000	68	68	69	66	65	67
2000	65	67	69	59	61	64
4000	55	58	60	50	52	55
8000	43	48	52	47	42	46
dB(a)	72	72	75	70	70	71

CONDITION 2nd Baseline - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	64	67	67	63	64	67
63	71	74	72	70	70	69
125	75	77	78	71	74	75
250	78	78	83	71	73	75
500	71	73	77	69	72	76
1000	70	71	74	68	69	70
2000	68	69	73	64	66	67
4000	59	60	66	55	56	60
8000	53	55	62	45	47	54
dB(a)	76	77	80	72	74	76

Table F-1 (continued)

CONDITION 2nd Baseline Old Pipe - Fan On - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	-	-	66	-	-	67
63		-	69	-	-	72
125	-	-	76	-	-	74
250	-	-	79	-	-	74
500	-	-	76	-	-	75
1000	-	-	78	-	-	69
2000	-	-	80	-	-	70
4000	-	-	77	-	-	67
8000	-	-	76	-	-	68
dB(a)	-	-	85	-	-	77

CONDITION 2nd Baseline Old Pipe - Fan Off - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	-	-	65	-	-	64
63	-	-	67	-	-	70
125	-	-	70	-	-	72
250	-	-	77	-	-	70
500	-	-	75	-	-	70
1000	-	-	79	-	-	68
2000	-	-	71	-	-	70
4000	-	-	79	-	-	68
8000	-	-	79	-	-	67
dB(a)	-	-	86	-	-	75

Table F-1 (continued)

CONDITION Kit No. 1 with Under Pans - Fan On - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	63	67	66	65	64	66
63	72	71	69	70	69	69
125	77	79	76	77	80	77
250	72	78	79	73	75	80
500	70	73	76	68	70	73
1000	68	70	75	66	66	67
2000	67	69	80	62	62	63
4000	58	63	77	52	54	55
8000	55	58	76	45	47	48
dB(a)	74	77	85	71	73	75

CONDITION Kit No. 1 with Under Pans - Fan Off - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	61	61	64	63	63	64
63	71	70	68	70	69	67
125	73	73	74	71	69	71
250	70	72	74	68	70	73
500	67	70	71	64	67	68
1000	66	68	68	64	64	65
2000	66	67	69	59	61	62
4000	57	59	61	52	54	55
8000	54	57	58	46	48	55
dB(a)	71	73	74.5	68	70	71

Table F-1 (continued)

CONDITION Kit No. 1 No Pans - Fan Off - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	63	62	64	61	65	64
63	72	69	68	68	69	65
125	73	74	72	70	69	70
250	69	72	74	68	70	72
500	67	69	73	65	67	69
1000	66	67	69	64	65	65
2000	66	66	69	62	63	64
4000	57	60	63	54	55	59
8000	56	58	61	55	58	59
dB(a)	71	73	75	69	70	72

CONDITION Kit No. 2 - Constant Speed Passby

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	63	66	68	65	64	67
63	73	70	70	71	69	69
125	75	74	75	70	69	73
250	74	74	77	70	71	75
500	69	69	73	66	68	71
1000	68	68	70	66	65	68
2000	66	66	68	62	63	64
4000	59	59	62	54	56	57
8000	50	51	54	46	47	48
dB(a)	75	75	78	72	72	75

Table F-2

CONDITION 1 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	59	61	61	65	61	63
63	67	71	67	69	66	69
125	69	67	65	64	68	68
250	71	71	71	63	67	69
500	65	67	71	65	65	68
1000	69	69	71	69	69	73
2000	65	67	69	67	67	70
4000	55	57	60	57	57	61
8000	44	47	52	47	49	56
dB(a)	71	71	75	71	72	75

CONDITION 2 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	65	65	63	67	70	70
63	69	73	68	70	70	71
125	66	68	67	65	64	65
250	69	70	69	64	65	63
500	61	63	66	58	58	61
1000	62	65	67	59	64	63
2000	59	61	64	55	58	59
4000	51	53	55	44	47	51
8000	35	41	45	31	39	41
dB(a)	67	69	71	64	66	67

Table F-2 (continued)

CONDITION 3 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	66	64	64	70	63	61
63	64	69	65	68	72	67
125	64	66	64	65	64	65
250	67	65	67	63	64	65
500	61	62	65	59	60	62
1000	61	62	64	58	60	62
2000	56	58	61	53	55	55
4000	45	47	51	41	44	48
8000	33	38	42	25	35	39
dB(a)	65	66	68	63	64	65

CONDITION 4 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	60	60	61	67	61	55
63	65	69	63	65	67	64
125	65	66	64	63	63	66
250	67	64	68	62	65	64
500	63	63	66	56	57	60
1000	64	66	69	58	59	60
2000	62	64	67	54	55	57
4000	54	55	58	44	46	51
8000	43	45	52	32	38	41
dB(a)	68	70	72	62	64	66

Table F-2 (continued)

CONDITION 5 Stationary

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	62	61	63	69	61	62
63	68	68	67	70	69	66
125	68	67	65	69	64	64
250	65	64	66	61	62	64
500	62	64	65	57	58	61
1000	65	67	68	60	62	66
2000	62	65	66	57	58	62
4000	54	56	58	45	51	55
8000	43	46	52	38	41	45
dB(a)	68	70	72	64	65	68

CONDITION 7b Stationary

OCTAVE BAND Hz	Left Hand Side			Right Hand Side		
	75%	85%	95%	75%	85%	95%
31.5	61	61	63	68	61	62
63	66	67	67	68	68	73
125	65	66	66	68	63	65
250	66	68	69	62	65	65
500	61	62	63	56	59	62
1000	62	66	66	59	62	64
2000	62	65	67	54	57	60
4000	53	55	57	43	47	54
8000	41	45	53	33	41	44
dB(a)	67	70	72	63	65	67

Table F-2 (continued)

CONDITION 9a Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	59	59	63	61	59	62
63	66	71	62	66	70	67
125	63	65	63	62	63	68
250	65	66	69	61	64	65
500	62	64	64	58	59	64
1000	65	66	67	60	61	64
2000	63	65	68	57	58	61
4000	53	56	58	46	53	55
8000	43	45	48	35	37	45
dB(a)	68	70	72	64	66	68

CONDITION 9b Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	61	63	63	60	65
63	67	72	67	66	69	65
125	73	77	79	66	69	73
250	71	73	82	64	68	76
500	65	67	73	65	63	70
1000	67	68	71	62	64	67
2000	65	68	71	58	61	65
4000	55	57	63	47	51	53
8000	54	55	53	42	44	45
dB(a)	70	74	78	66	68	72

Table F-2 (continued)

CONDITION 11b Stationary

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	60	59	61	62	58	62
63	64	68	65	66	68	66
125	70	65	66	71	67	66
250	69	67	69	67	68	66
500	61	62	64	57	61	61
1000	63	64	66	60	62	62
2000	62	64	68	56	58	59
4000	52	54	58	45	53	52
8000	42	45	52	32	43	45
dB(a)	67	68	71	64	67	68

CONDITION 14 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	61	64	61	59 ,	61	60
63	70	67	63	70	64	64
125	67	67	66	63	65	67
250	66	69	68	63	67	65
500	62	65	63	59	63	63
1000	65	67	65	62	64	64
2000	64	68	66	59	61	63
4000	54	58	56	52	55	58
8000	45	51	51	41	45	56
dB(a)	69	72	70	66	68	70

Table F-2 (continued)

CONDITION 14c Stationary Fan On

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	65	69	66	63	65	68
63	72	72	71	70	70	71
125	75	77	77	69	72	72
250	73	77	83	69	73	77
500	68	72	75	64	67	70
1000	68	71	72	64	65	66
2000	69	72	73	61	63	63
4000	58	63	64	53	56	56
8000	52	55	56	42	44	50
dB(a)	74	77	79	69	71	72

CONDITION 14c Stationary Fan Off

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	61	62	64	62	63	69
63	71	65	63	71	67	69
125	65	68	67	66	66	69
250	65	69	66	66	66	68
500	64	62	67	59	62	65
1000	67	67	68	64	65	63
2000	65	68	69	60	61	62
4000	55	57	60	53	55	59
8000	46	51	53	41	45	51
dB(a)	69	71	73	67	67	69

Table F-2 (continued)

CONDITION 14d Stationary

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	68	59	59	59	59	61
63	72	66	67	66	66	65
125	67	72	70	66	72	70
250	68	71	72	69	70	70
500	62	63	66	63	64	66
1000	63	65	69	61	63	64
2000	62	65	67	58	58	62
4000	54	55	58	54	54	60
8000	47	46	51	41	43	50
dB(a)	68	71	72	66	68	70

CONDITION 15 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	Left Hand Side 85%	Left Hand Side 95%	Right Hand Side 75%	Right Hand Side 85%	Right Hand Side 95%
31.5	59	61	61	60	62	62
63	67	62	65	68	65	65
125	65	63	65	64	64	67
250	64	68	67	65	63	68
500	60	61	64	59	59	63
1000	63	65	66	60	60	62
2000	63	65	67	56	57	60
4000	52	55	59	50	53	55
8000	45	46	52	40	44	45
dB(a)	67	69	71	64	64	66

Table F-2 (continued)

CONDITION 17 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	57	59	62	59	57	62
63	68	65	65	71	67	66
125	67	71	73	64	66	67
250	69	70	72	66	66	70
500	63	64	68	61	62	69
1000	66	68	70	62	63	66
2000	63	67	68	59	62	68
4000	54	57	58	51	54	58
8000	50	51	53	43	43	52
dB(a)	70	72	74	66	68	71

CONDITION 18 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	61	62	64	61	63	63
63	73	68	69	75	70	67
125	72	77	77	69	70	73
250	73	77	81	68	71	77
500	70	74	79	65	69	72
1000	70	71	75	63	66	70
2000	67	71	71	61	63	62
4000	57	60	61	51	53	53
8000	50	52	51	40	48	49
dB(a)	74	77	80	68	71	74

Table F-2 (continued)

CONDITION 19 Stationary Fan On

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	62	63	62	62	64
63	72	67	68	73	72	73
125	73	76	76	74	77	76
250	71	73	82	70	73	81
500	70	73	77	67	70	75
1000	68	71	74	66	68	70
2000	68	71	73	64	64	64
4000	60	63	66	54	55	56
8000	54	59	63	45	51	49
dB(a)	73	76	79	71	73	76

CONDITION 19d Stationary Fan Off

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%	
31.5	-	-	63	-	-	-	-
63	-	-	66	-	-	-	
125	-	-	68	-	-	-	
250	-	-	69	-	-	-	
500	-	-	67	-	-	-	
1000	-	-	69	-	-	-	
2000	-	-	69	-	-	-	
4000	-	-	60	-	-	-	
8000	-	-	56	-	-	-	
dB(a)	-	-	73	-	-	-	

Table F-2 (continued)

CONDITION 19d Stationary Fan On

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	–	–	65	–	–	–
63	–	–	70	–	–	–
125	–	–	77	–	–	–
250	–	–	80	–	–	–
500	–	–	77	–	–	–
1000	–	–	73	–	–	–
2000	–	–	72	–	–	–
4000	–	–	64	–	–	–
8000	–	–	61	–	–	–
dB(a)	–	–	79	–	–	–

CONDITION 19e Fan Off

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	–	–	62	–	–	–
63	–	–	63	–	–	–
125	–	–	66	–	–	–
250	–	–	67	–	–	–
500	–	–	66	–	–	–
1000	–	–	70	–	–	–
2000	–	–	67	–	–	–
4000	–	–	61	–	–	–
8000	–	–	57	–	–	–
dB(a)	–	–	74	–	–	–

Table F-2 (continued)

CONDITION 19e Stationary Fan On

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	–	–	–	–	–	–
63	–	–	70	–	–	–
125	–	–	76	–	–	–
250	–	–	76	–	–	–
500	–	–	74	–	–	–
1000	–	–	72	–	–	–
2000	–	–	71	–	–	–
4000	–	–	64	–	–	–
8000	–	–	63	–	–	–
dB(a)	–	–	77	–	–	–

CONDITION 19f Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	59	61	60	60	65
63	75	68	66	71	68	67
125	66	66	69	68	69	70
250	66	71	71	65	66	68
500	64	66	68	63	66	68
1000	68	69	72	63	65	68
2000	66	67	69	62	62	65
4000	56	57	60	52	55	57
8000	50	54	55	49	51	53
dB(a)	71	73	75	66	68	72

Table F-2 (continued)

CONDITION 19g Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	63	61	62	63	59	64
63	74	70	72	74	71	69
125	68	69	70	70	69	68
250	68	71	73	65	69	68
500	66	68	70	63	65	69
1000	70	71	74	66	66	68
2000	67	69	70	60	63	67
4000	59	63	64	53	57	60
8000	46	50	52	41	47	46
dB(a)	72	75	76	69	70	72

CONDITION 19h Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	63	63	62	63	63	65
63	72	67	68	75	70	70
125	65	67	69	66	66	68
250	66	68	69	66	65	64
500	63	65	68	61	64	64
1000	69	71	72	64	65	65
2000	66	66	69	60	56	62
4000	55	56	60	51	53	55
8000	45	46	53	49	42	45
dB(a)	72	73	74	67	68	69

Table F-2 (continued)

CONDITION 2nd Baseline - Stationary Fan On

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	62	64	65	61	66
63	73	70	69	75	66	68
125	77	77	79	73	73	74
250	74	76	85	70	72	75
500	69	73	77	67	70	77
1000	71	73	76	66	68	70
2000	68	72	74	64	65	67
4000	61	64	66	52	55	59
8000	52	59	61	41	50	46
dB(a)	75	78	81	70	73	76.5

CONDITION 2nd Baseline - Stationary Fan Off

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	-	-	65	-	-	-
63	-	-	64	-	-	-
125	-	-	69	-	-	-
250	-	-	73	-	-	-
500	-	-	72	-	-	-
1000	-	-	73	-	-	-
2000	-	-	67	-	-	-
4000	-	-	61	-	-	-
8000	-	-	55	-	-	-
dB(a)	-	-	76	-	-	-

Table F-2 (continued)

CONDITION Kit No. 1 with Under Pans - Fan Off - Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	61	59	59	61	60	62
63	69	65	62	71	64	66
125	66	66	66	67	64	70
250	65	69	71	66	67	67
500	63	65	67	59	62	65
1000	66	68	68	60	63	64
2000	65	66	68	59	60	62
4000	55	57	60	50	51	55
8000	51	52	57	42	48	53
dB(a)	70	71	73	65	67	69

CONDITION

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5						
63						
125						
250						
500						
1000						
2000						
4000						
8000						
dB(a)						

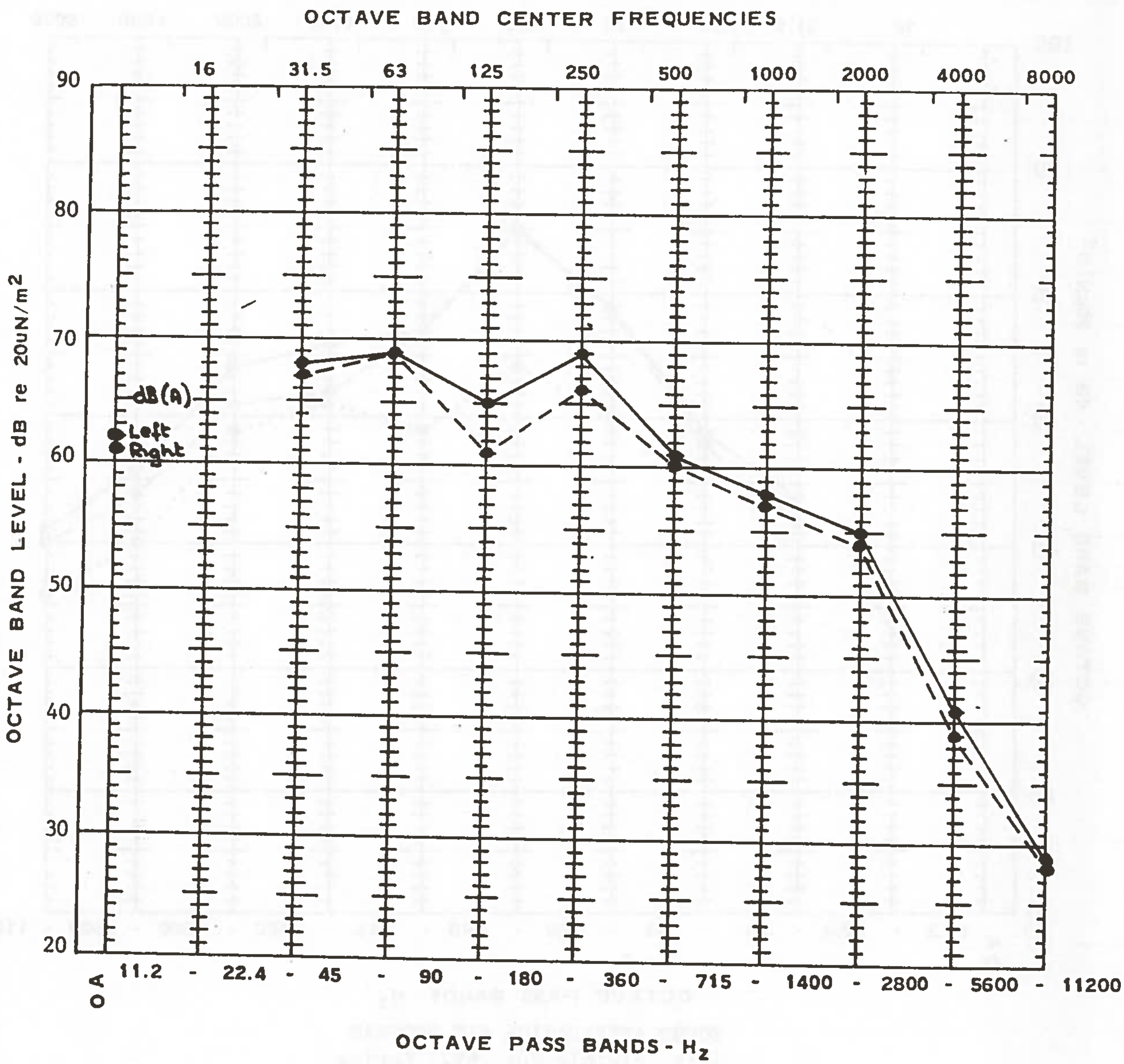
Table F-2 (continued)

CONDITION 7 Kit No. 1 with Under Pans - Fan On Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	62	61	62	58	61	63
63	69	68	68	68	69	67
125	74	79	79	72	74	75
250	71	75	85	70	71	79
500	69	72	77	65	67	72
1000	68	70	72	63	66	66
2000	66	68	71	60	61	62
4000	58	61	64	51	53	54
8000	52	56	60	47	50	51
dB(a)	73	75.5	79	68	70	73.5

CONDITION Kit No. 2 Stationary

OCTAVE BAND Hz	Left Hand Side 75%	85%	95%	Right Hand Side 75%	85%	95%
31.5	63	60	64	66	66	64
63	69	70	66	72	68	66
125	65	68	70	67	69	70
250	70	63	74	66	68	69
500	64	66	69	61	62	67
1000	68	70	71	65	65	68
2000	65	68	69	61	62	65
4000	55	57	60	51	53	56
8000	50	51	56	44	47	52
dB(a)	72	73	74.5	68	69	71



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

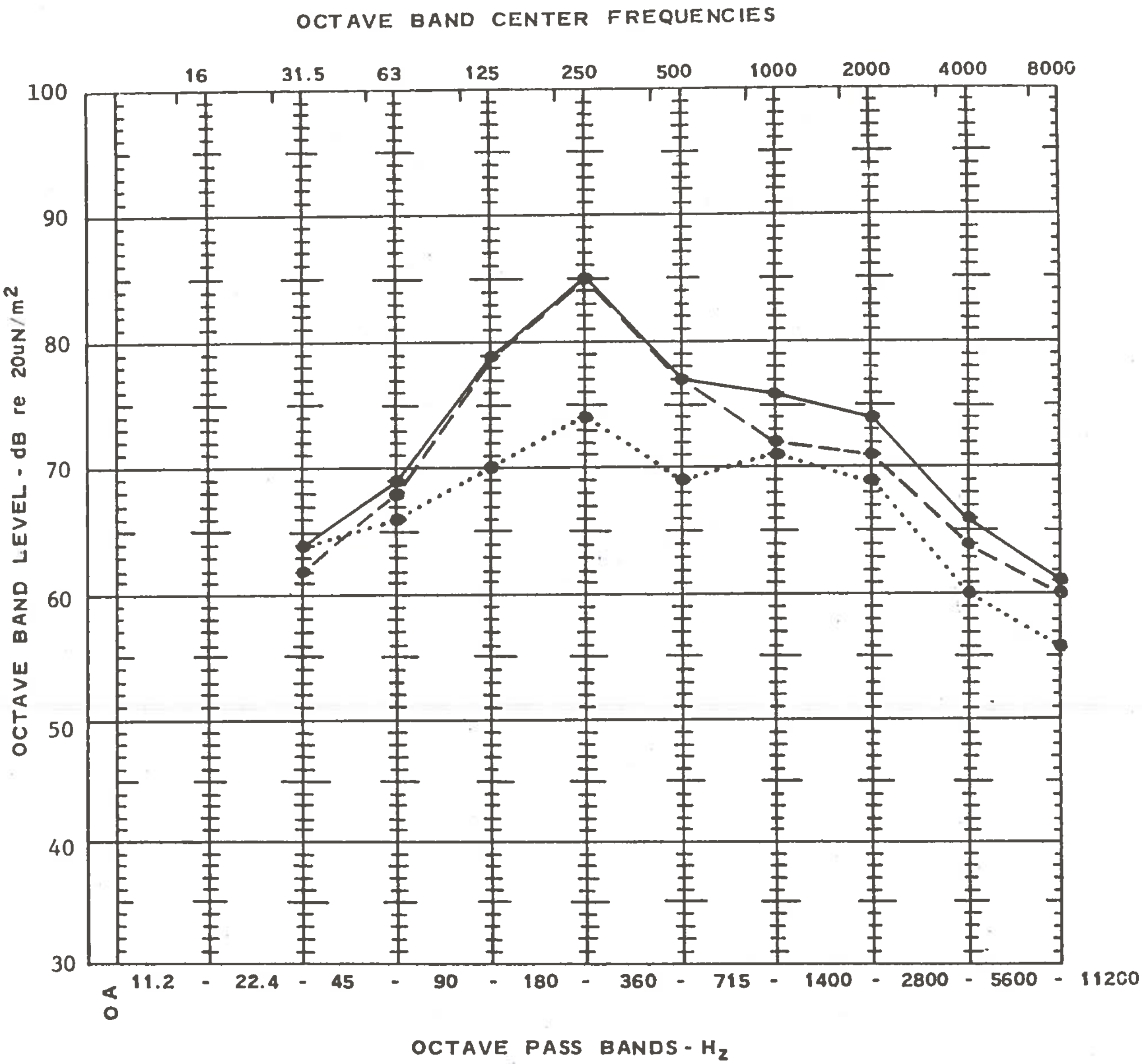
50 ft. Constant Speed Passby
Vehicle Coasting at 25MPH

Baseline

Left Side

Right Side

Figure F.2-1
Vehicle Coasting at 25 mph



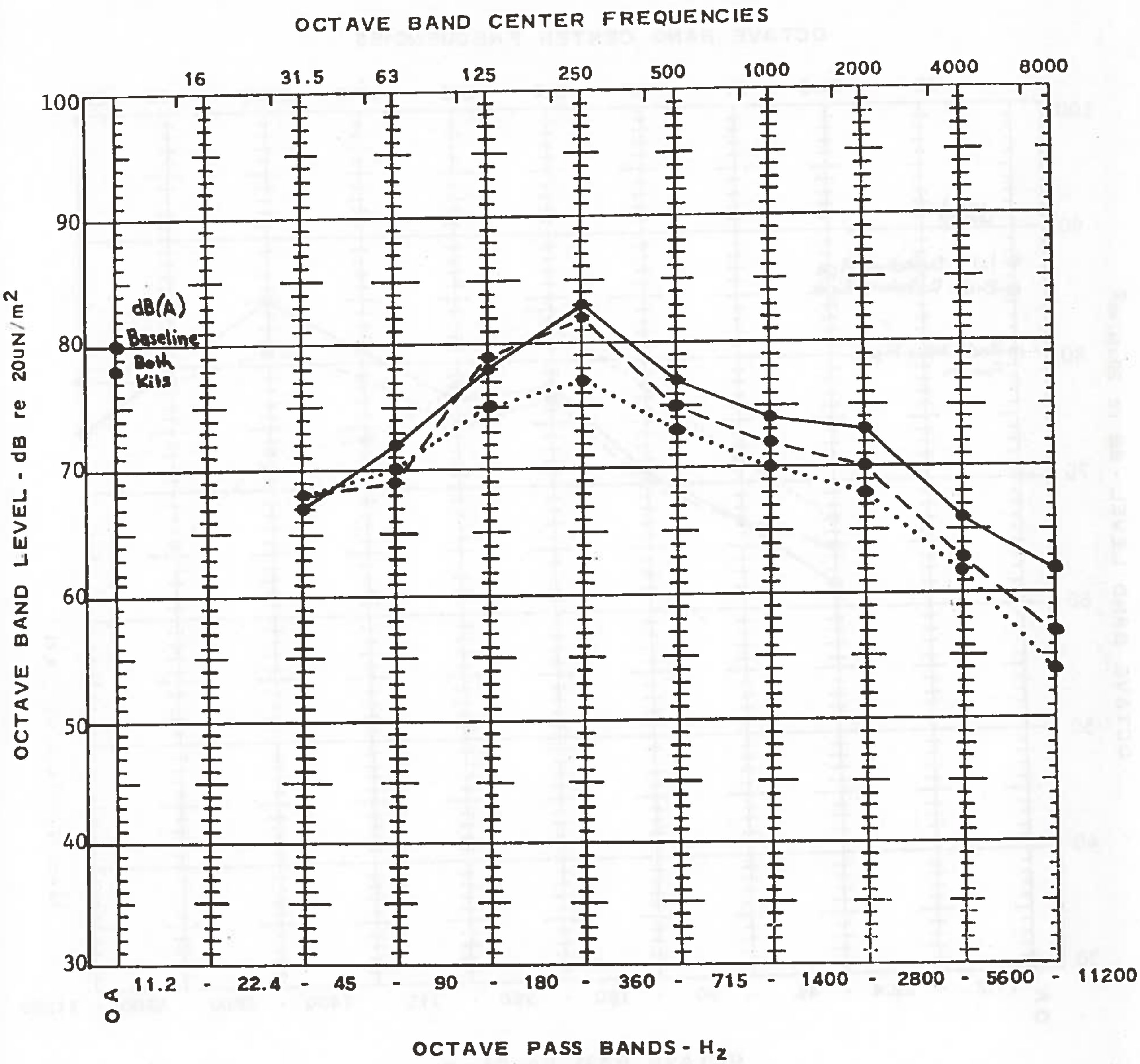
SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus 6V71 Engine

Stationary Bus at 50 ft.
Left Hand Side of Bus

Condition: Baseline Versus Sound Attenuation
Kits Nos. 1 and 2 - Radiator
Cooling Fan On

Baseline)
Kit 1) Engine Speed 95%
Kit 2)

Figure F.2-2



SOUND ATTENUATION KIT PROGRAM

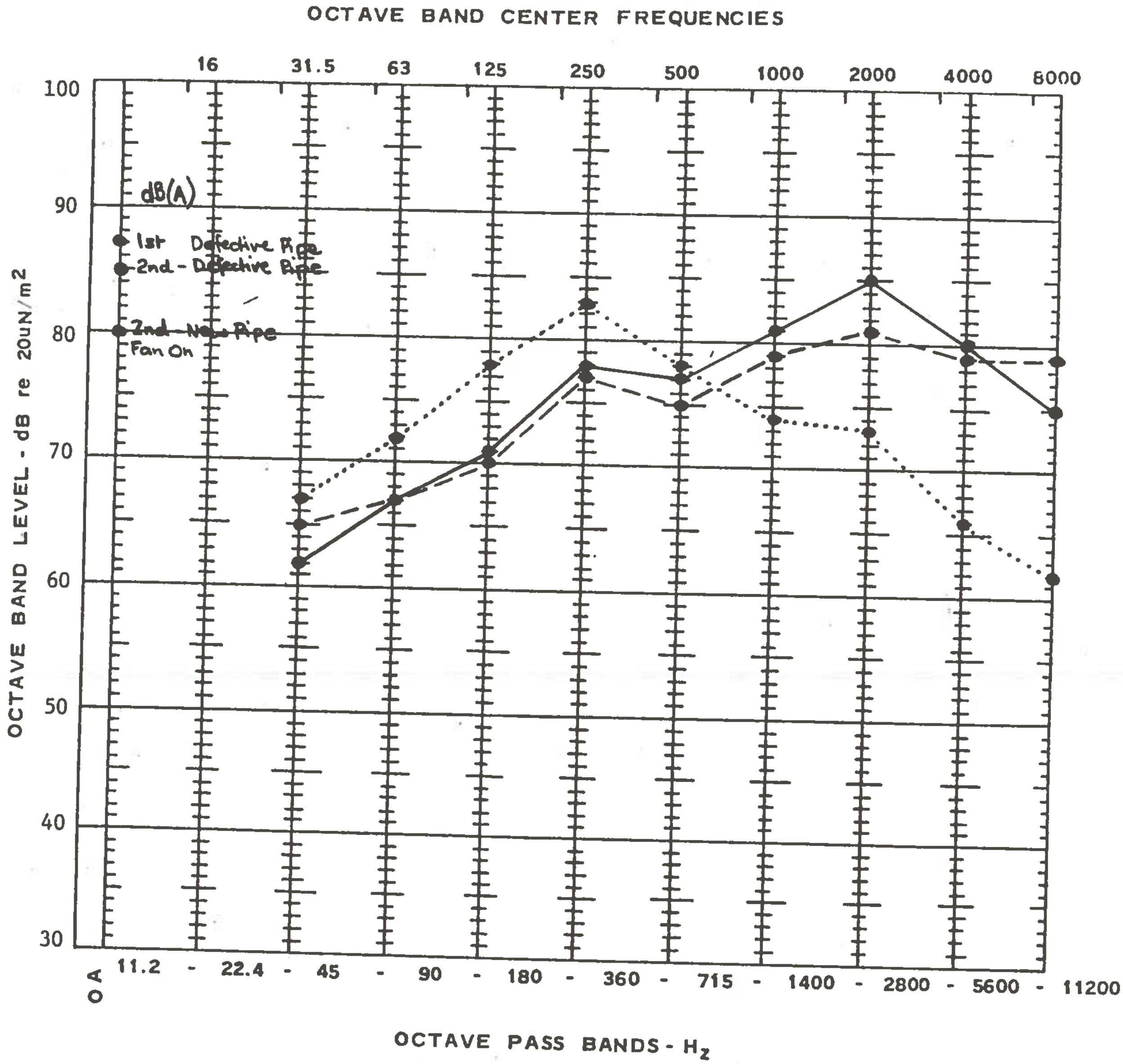
35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

Condition - Baseline Versus Sound Attenuation
Kits Nos. 1 and 2 Radiator Cooling
Fan On

Baseline)
Kit No. 1) Engine Speed 95%
Kit No. 2)

Figure F.2-3



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

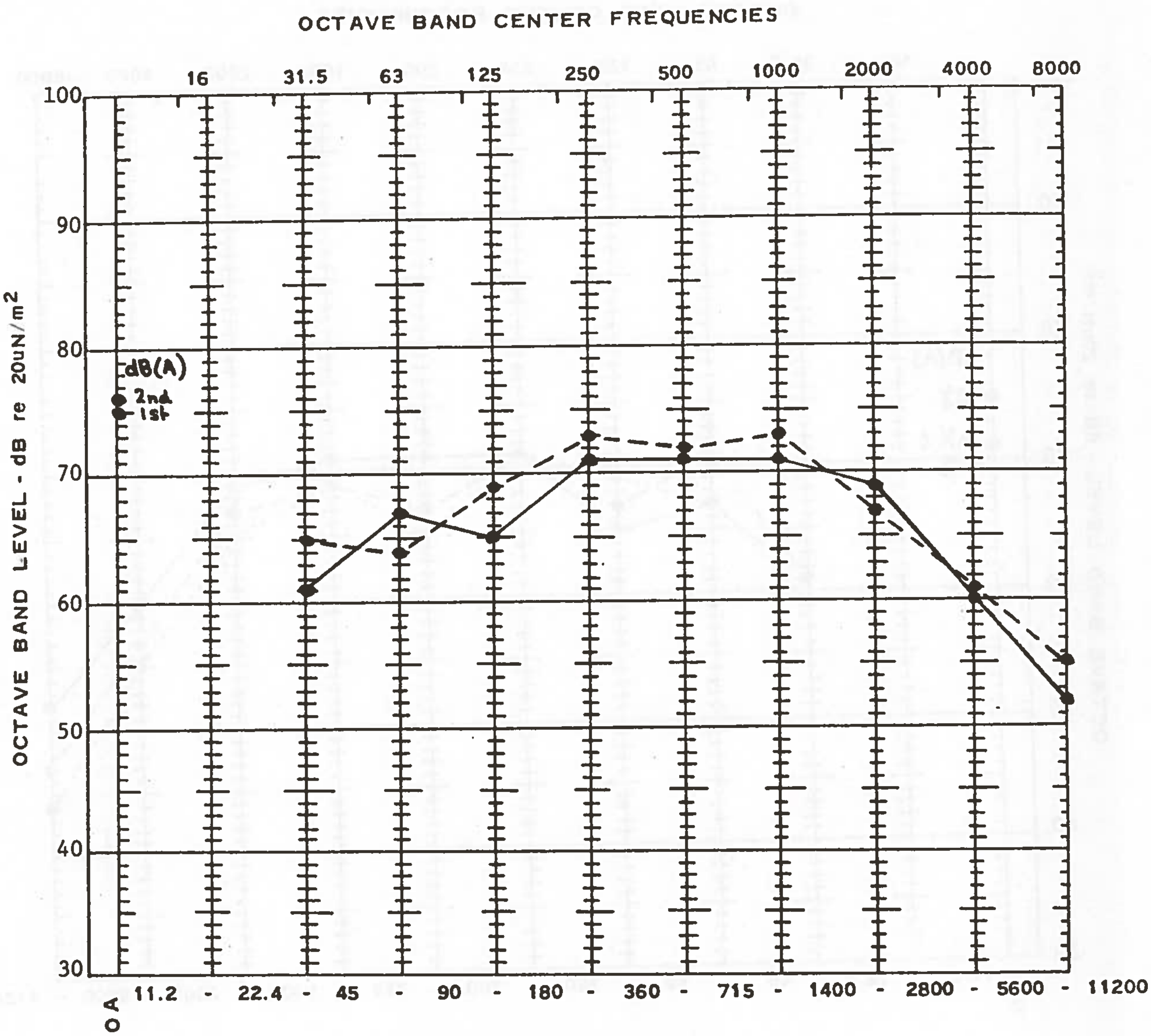
Condition - Baselines, Engine Speed 95%

●———● 1st Baseline - Defective Tail Pipe - Fan on Auto

●— — —● 2nd Baseline - Defective Tail Pipe - Fan Off

●·······● 2nd Baseline - New Tail Pipe - Fan On

Figure F.2-4



OCTAVE PASS BANDS - H_z

SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

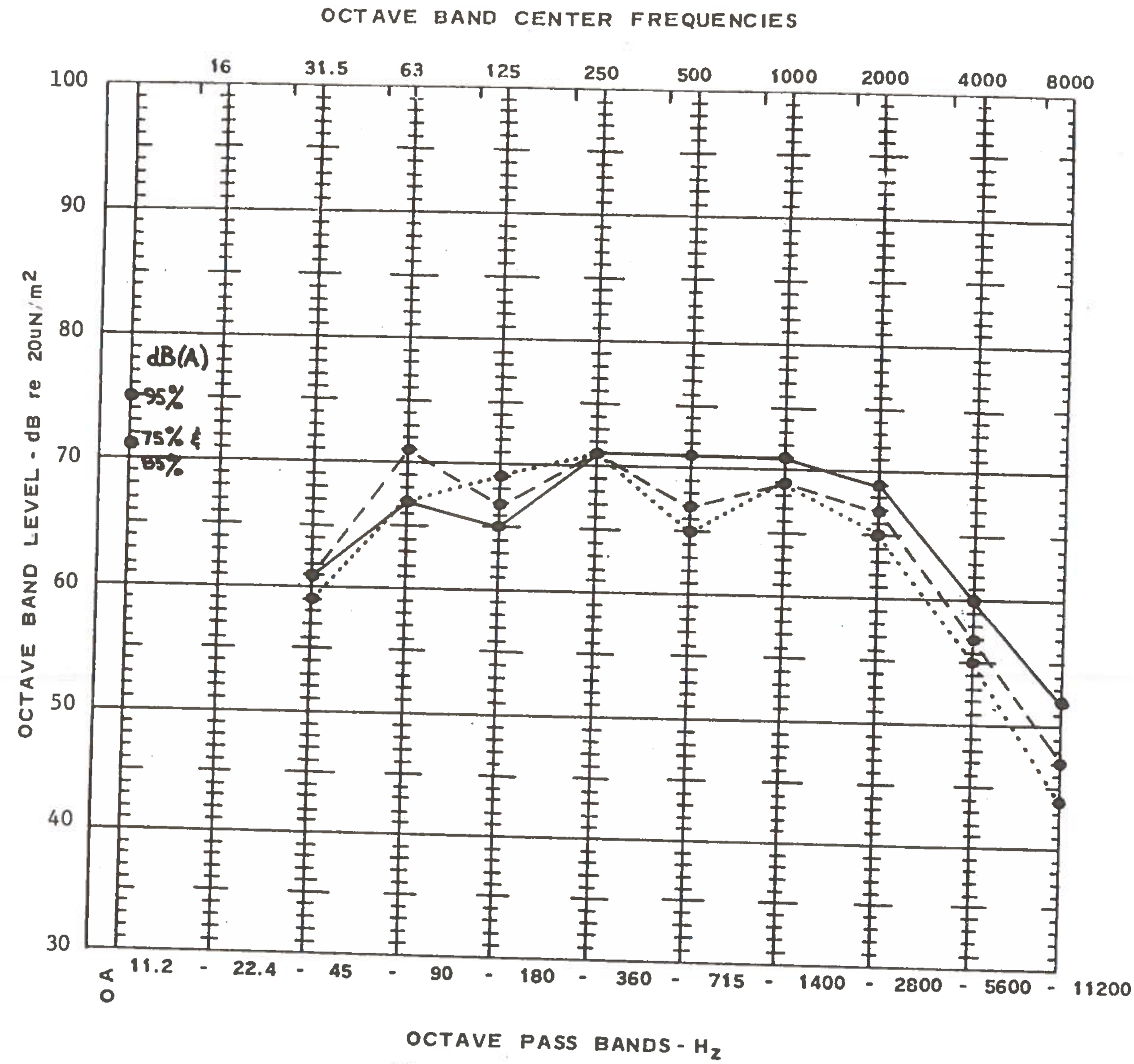
Stationary Bus at 50 ft.
Left Hand Side of Bus

Condition - First versus Second Baselines
Cooling Fan Off

●———● 1st Baseline after correction of defective tail pipe

●– – –● 2nd Baseline

Figure F.2-5

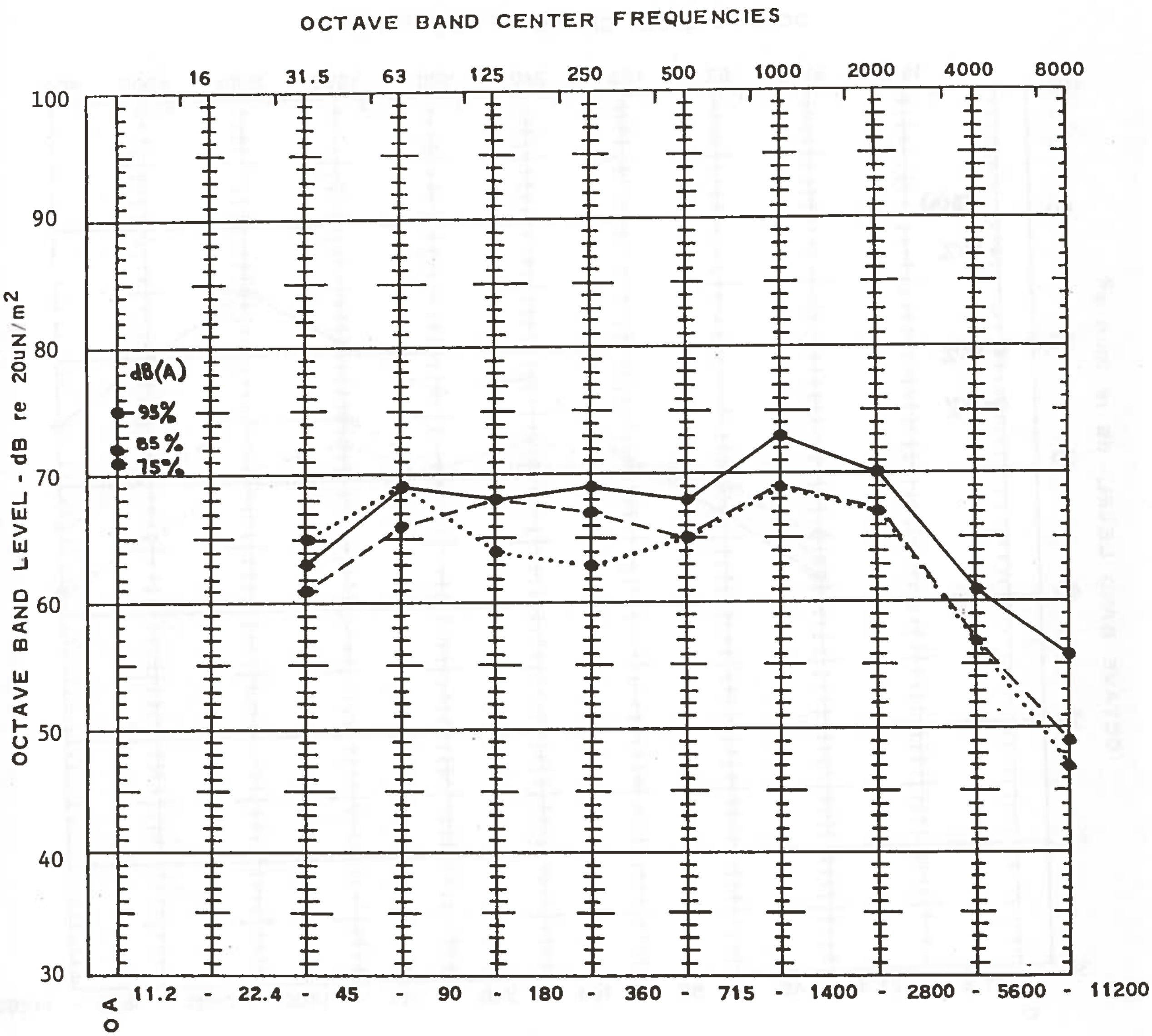


SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus, 6V71 Engine
Stationary Bus at 50 ft.
Left Hand Side of Bus

Condition – First Baseline

●........● 75% Engine Speed
●— — —● 85% Engine Speed
●————● 95% Engine Speed

Figure F.2-6



SOUND ATTENUATION KIT PROGRAM

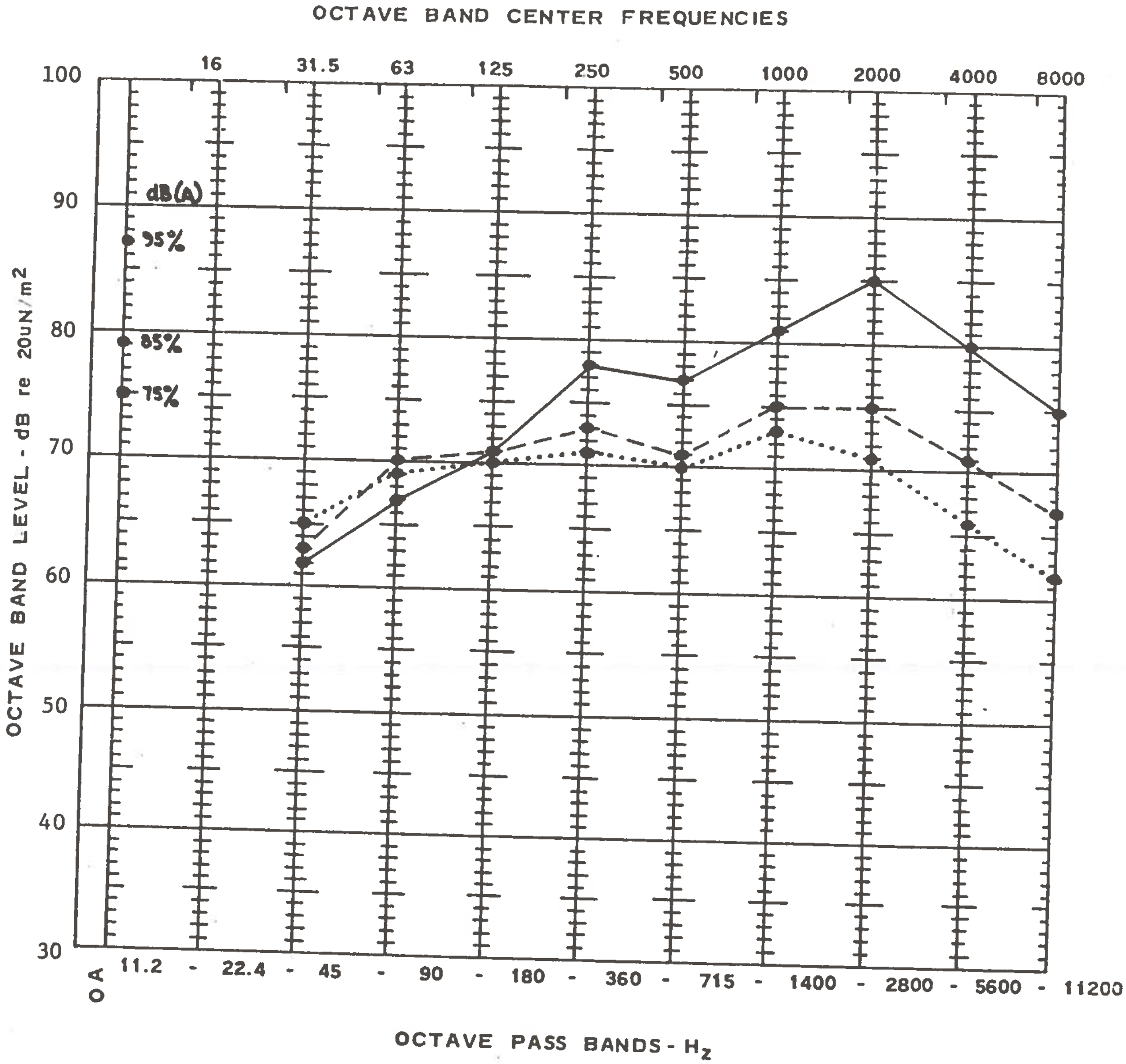
35 ft. Flxible Bus, 6V71 Engine

Stationary Bus at 50 ft.
Right Hand Side of Bus

Condition - First Baseline

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.2-7



SOUND ATTENUATION KIT PROGRAM

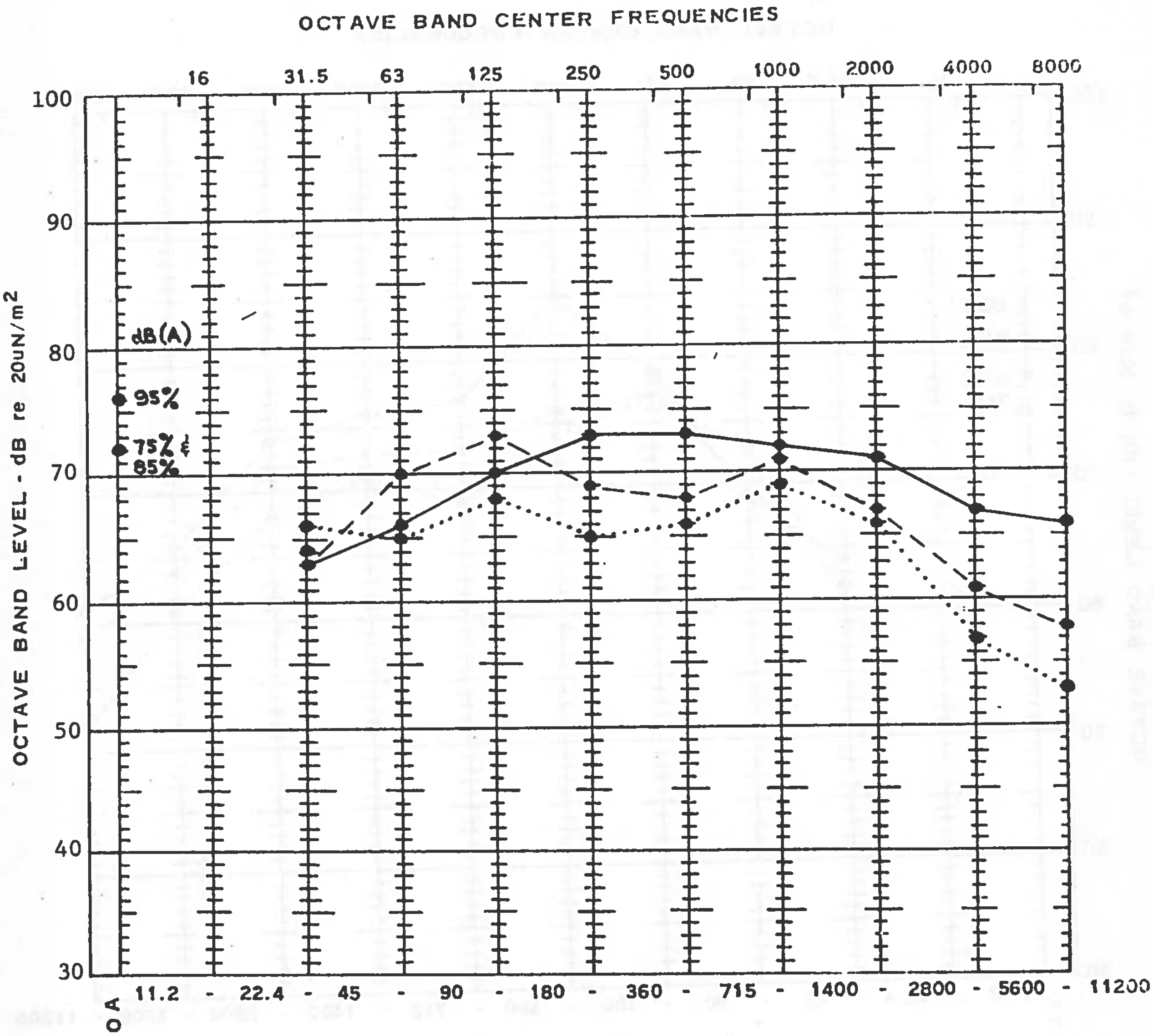
35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

Condition - First Baseline

- 75% Engine Speed
- 85% Engine Speed
- 95% Engine Speed

Figure F.2-8



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Right Hand Side of Bus

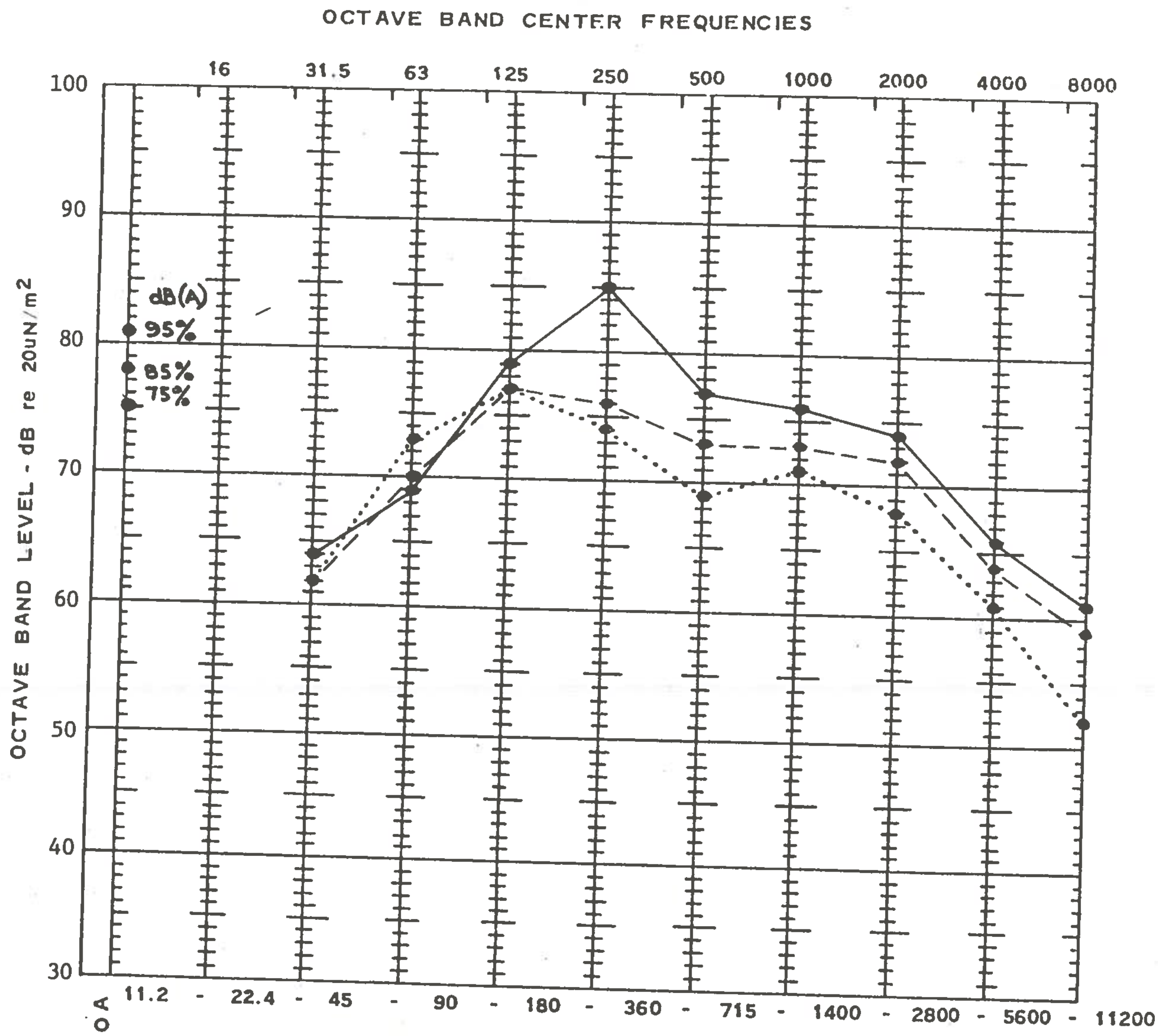
Condition - First Baseline

75% Engine Speed

85% Engine Speed

95% Engine Speed

Figure F.2-9



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine
Stationary Bus at 50 ft.
Left Hand Side of Bus

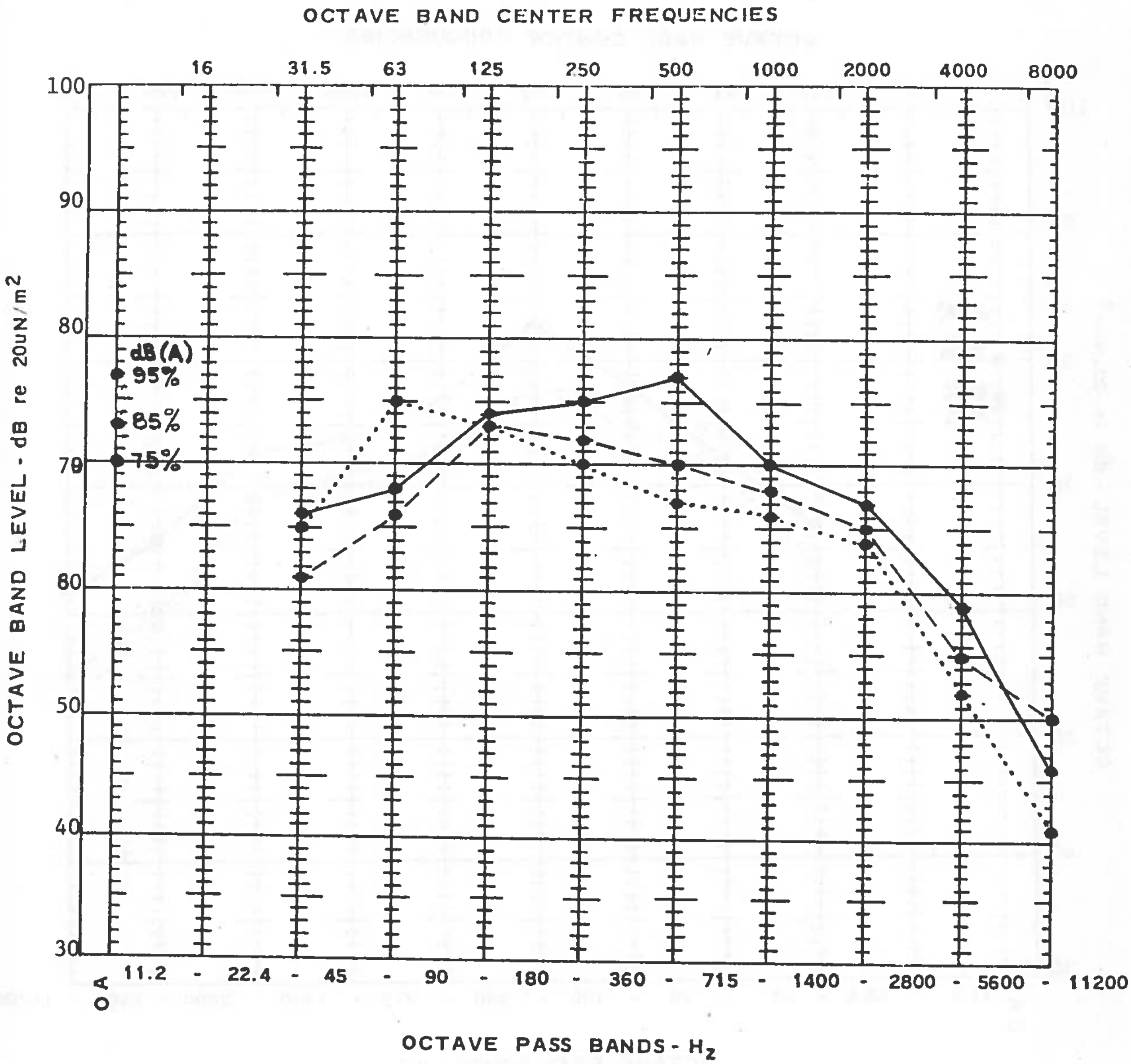
Condition - Second Baseline
Cooling Fan Locked On

●·······● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.2-10



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

Stationary Bus at 50 ft.
Right Hand Side of Bus

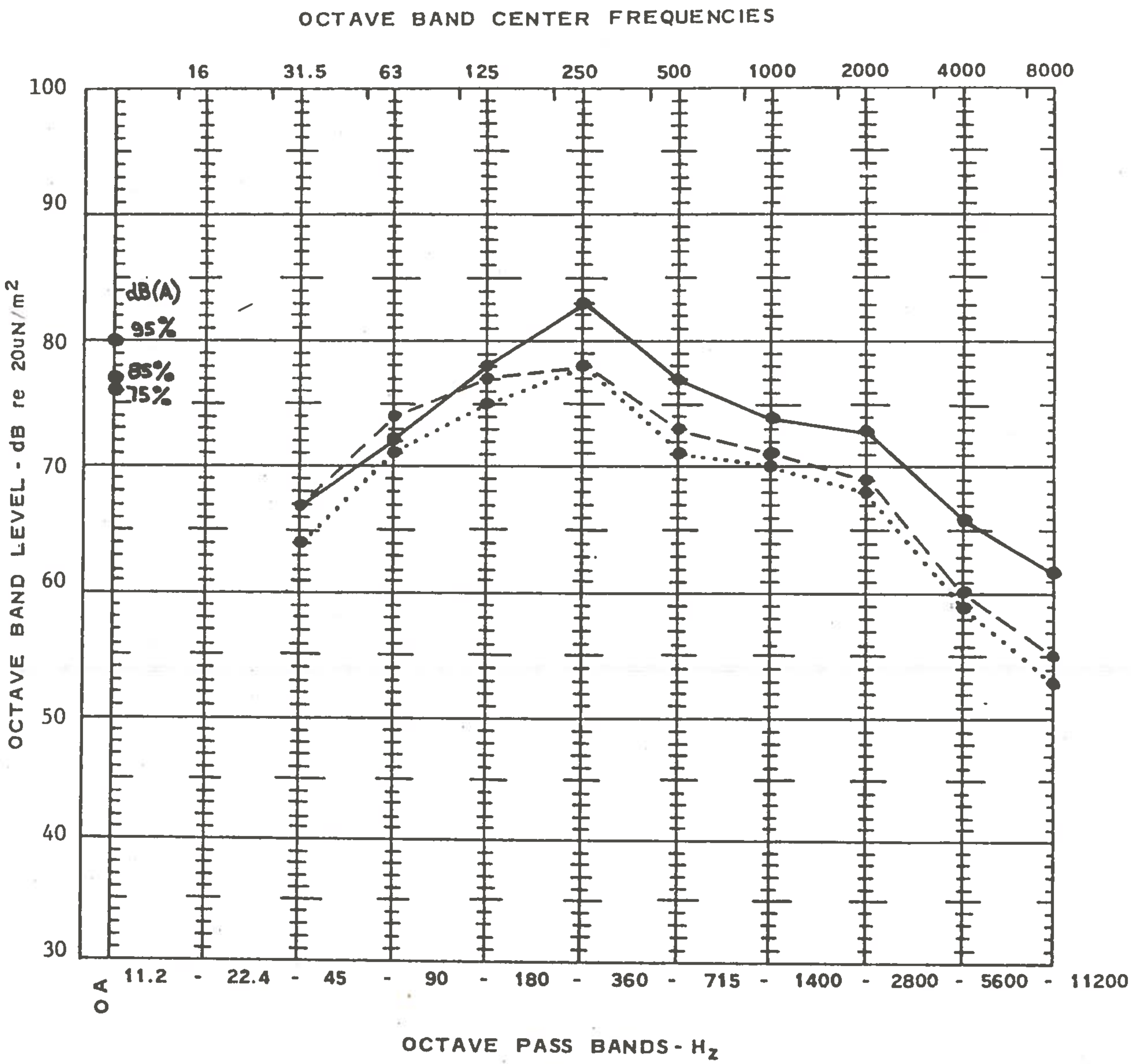
Condition - Second Baseline
Cooling Fan Locked On

75% Engine Speed

85% Engine Speed

95% Engine Speed

Figure F.2-11



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

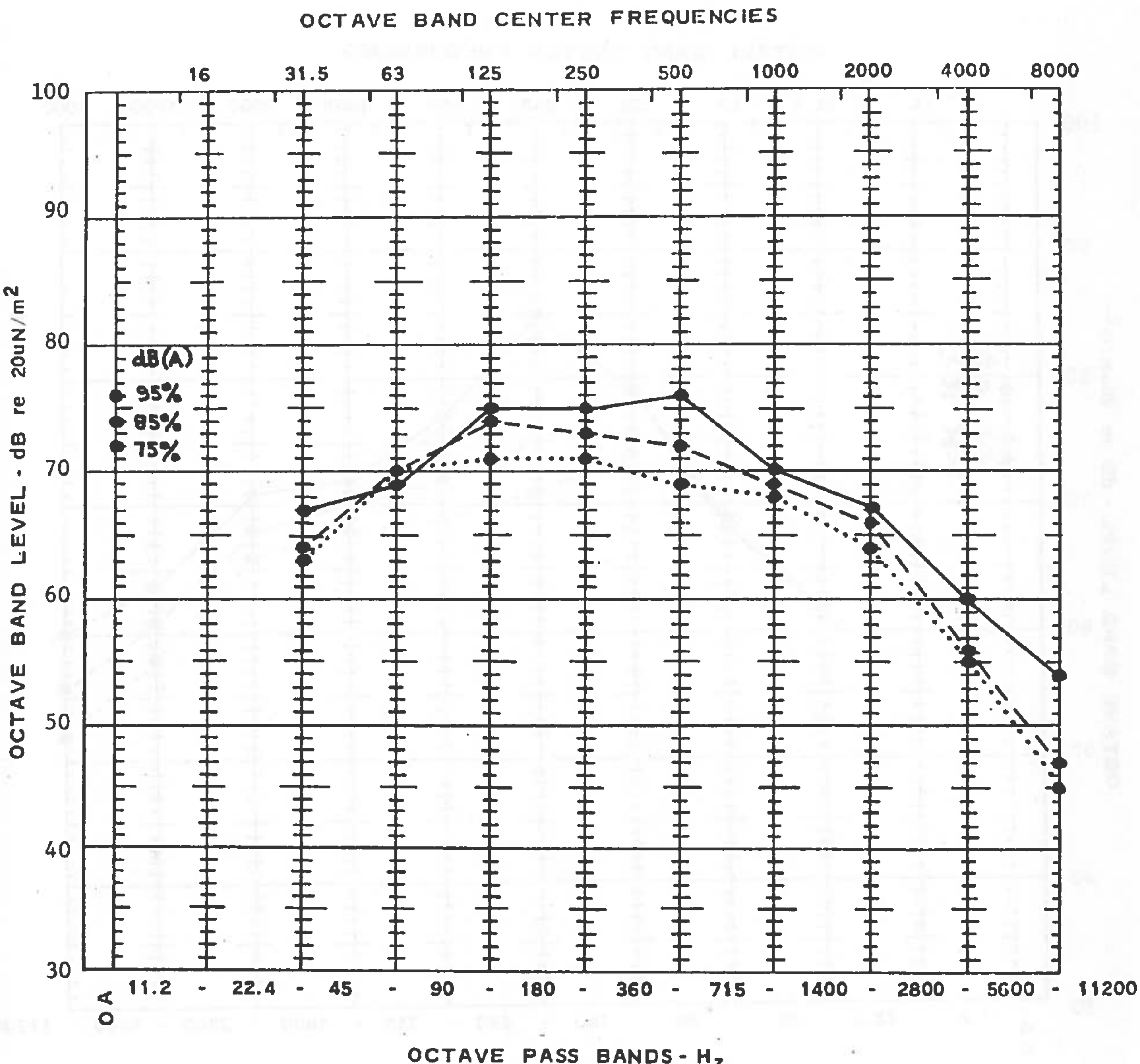
Condition - Second Baseline Cooling Fan Locked On

●·······● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.2-12



SOUND ATTENUATION KIT PROGRAM

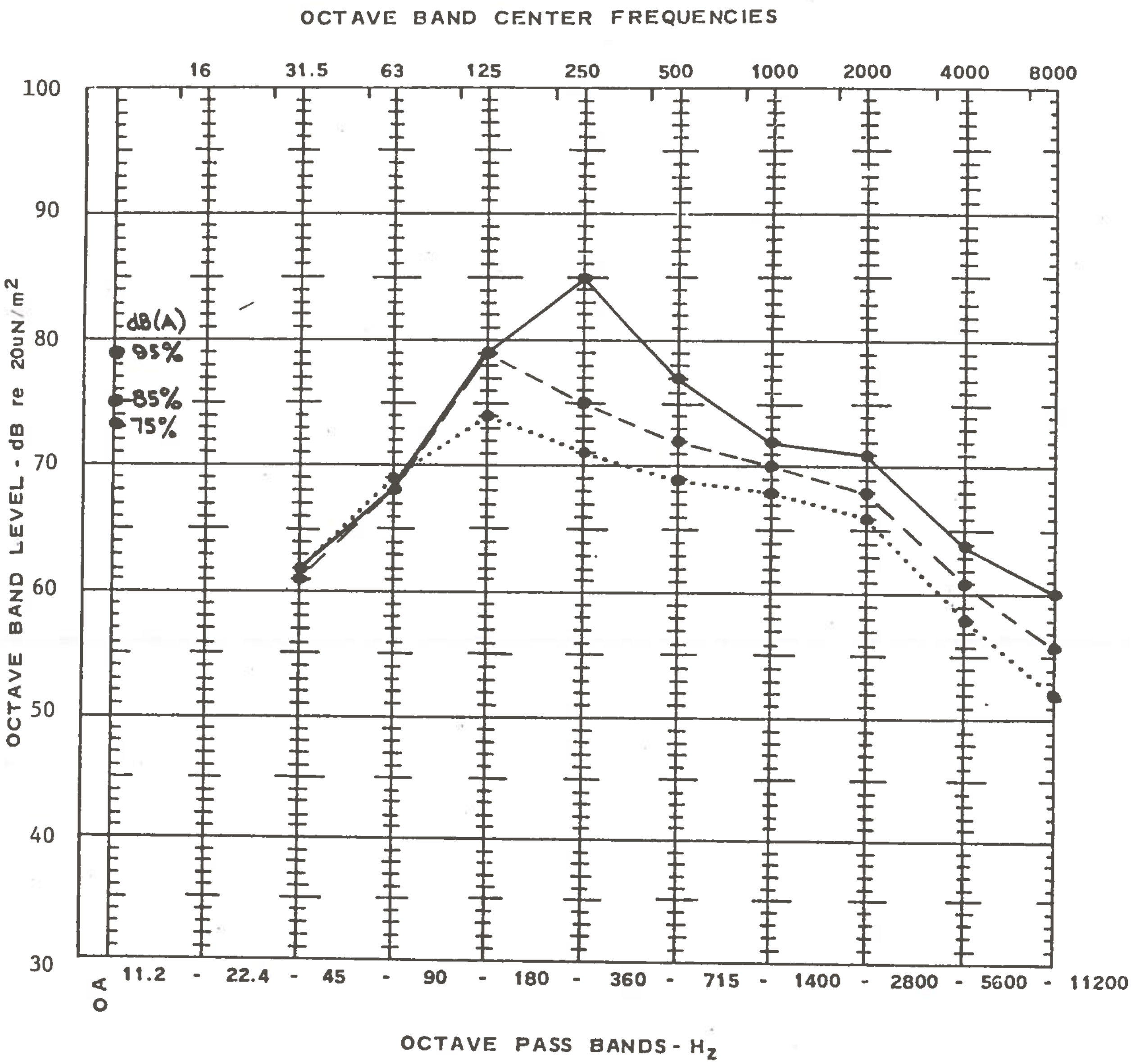
35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Right Hand Side of Bus

Condition - Second Baseline Cooling Fan
Locked On

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.2-13



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

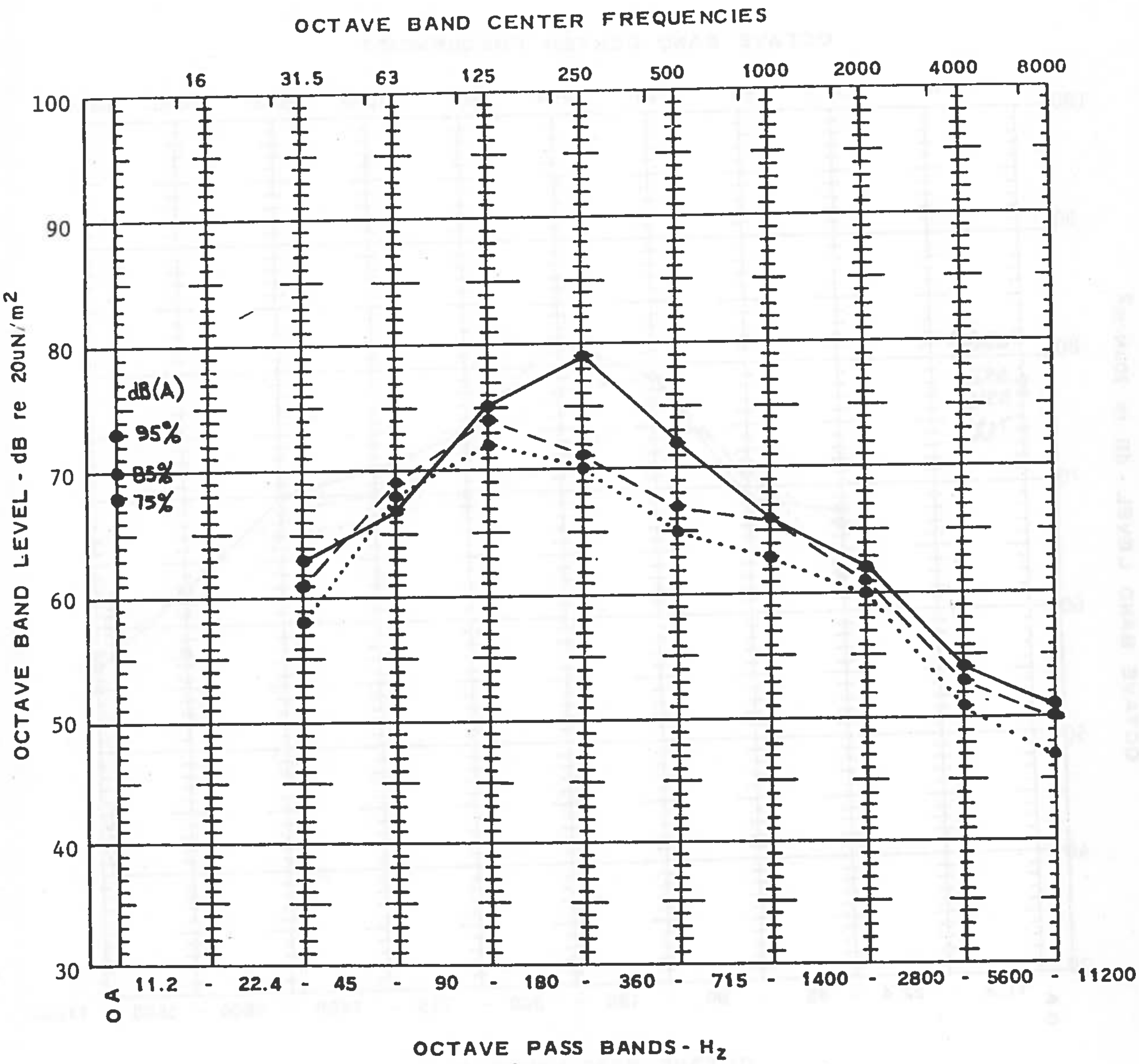
Stationary Bus at 50 ft.
Left Hand Side of Bus
Condition - Sound Attenuation Kit No. 1
Cooling Fan Locked On

●·········● 75% Engine Speed

● — — — ● 85% Engine Speed

●————● 95% Engine Speed

Figure F.2-14

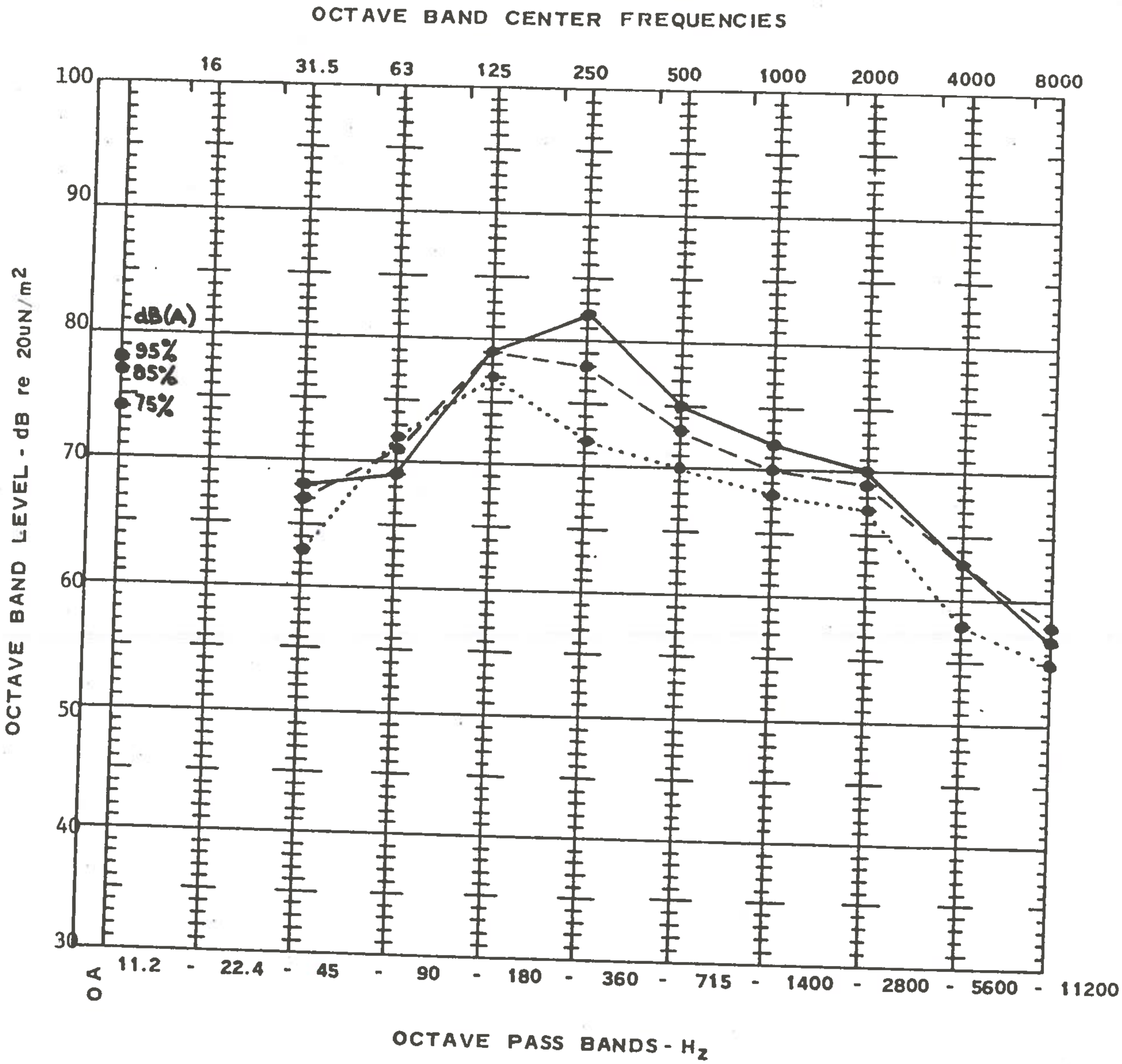


SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine
Stationary Bus at 50 ft.
Right Hand Side of Bus
Condition - Sound Attenuation Kit No. 1
Cooling Fan Locked On

- ●......● 75% Engine Speed
- ●— — —● 85% Engine Speed
- ●———● 95% Engine Speed

Figure F.2-15



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

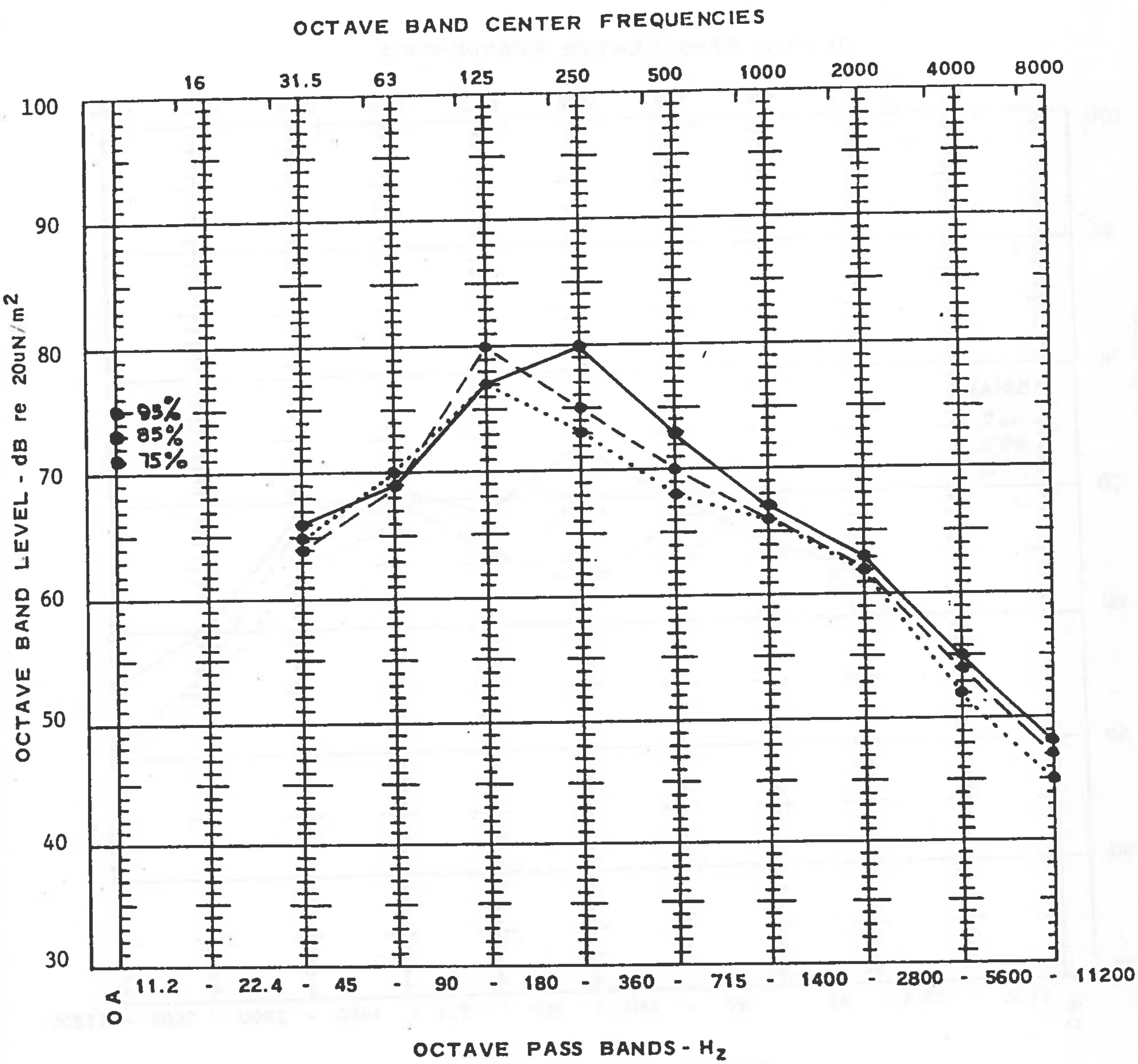
Condition - Sound Attenuation Kit No. 1
Cooling Fan Locked On

Engine Speed 75%

Engine Speed 85%

Engine Speed 95%

Figure F.2-16



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Right Hand Side of Bus

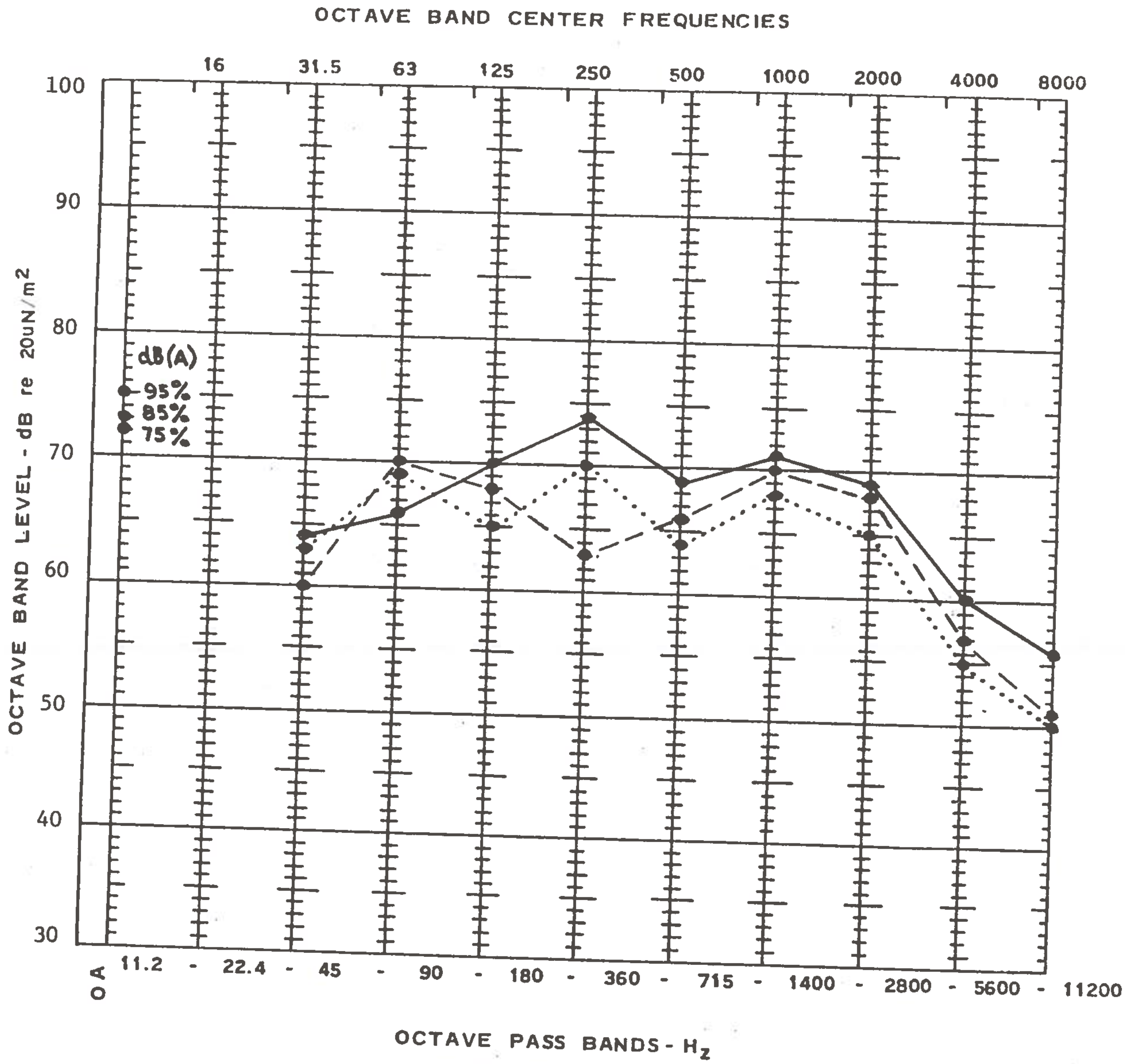
Condition - Sound Attenuation Kit No. 1
Cooling Fan Locked On

●·······● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.2-17



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

Stationary Bus at 50 ft.
Left Hand Side of Bus

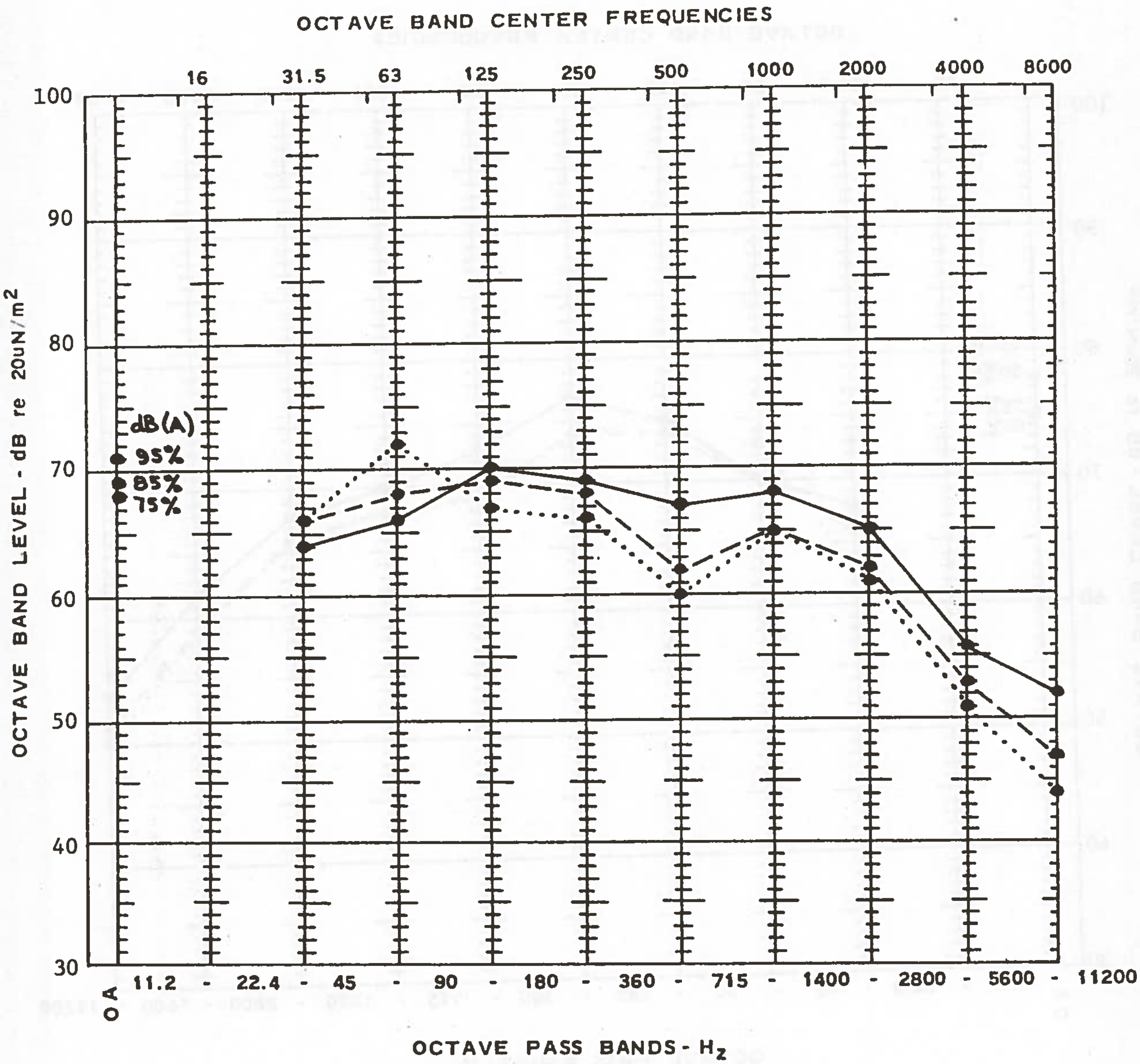
Condition - Sound Attenuation Kit No. 2

●·······● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.2-18



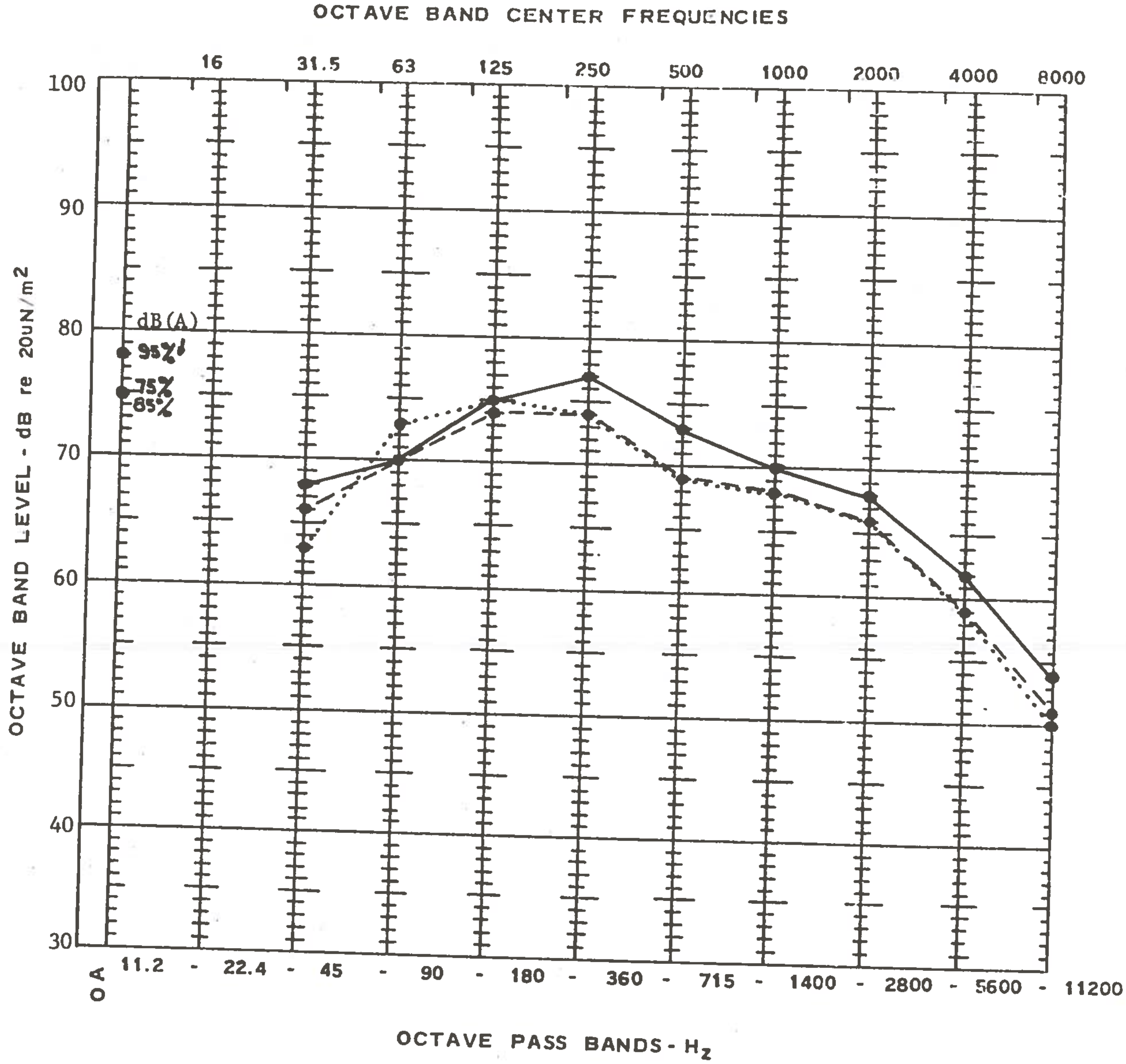
SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus, 6V71 Engine

Stationary Bus at 50 ft.
Right Hand Side of Bus

Condition - Sound Attenuation Kit No. 2

●········● 75% Engine Speed
● — — — ● 85% Engine Speed
●———● 95% Engine Speed

Figure F.2-19



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

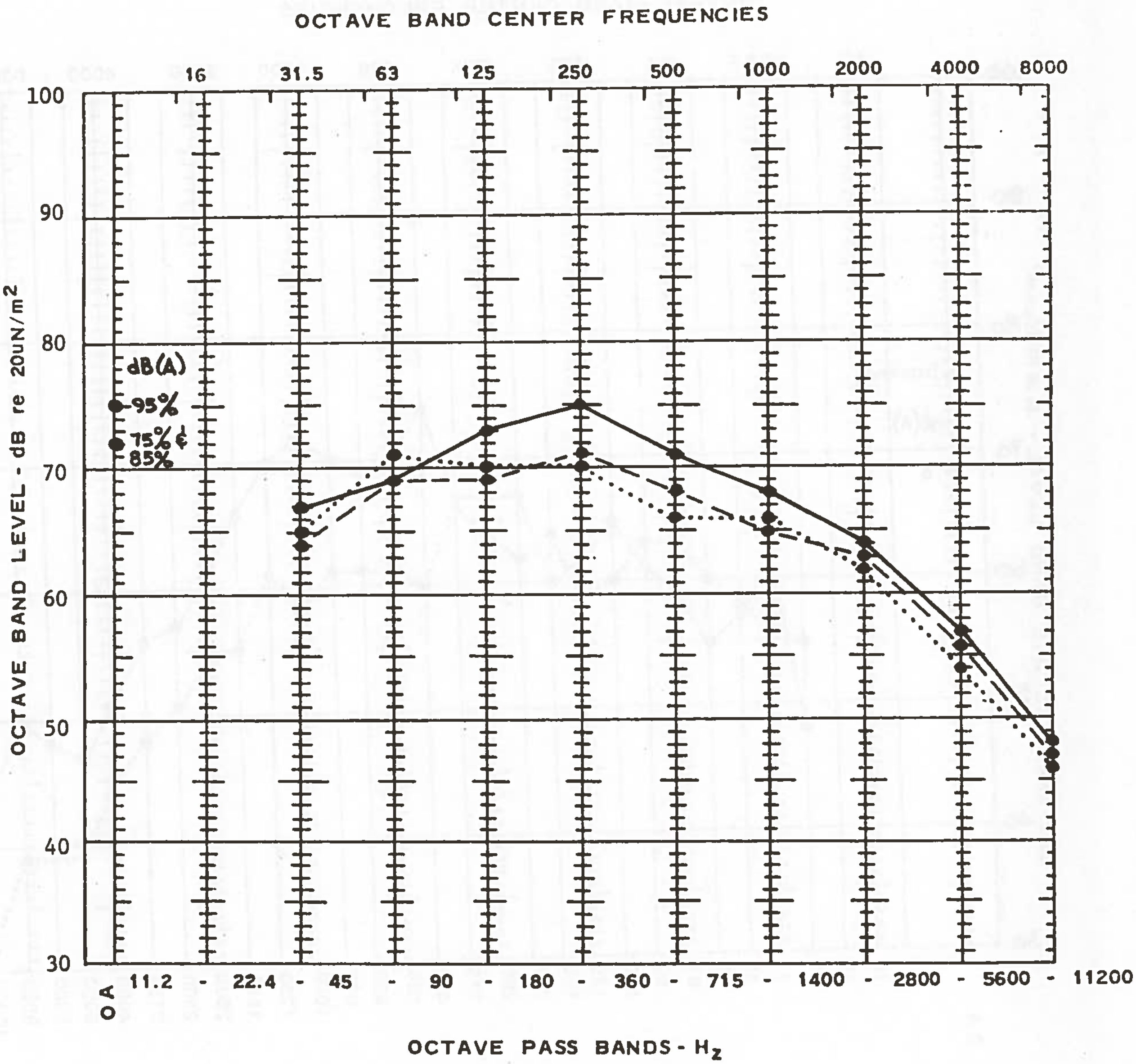
Condition - Sound Attenuation Kit No. 2

75% Engine Speed

85% Engine Speed

95% Engine Speed

Figure F.2-20



SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Right Hand Side of Bus

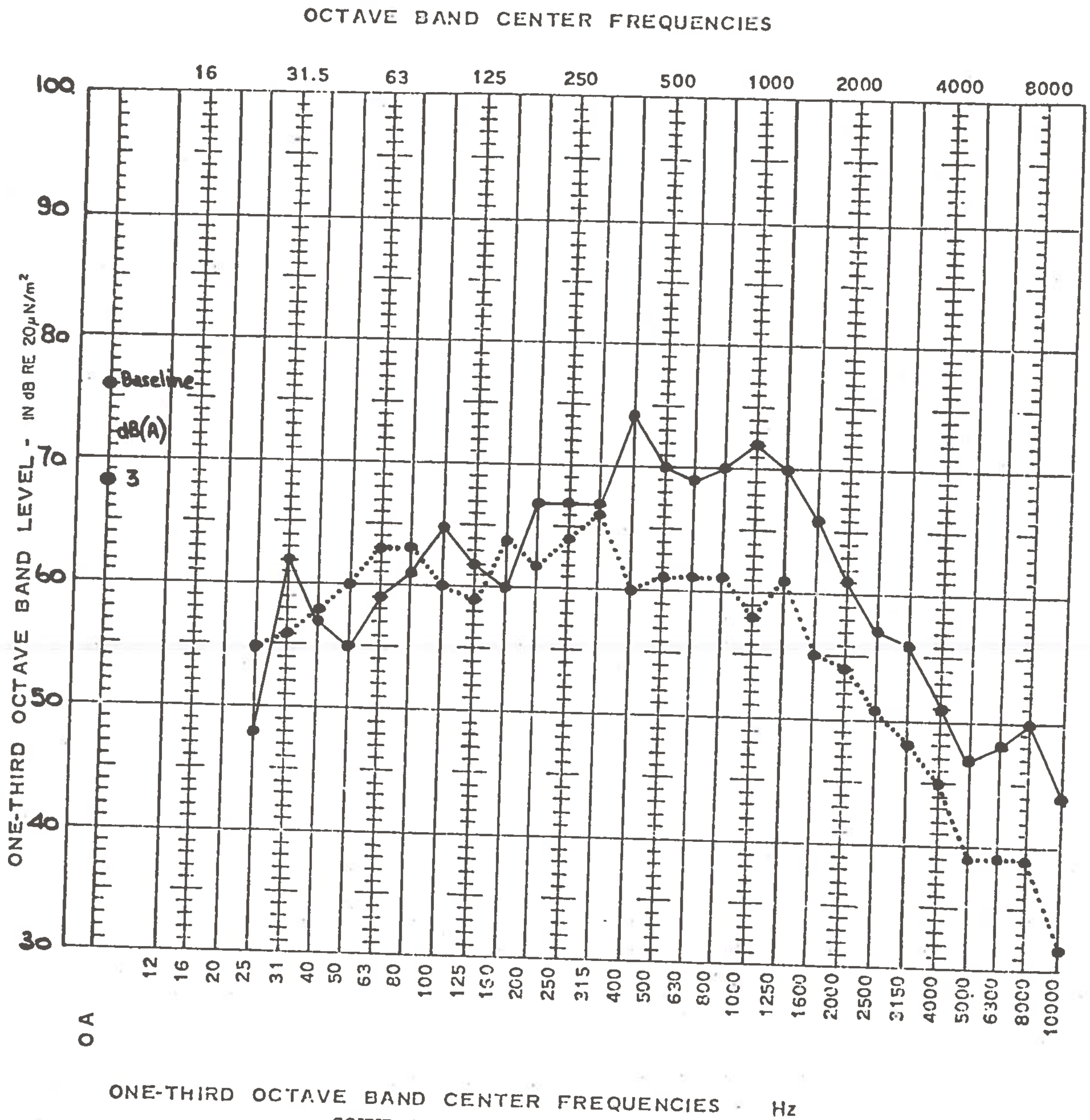
Condition - Sound Attenuation Kit No. 2

●········● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.2-21



SOUND ATTENUATION KIT PROGRAM

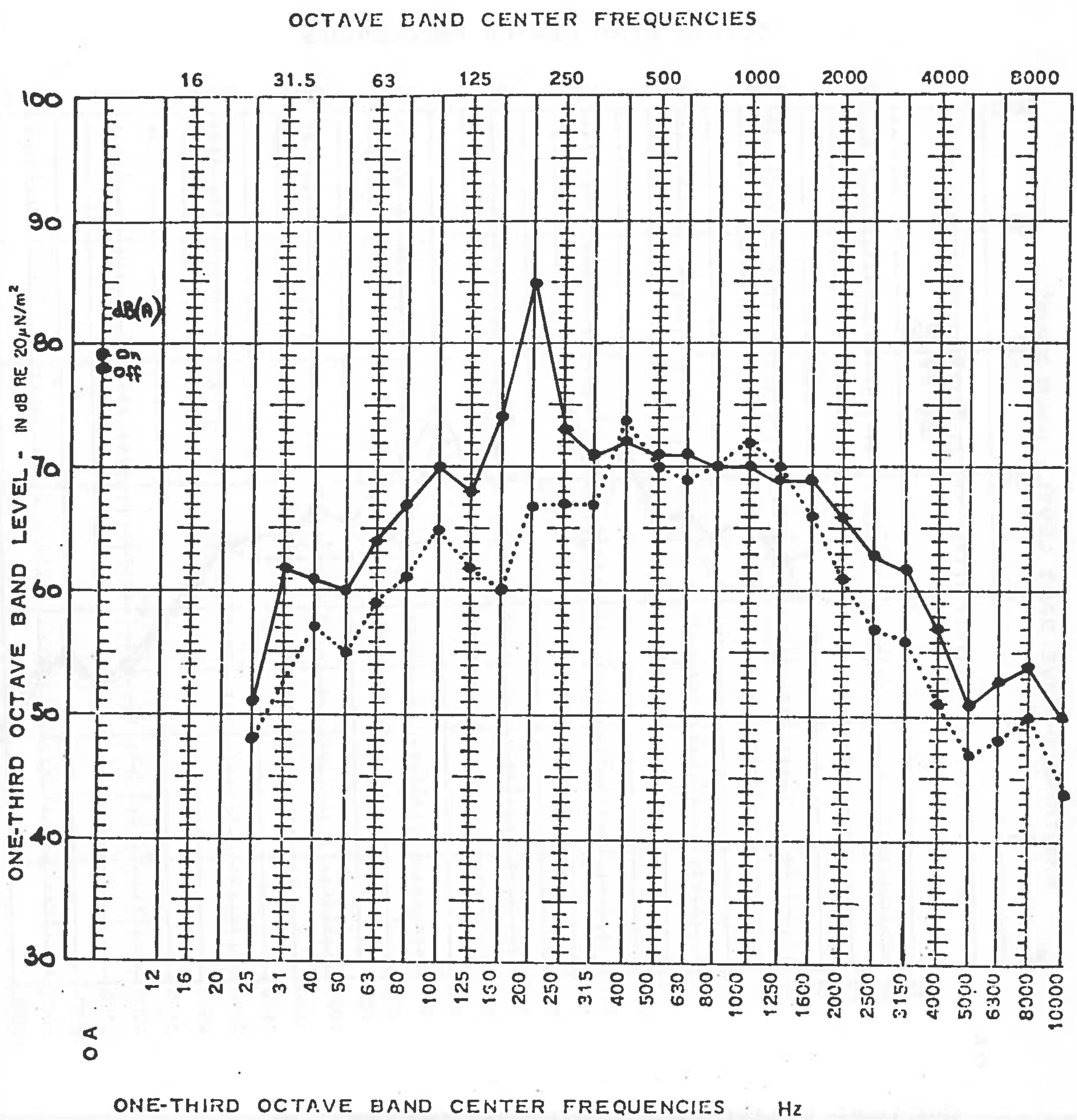
35 ft. Flxible Bus, 6V71 Engine

Stationary Bus at 50 ft.
Left Hand Side of Bus

Condition - Second Baseline vs. 3 - Effect of Engine Capsule - Radiator Cooling Fan Locked Off

Baseline } Engine Speed 95%
Condition 3 }

Figure F.3-1



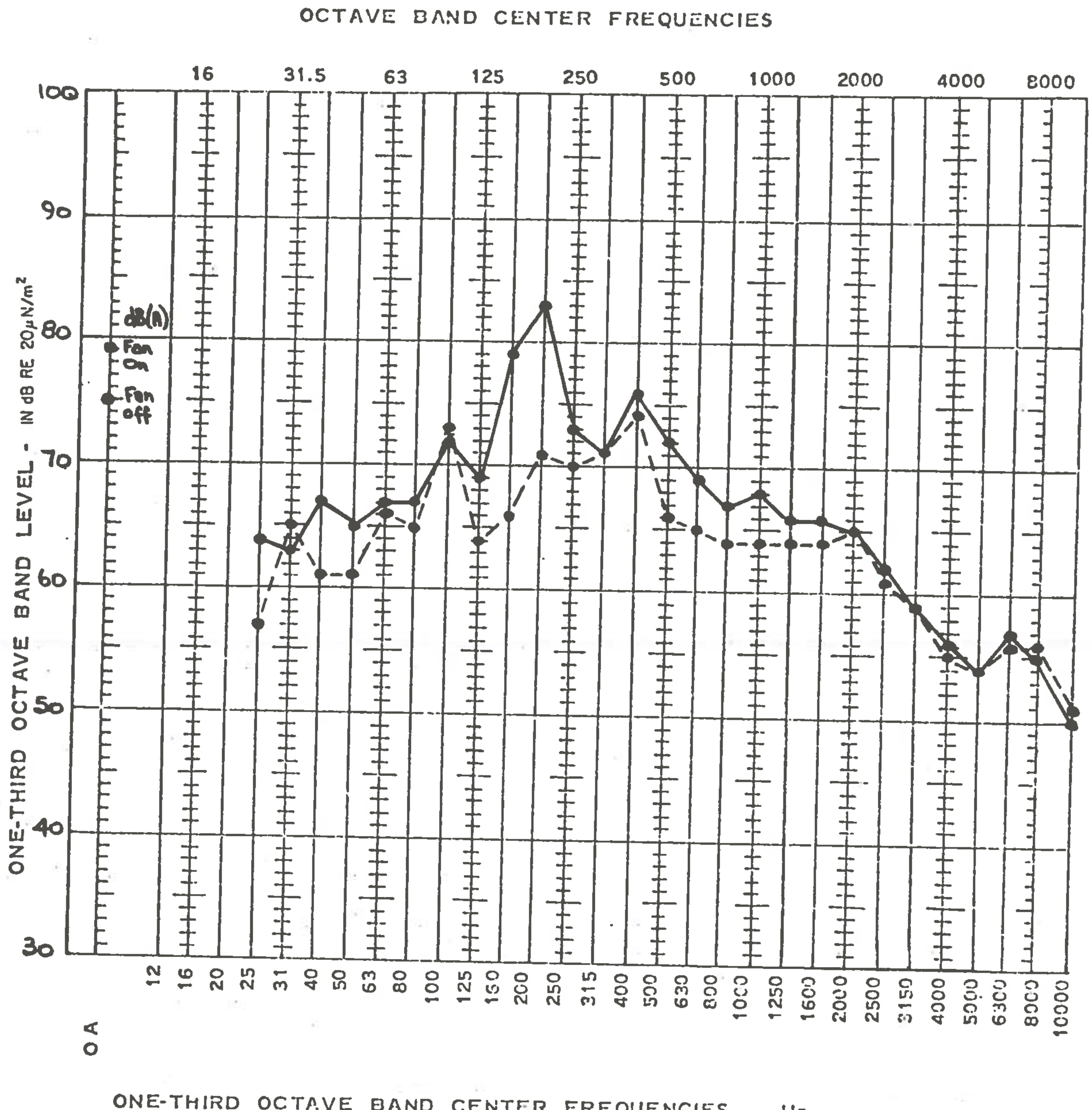
SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine

Stationary Bus at 50 ft.
Left Hand Side of Bus
Condition - Second Baseline - Radiator Cooling
Fan Locked On and Off

Fan On)
) Engine Speed 95%
Fan Off)

Figure F.3-2



SOUND ATTENUATION KIT PROGRAM

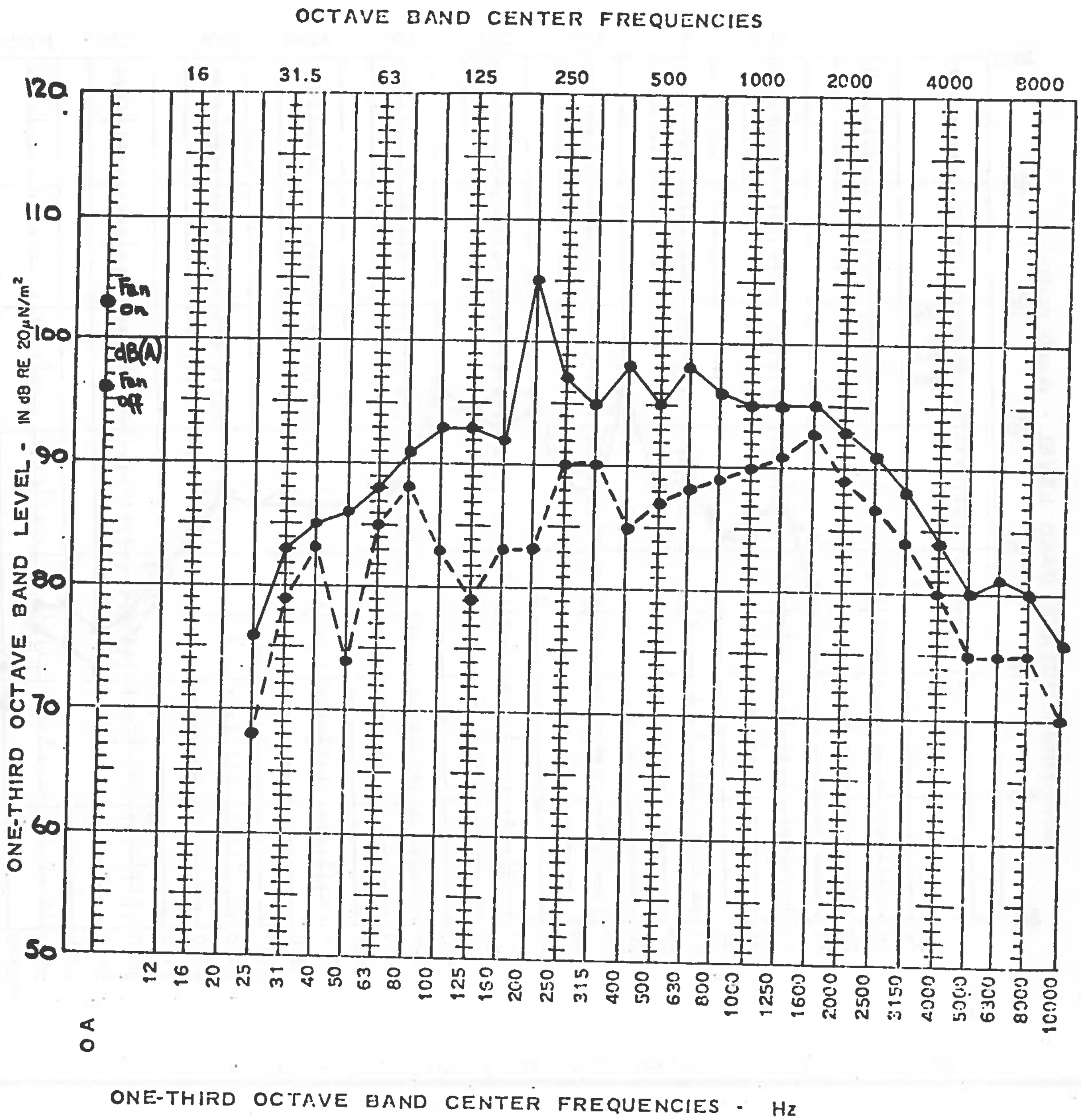
35 ft. Flxible Bus, 6V71 Engine

50 ft. Constant Speed Passbys
Left Hand Side of Bus

Condition - Sound Attenuation Kit No. 1
Radiator Cooling Fan Locked On and Off

●———● Fan On)
)
●– – –● Fan Off) Engine Speed 95%

Figure F.3-3

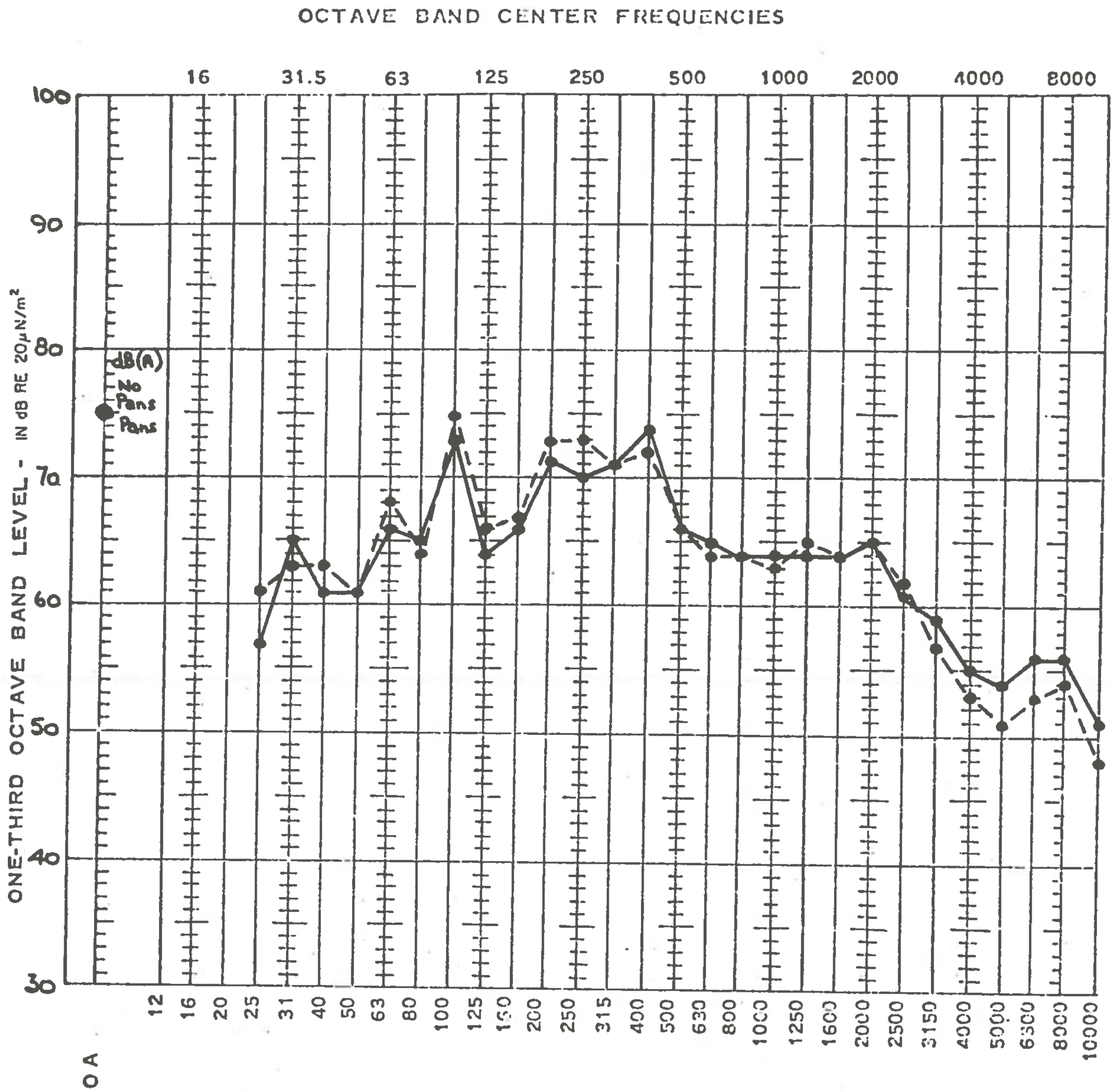


SOUND ATTENUATION KIT PROGRAM
35 Ft. Flxible Bus, 6V71 Engine
Stationary Bus, 3 ft. from Center of Radiator
Left Hand Side of Bus

Condition - 14c, Radiator Cooling Fan Locked
On and Off

Fan On)
Fan Off) Engine Speed 95%

Figure F.3-4



ONE-THIRD OCTAVE BAND CENTER FREQUENCIES - Hz

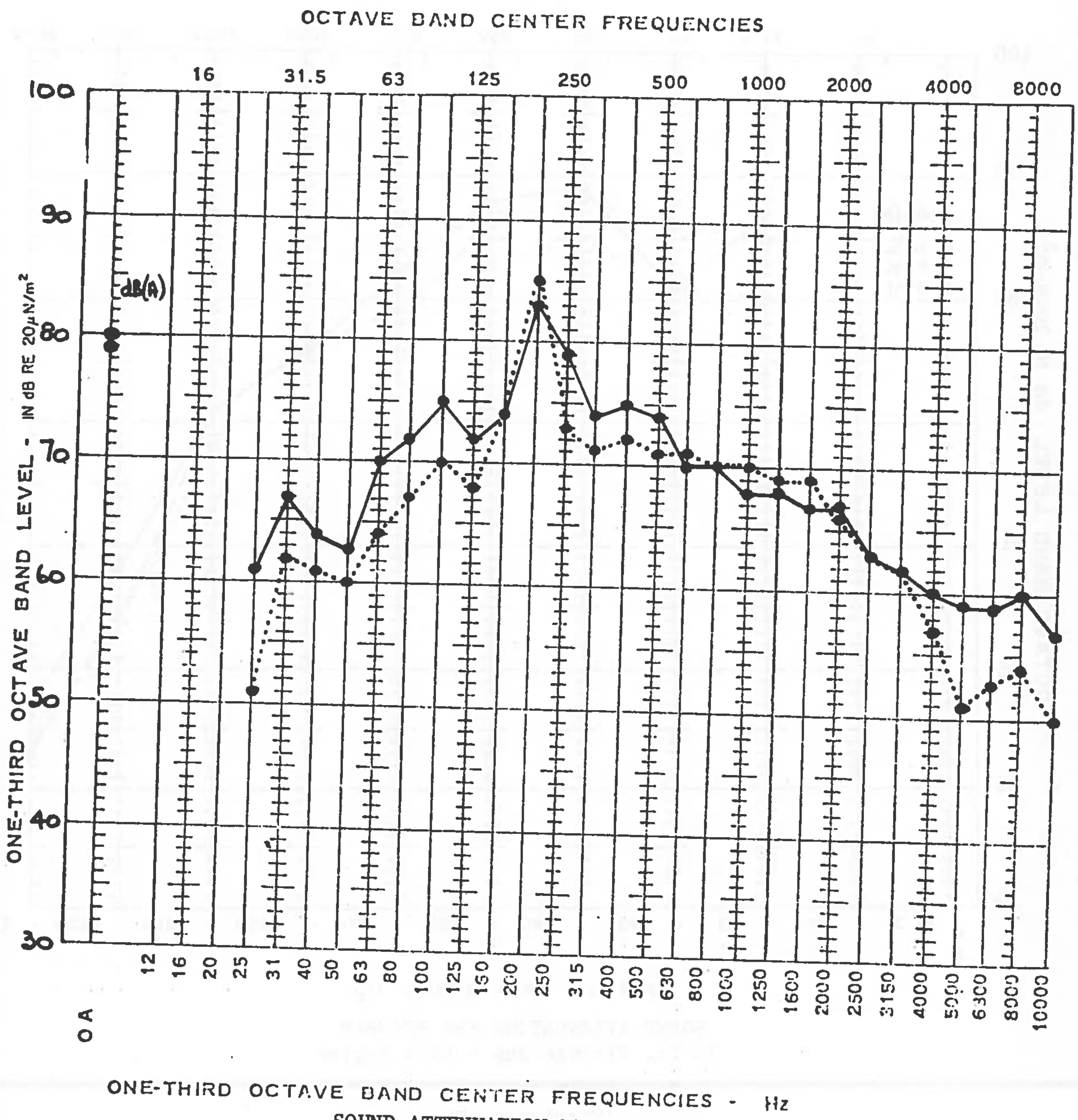
SOUND ATTENUATION KIT PROGRAM

35 ft. Flxible Bus, 6V71 Engine
50 ft. Constant Speed Passbys
Left Hand Side of Bus

Condition - Sound Attenuation Kit No. 1
With and Without Engine Underpans

Without Underpan) Radiator Cooling Fan Off
With Underpan) Engine Speed 95%

Figure F.3-5



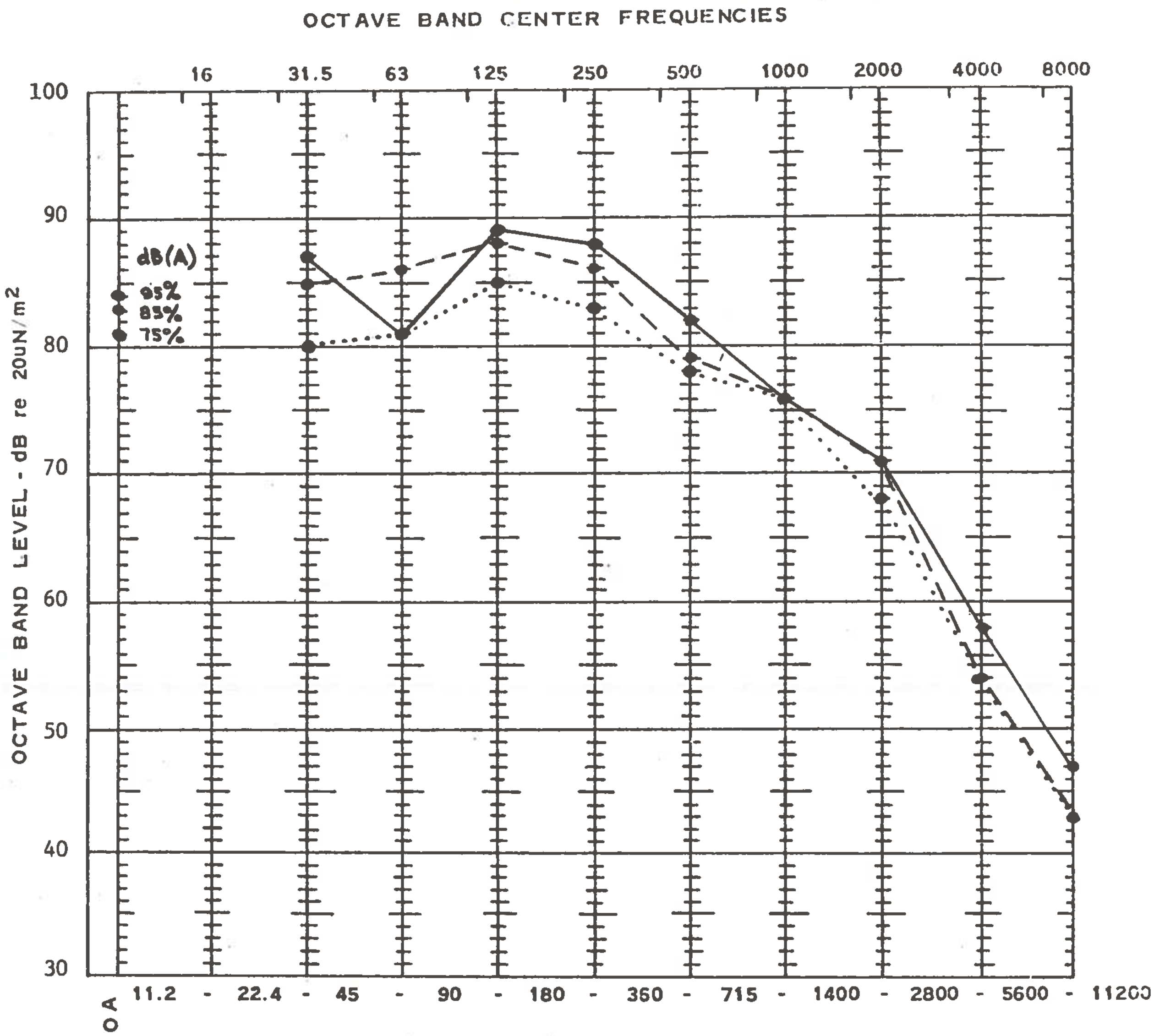
SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

50 ft. Constant Speed Passby versus
Stationary Bus at 50 ft.

Condition - Second Baseline, Radiator Cooling
Fan Locked On

●———● Passby)
●·······● Stationary) Engine Speed 95%
)

Figure F.3-6

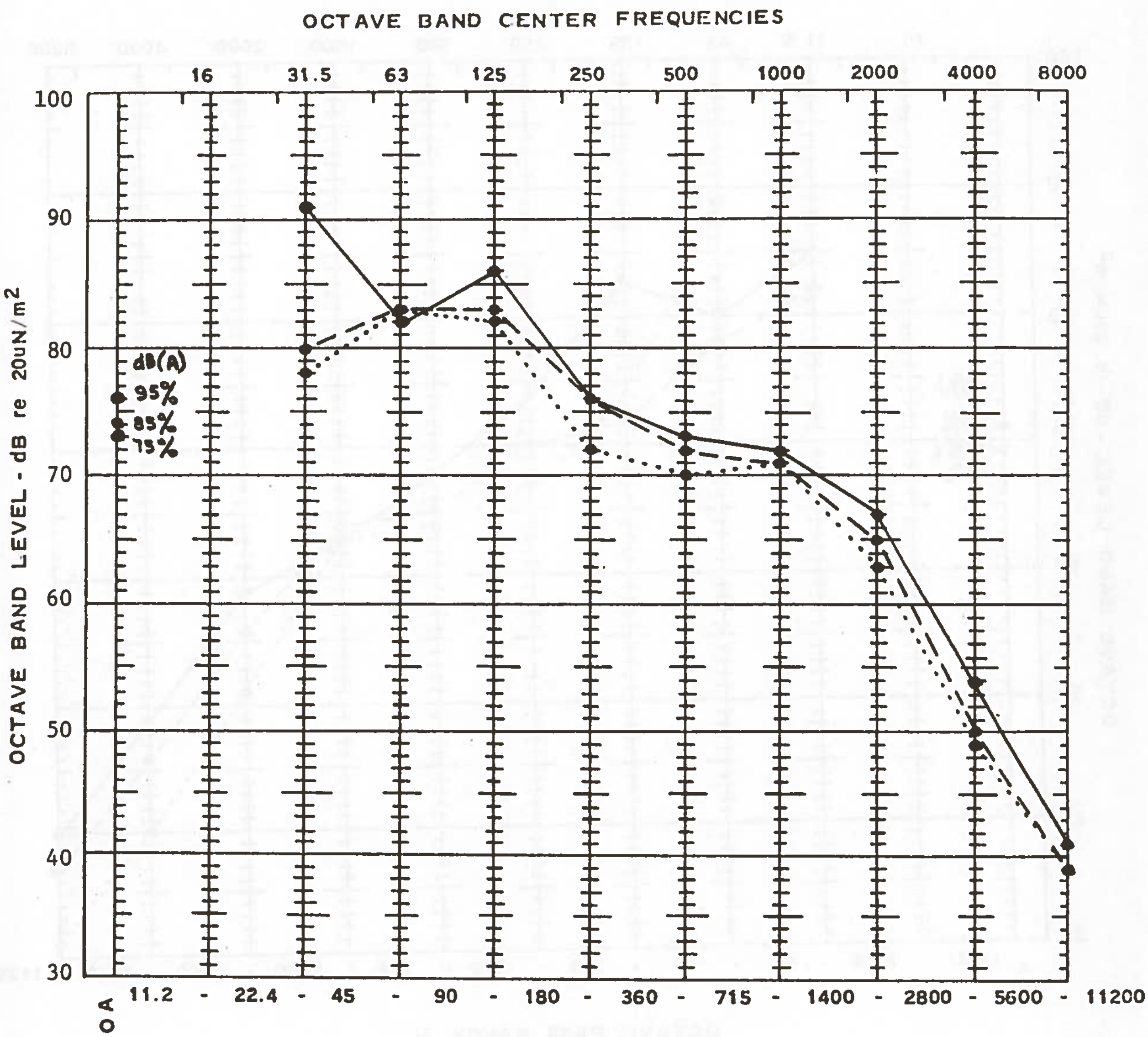


SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Stationary Bus
Center of Rear Seat
Condition - Second Baseline

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.4-1



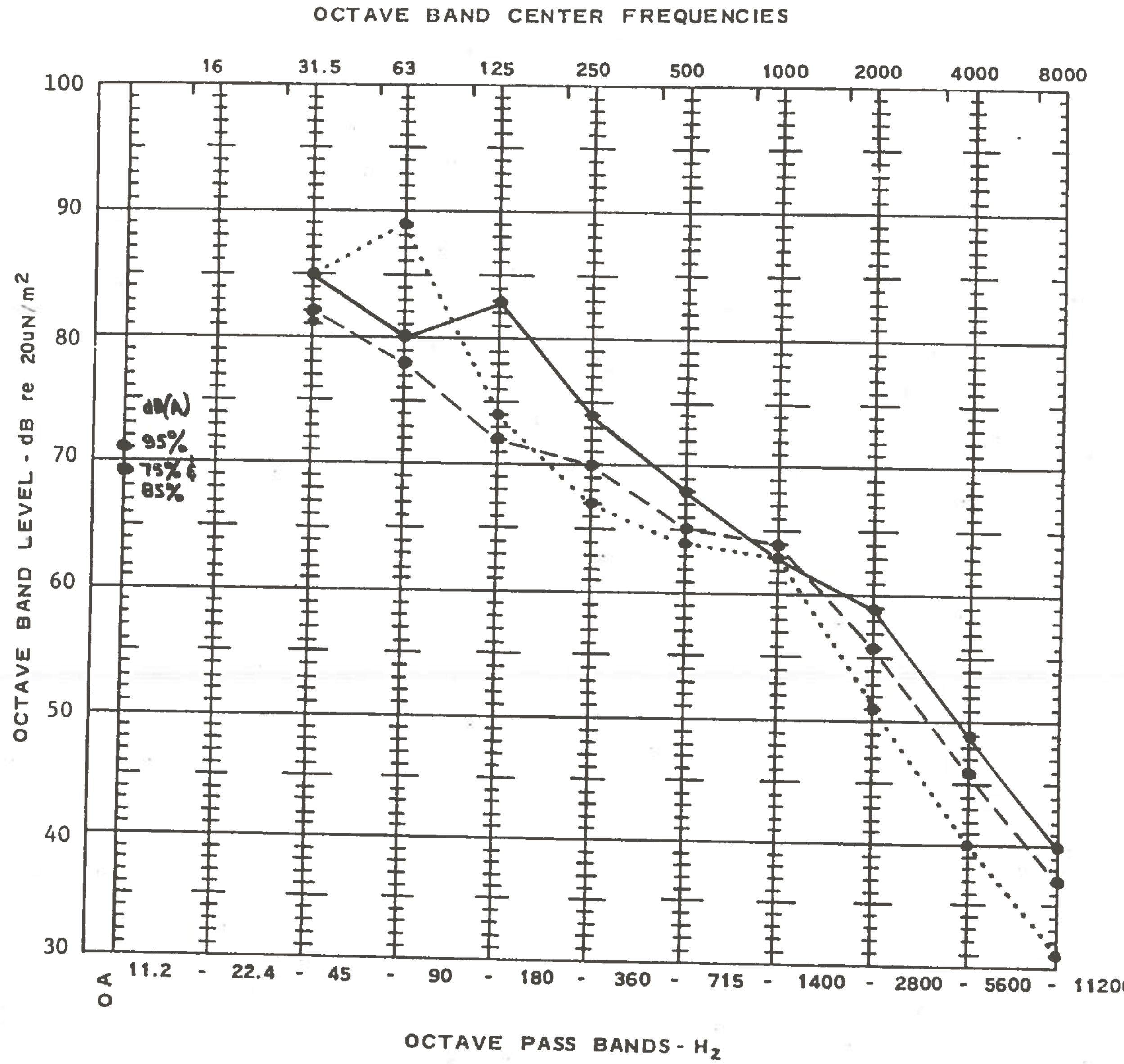
SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Stationary Bus

Mid-Coach Seat
Condition - Second Baseline

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.4-2



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Stationary Bus

Driver's Ear Position

Condition - Second Baseline

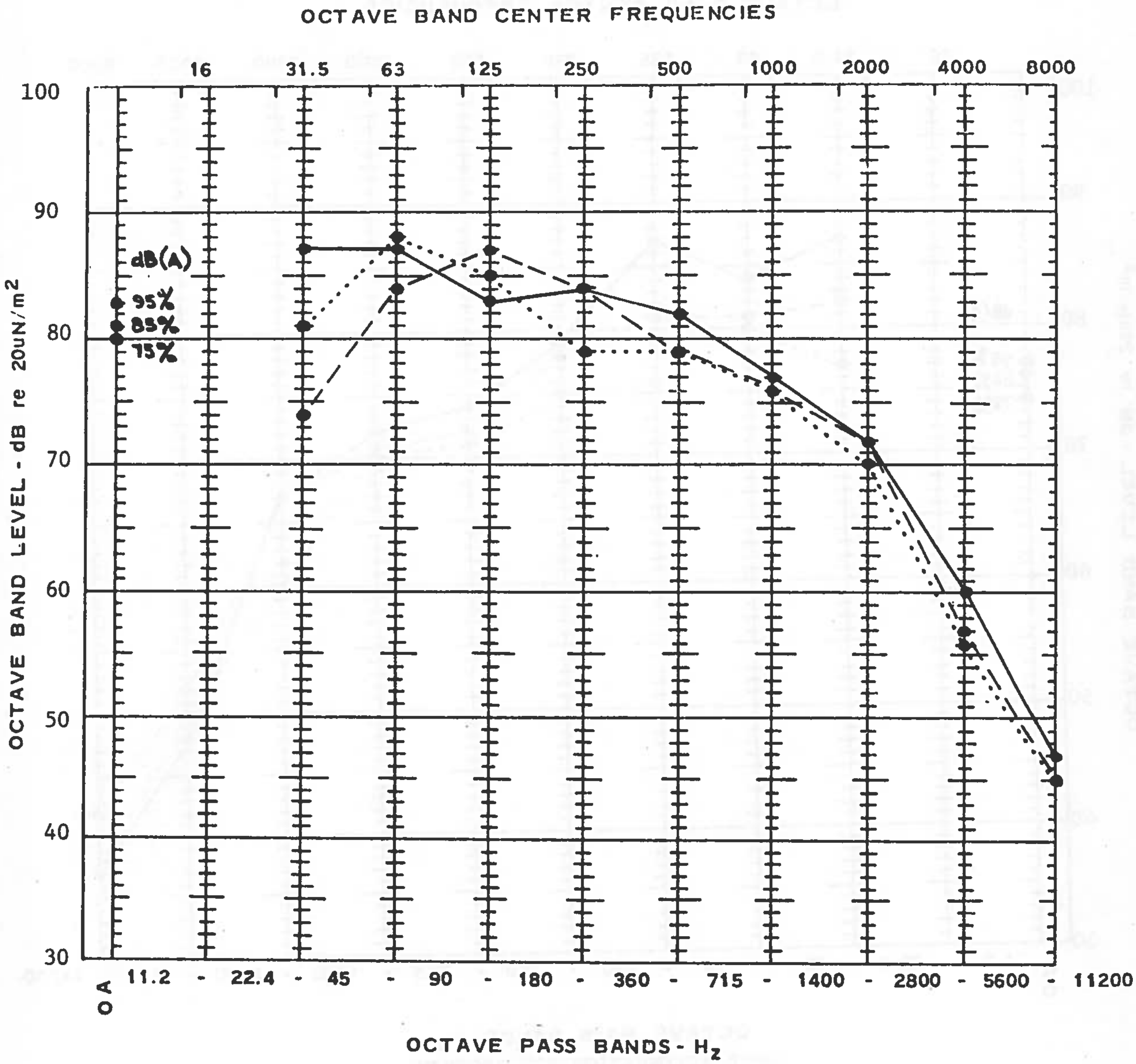
75% Engine Speed

85% Engine Speed

95% Engine Speed

Figure F.4-3

FORM NO. 1382-1



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Stationary Bus
Center of Rear Seat

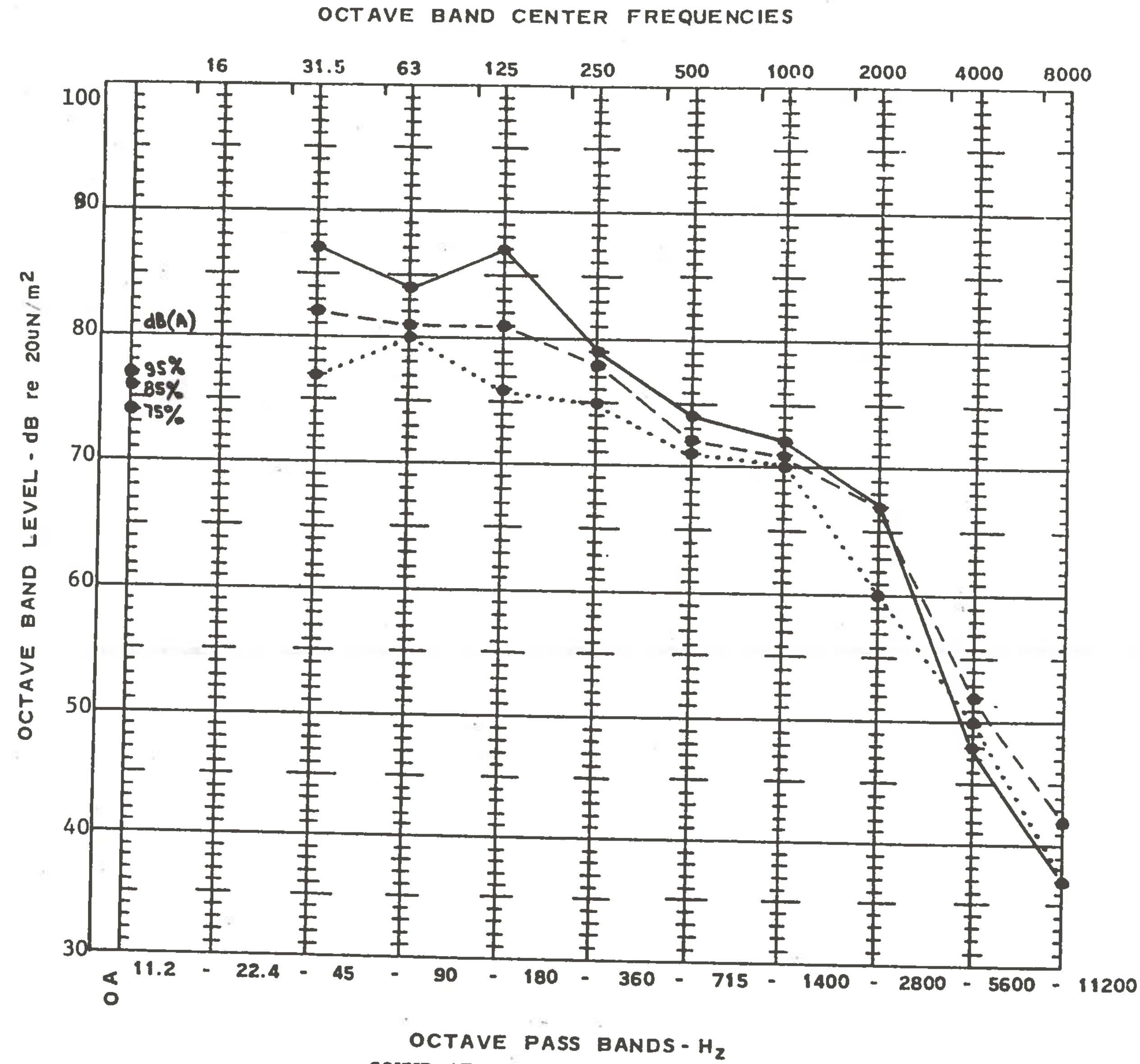
Condition - Sound Attenuation Kit No. 1

●·······● 75% Engine Speed

●– – –● 85% Engine Speed

●———● 95% Engine Speed

Figure F.4-4



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Stationary Bus

Mid-Coach Seat

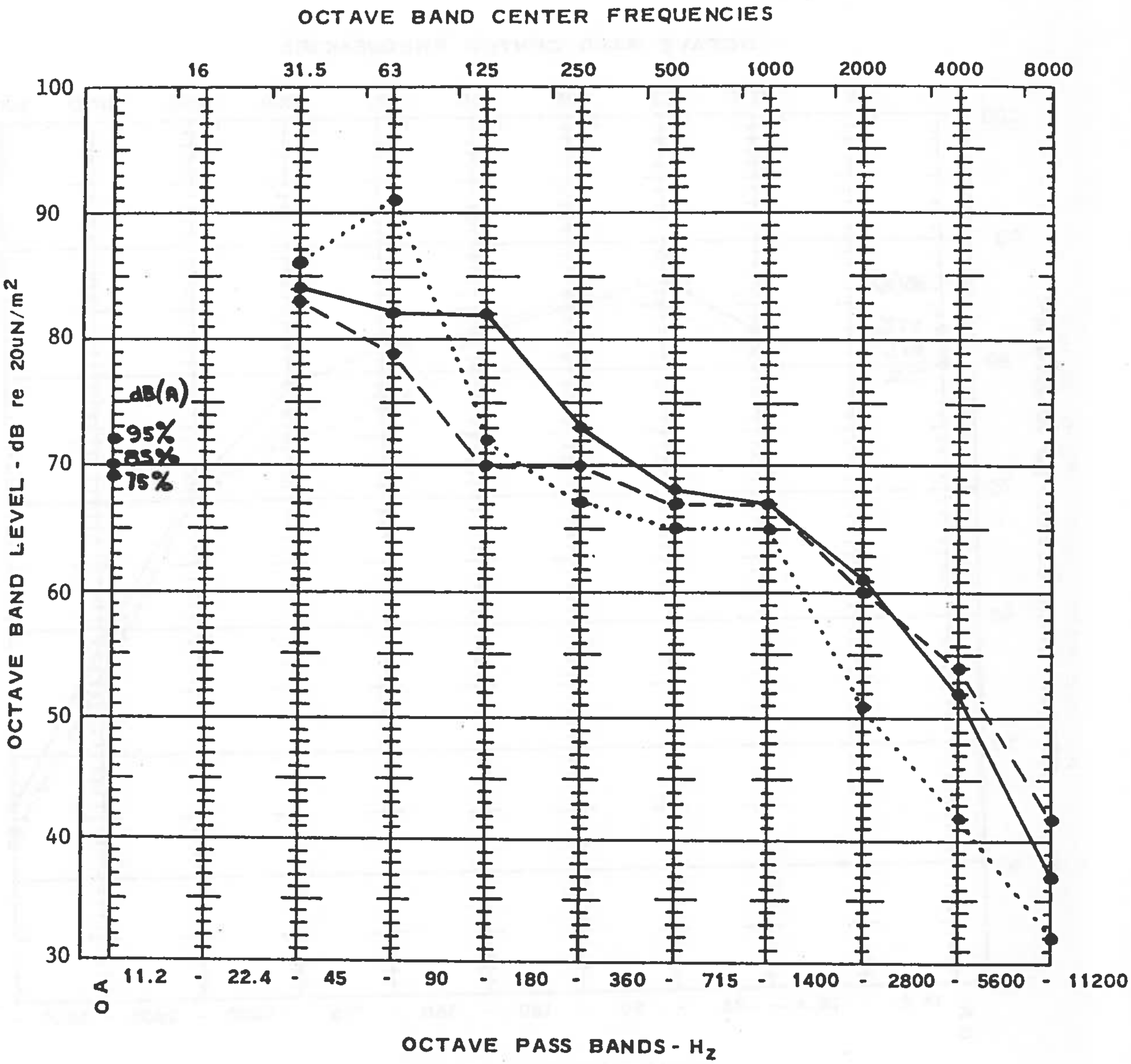
Condition - Sound Attenuation Kit No. 1

75% Engine Speed

85% Engine Speed

95% Engine Speed

Figure F.4-5

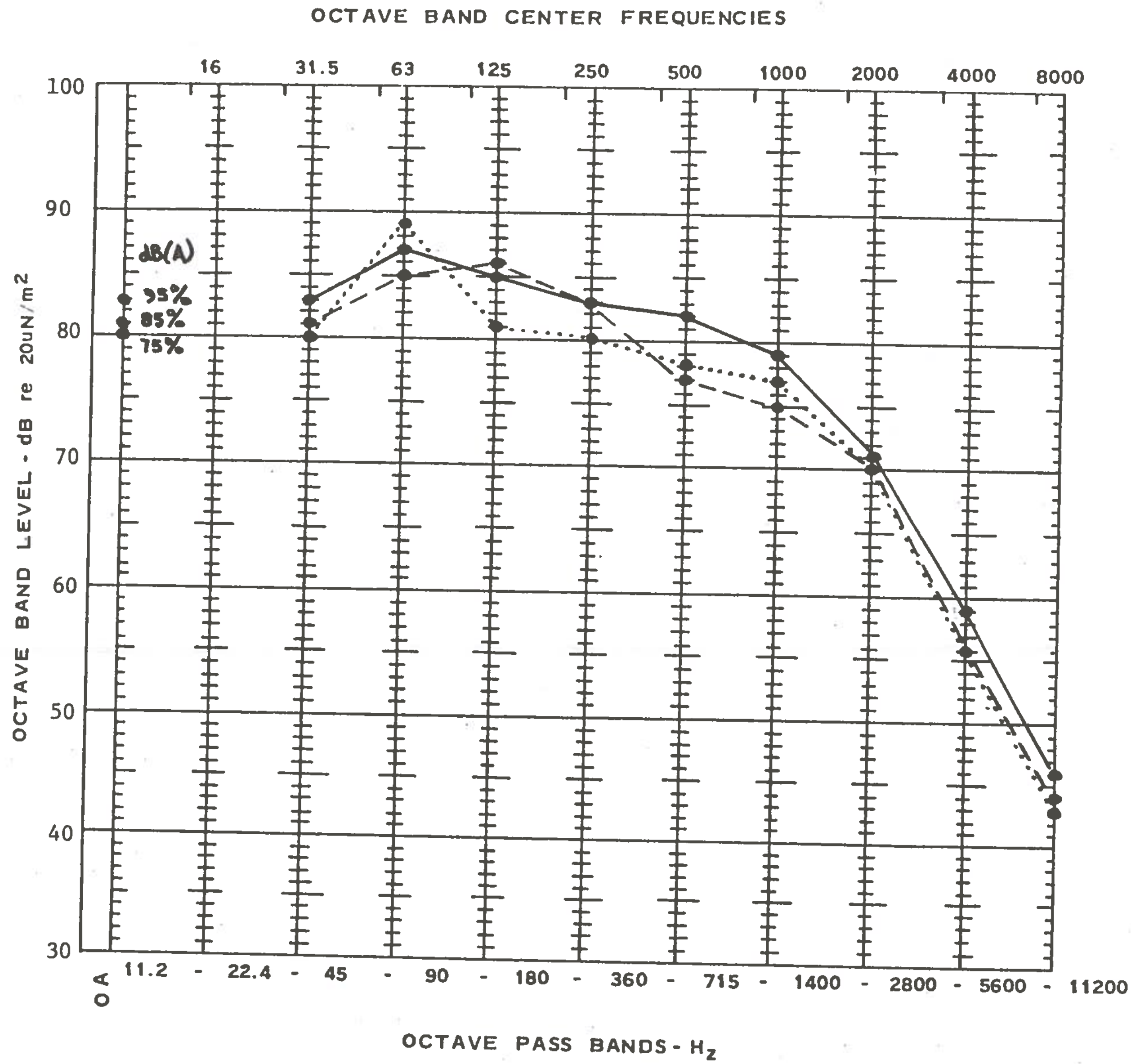


SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine
Interior Noise Measurements
Stationary Bus
Driver's Ear Position

Condition - Sound Attenuation Kit No. 1

75% Engine Speed (dotted line)
85% Engine Speed (dashed line)
95% Engine Speed (solid line)

Figure F.4-6



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

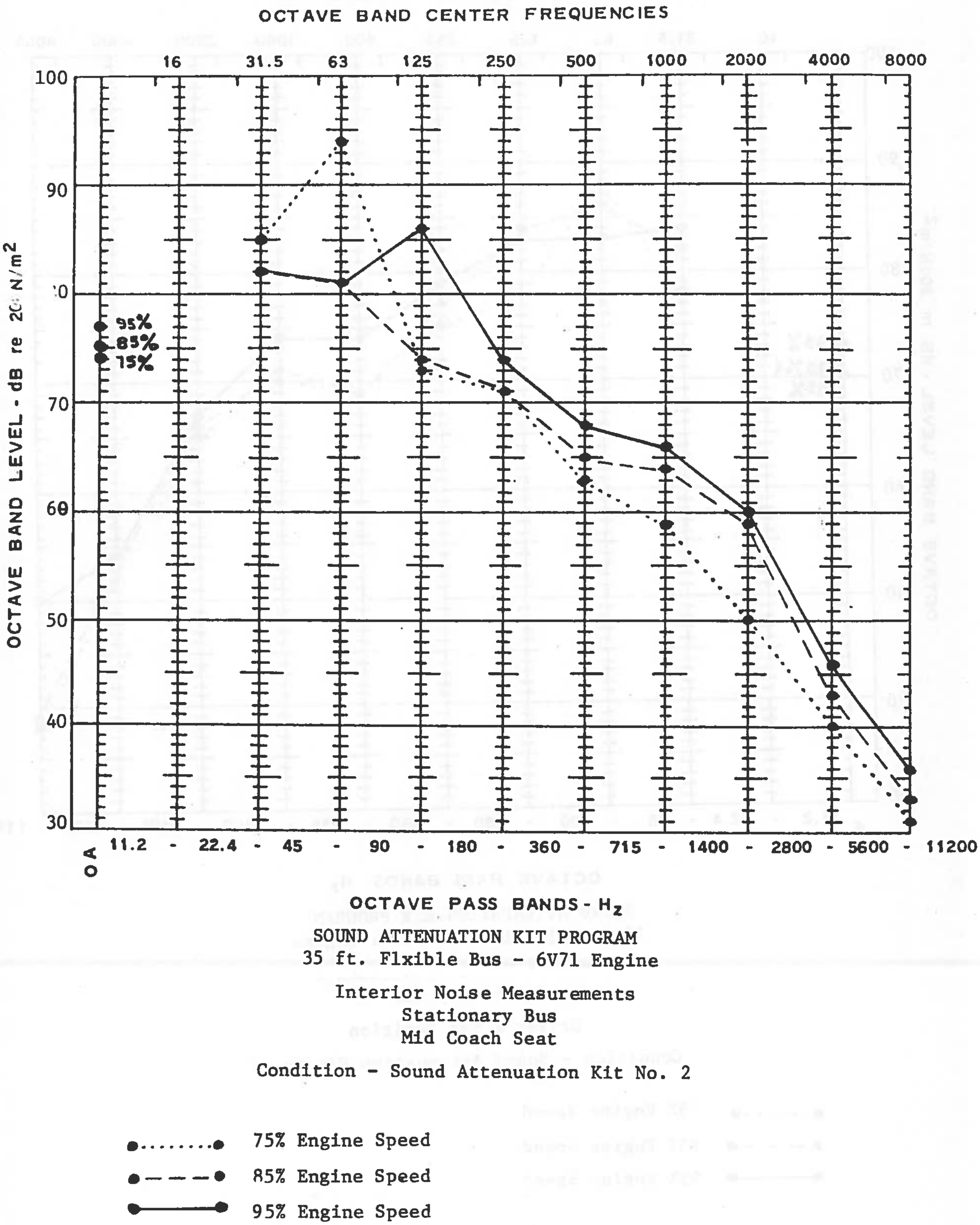
Interior Noise Measurements
Stationary Bus

Center of Rear Seat

Condition - Sound Attenuation Kit No. 2

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.4-7

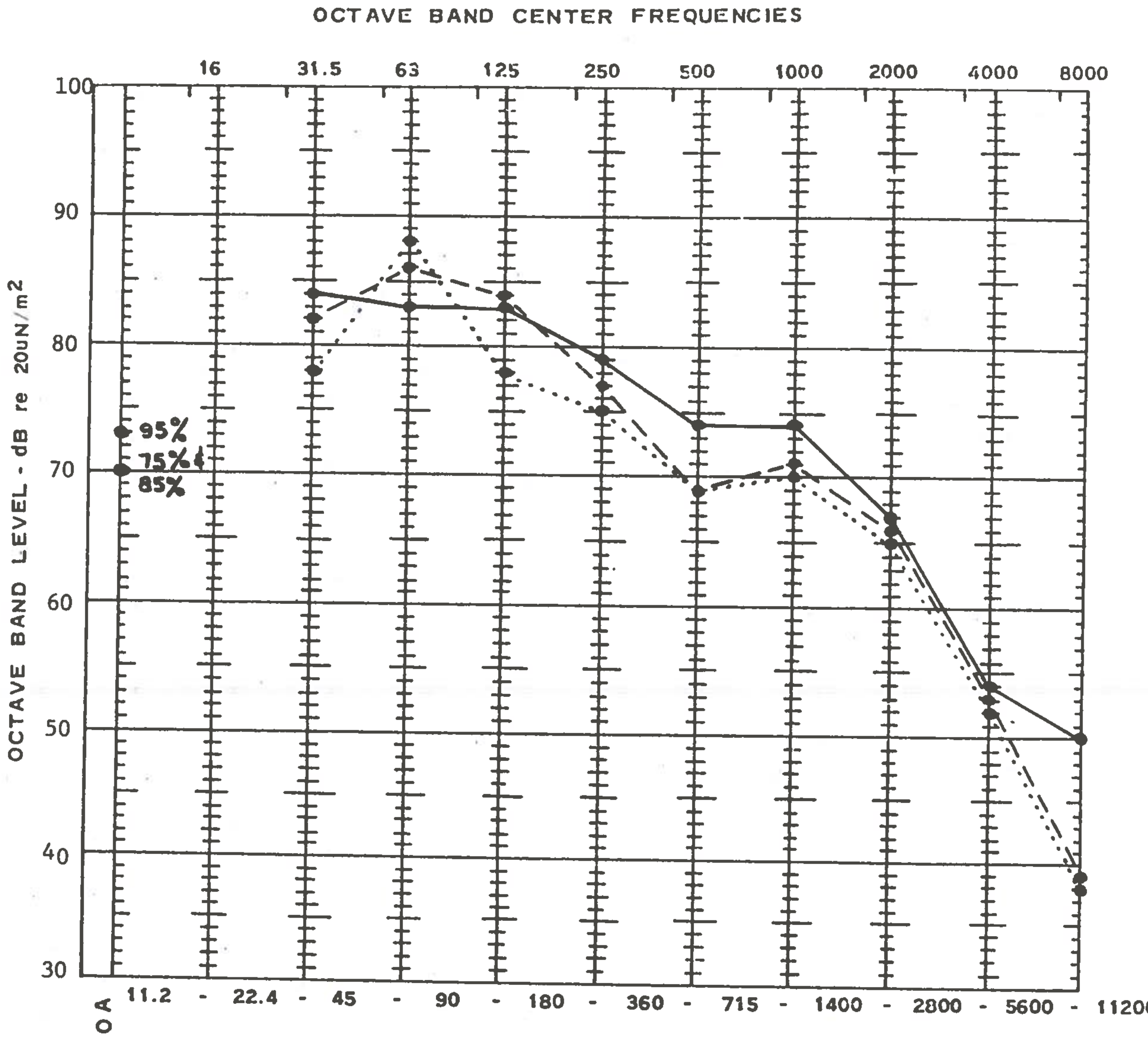


SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Stationary Bus
Mid Coach Seat

Condition - Sound Attenuation Kit No. 2

Figure F.4-8



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

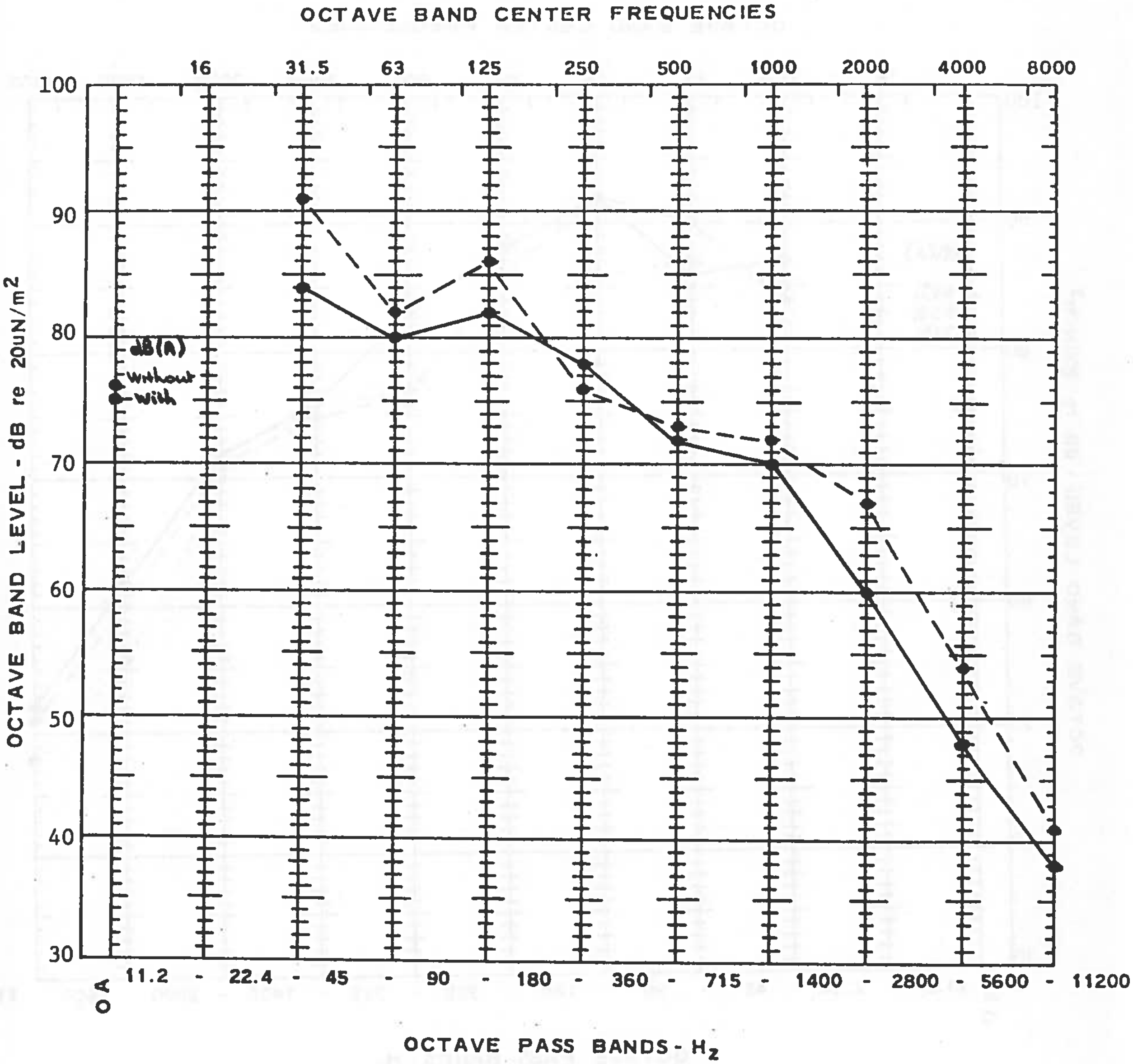
Interior Noise Measurements
Stationary Bus

Driver's Ear Position

Condition - Sound Attenuation Kit No. 2

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.4-9



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

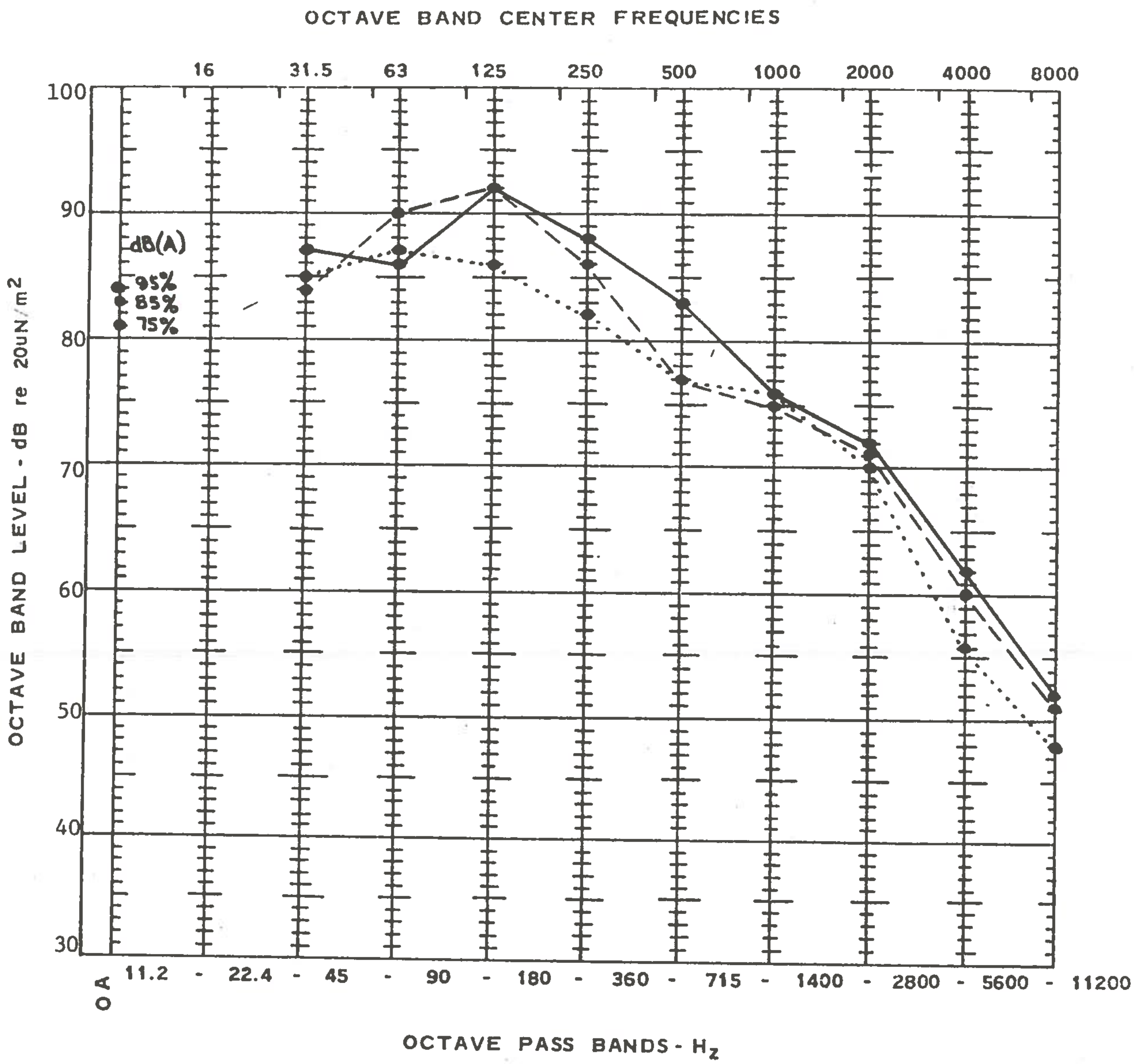
Interior Noise Measurements
Stationary Bus

Mid-Coach Seat
Condition - Second Baseline, Effect of a Complete Barrier across the Rear of the Bus

With Barrier

Without Barrier

Figure F.4-10



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Moving Bus

Center of Rear Seat

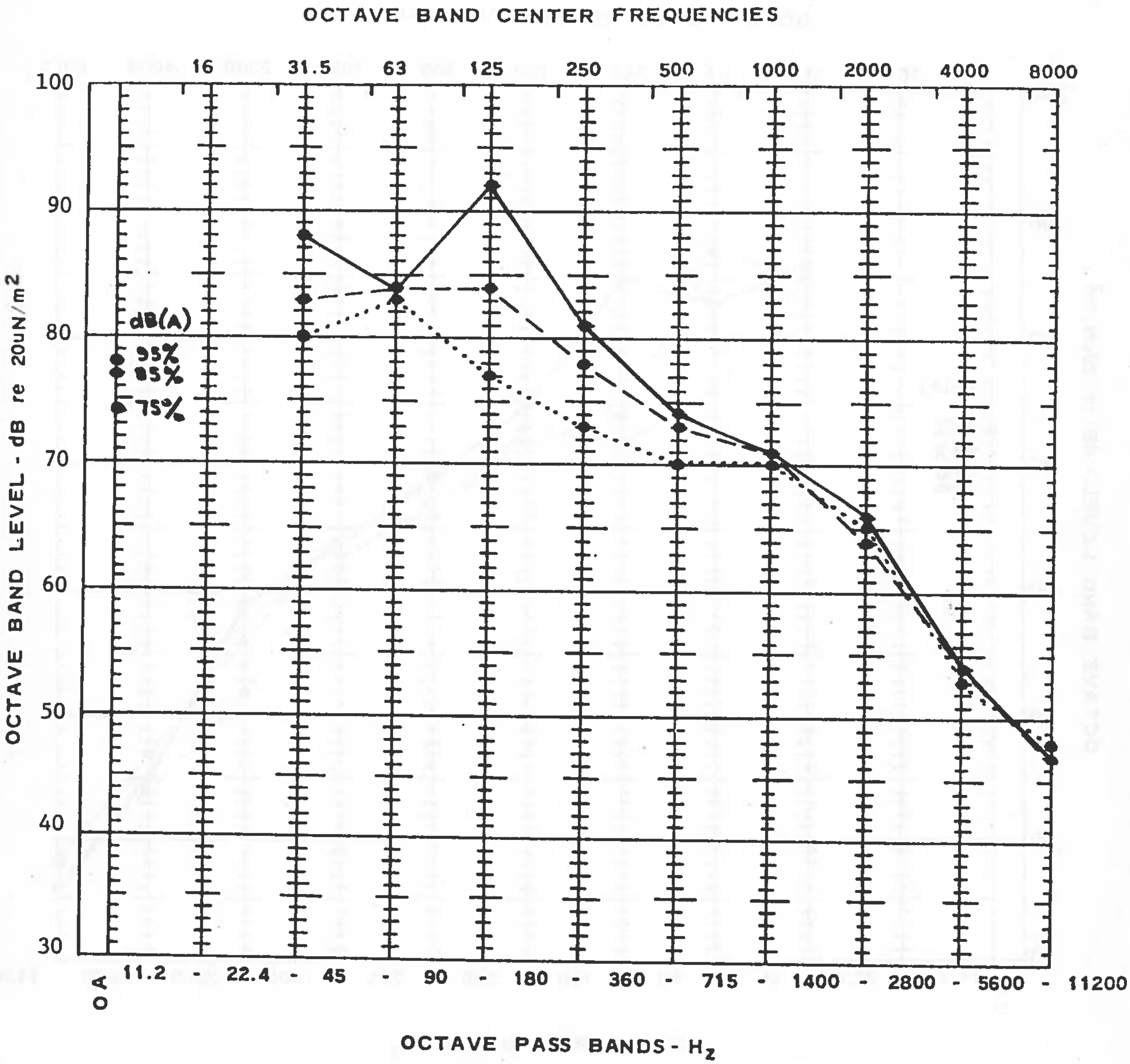
Condition - Second Baseline

●·······● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.4-11



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine
Moving Bus
Mid-Coach Seat

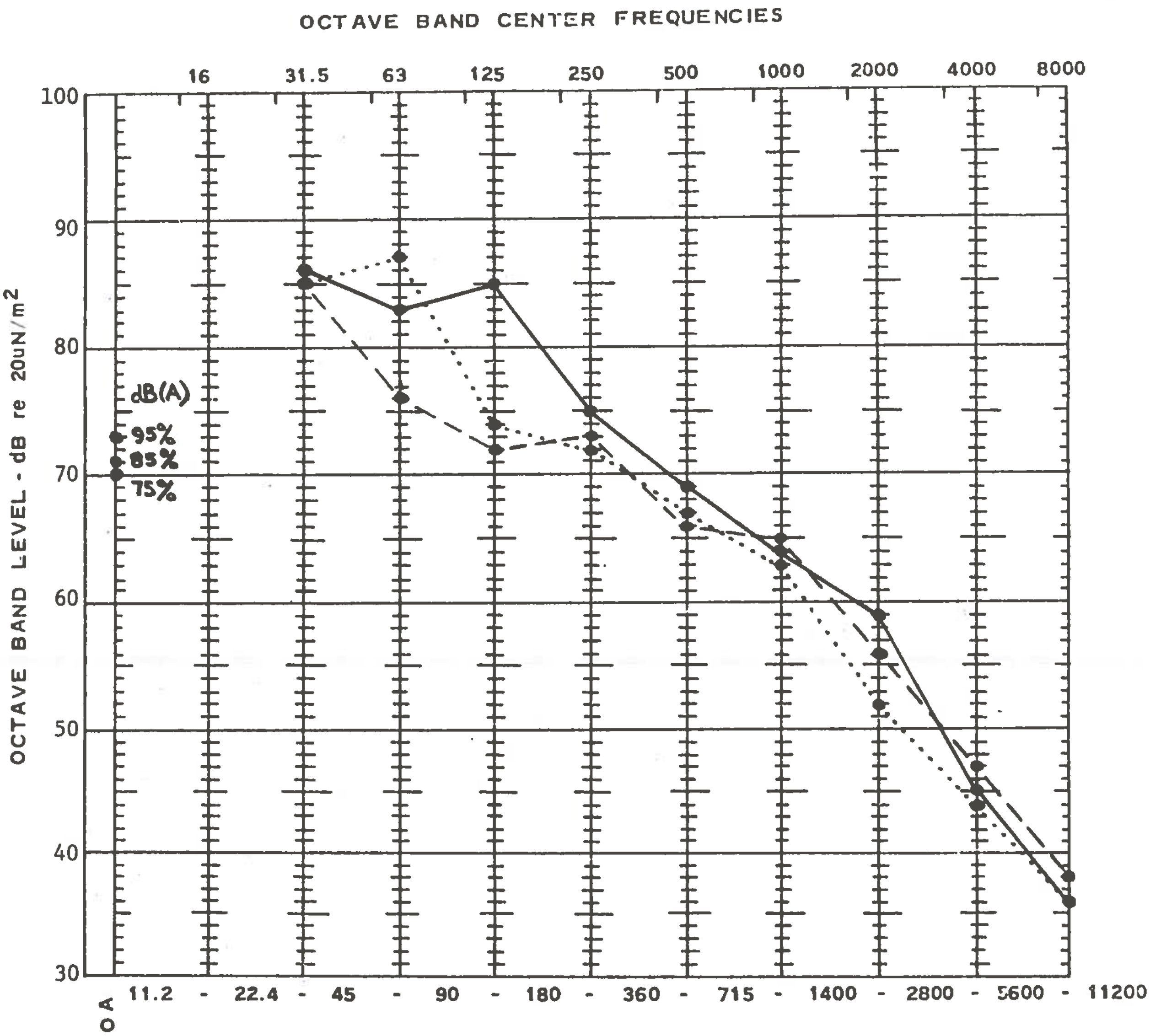
Condition - Second Baseline

75% Engine Speed

85% Engine Speed

95% Engine Speed

Figure F.4-12



SOUND ATTENUATION KIT PROGRAM
35 Ft. Flxible Bus - 6V71 Engine

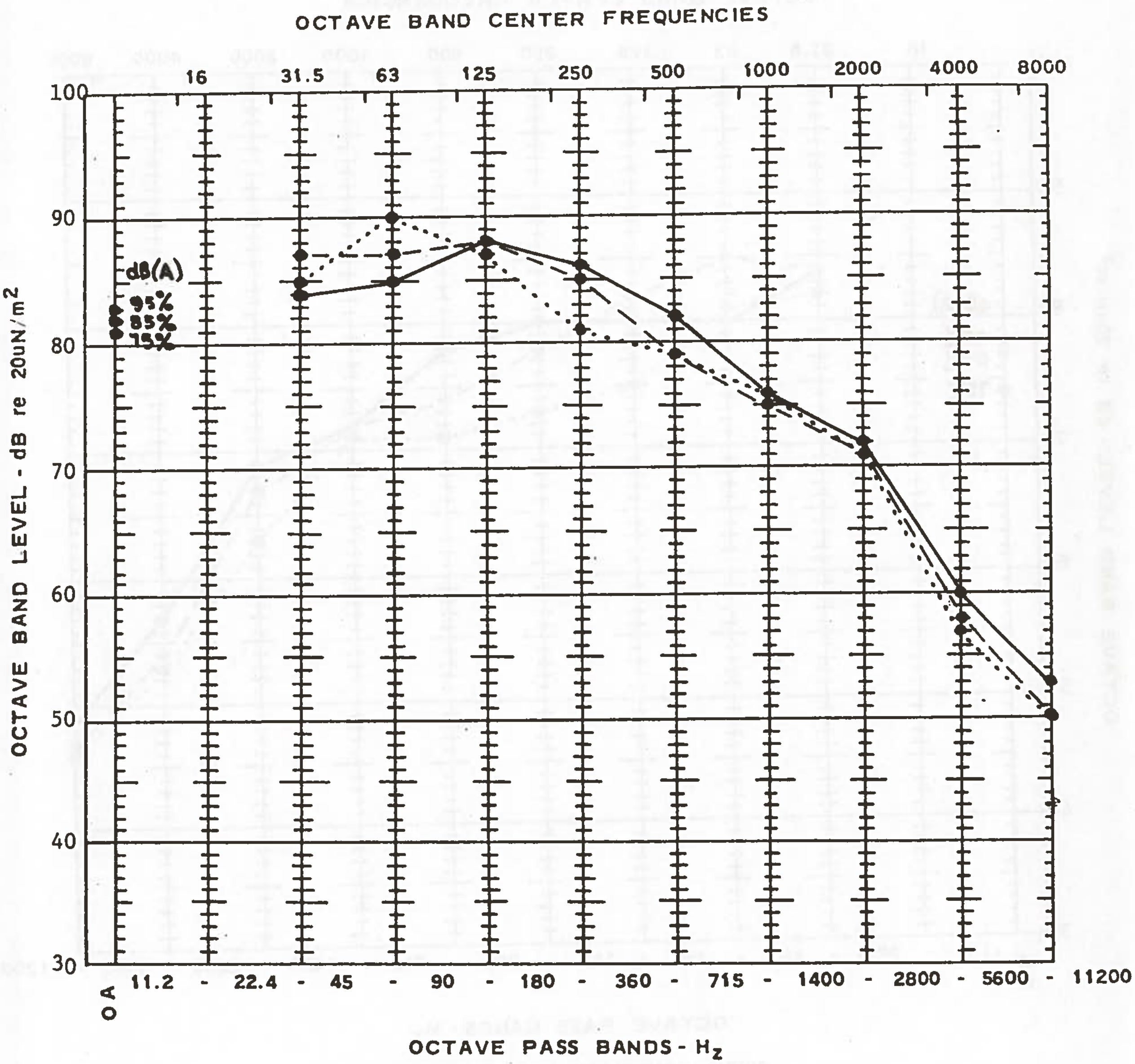
Interior Noise Measurements
Moving Bus

Driver's Ear Position

Condition - Second Baseline

75% Engine Speed
85% Engine Speed
95% Engine Speed

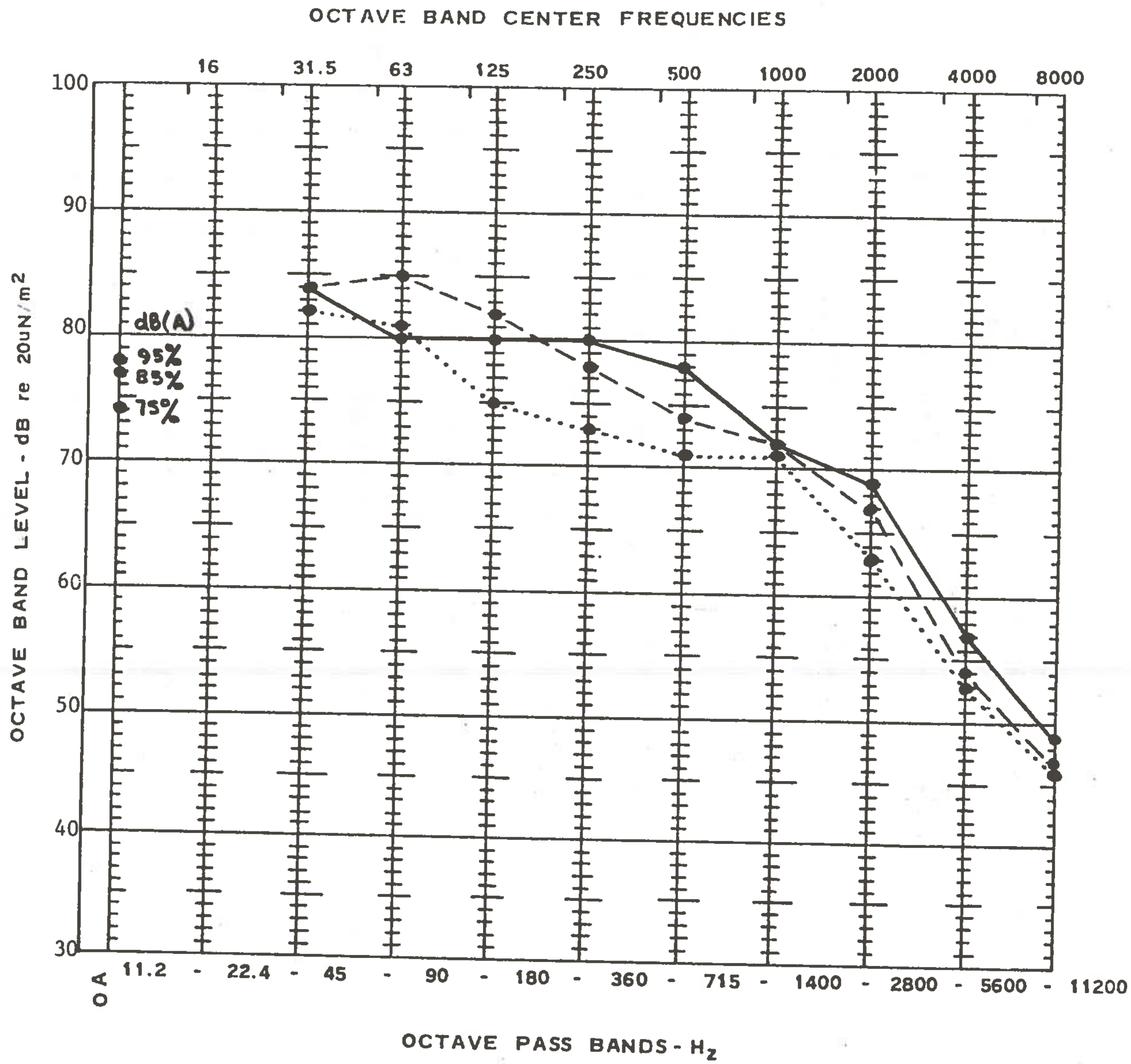
Figure F.4-13



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine
Interior Noise Measurements
Moving Bus
Center of Rear Seat
Condition - Sound Attenuation Kit No. 1

●········● 75% Engine Speed
● — — — ● 85% Engine Speed
●————● 95% Engine Speed

Figure F.4-14



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements

Moving Bus

Mid-Coach Seat

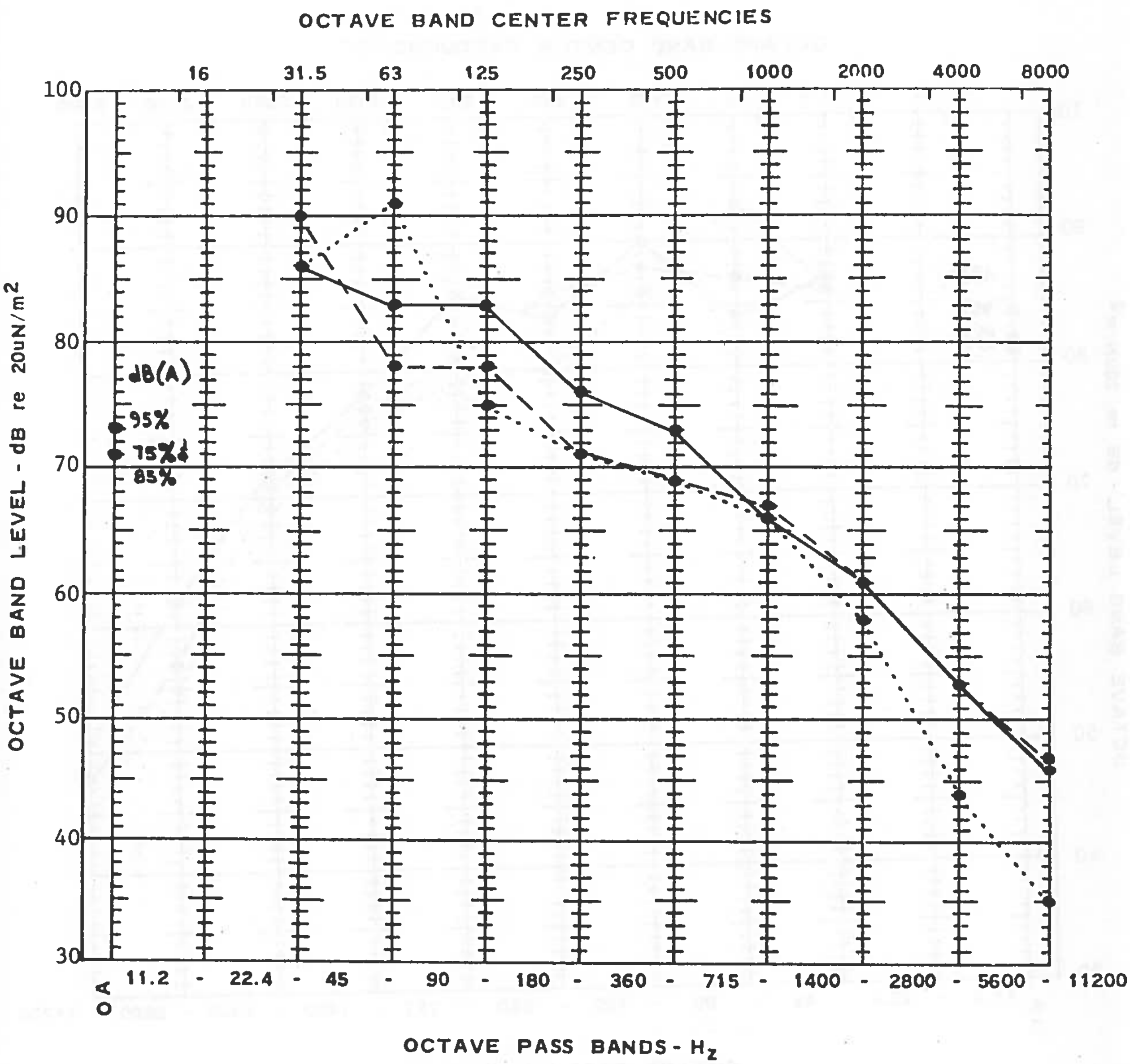
Condition - Sound Attenuation Kit No. 1

●·········● 75% Engine Speed

●— — — ● 85% Engine Speed

●————● 95% Engine Speed

Figure F.4-15



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

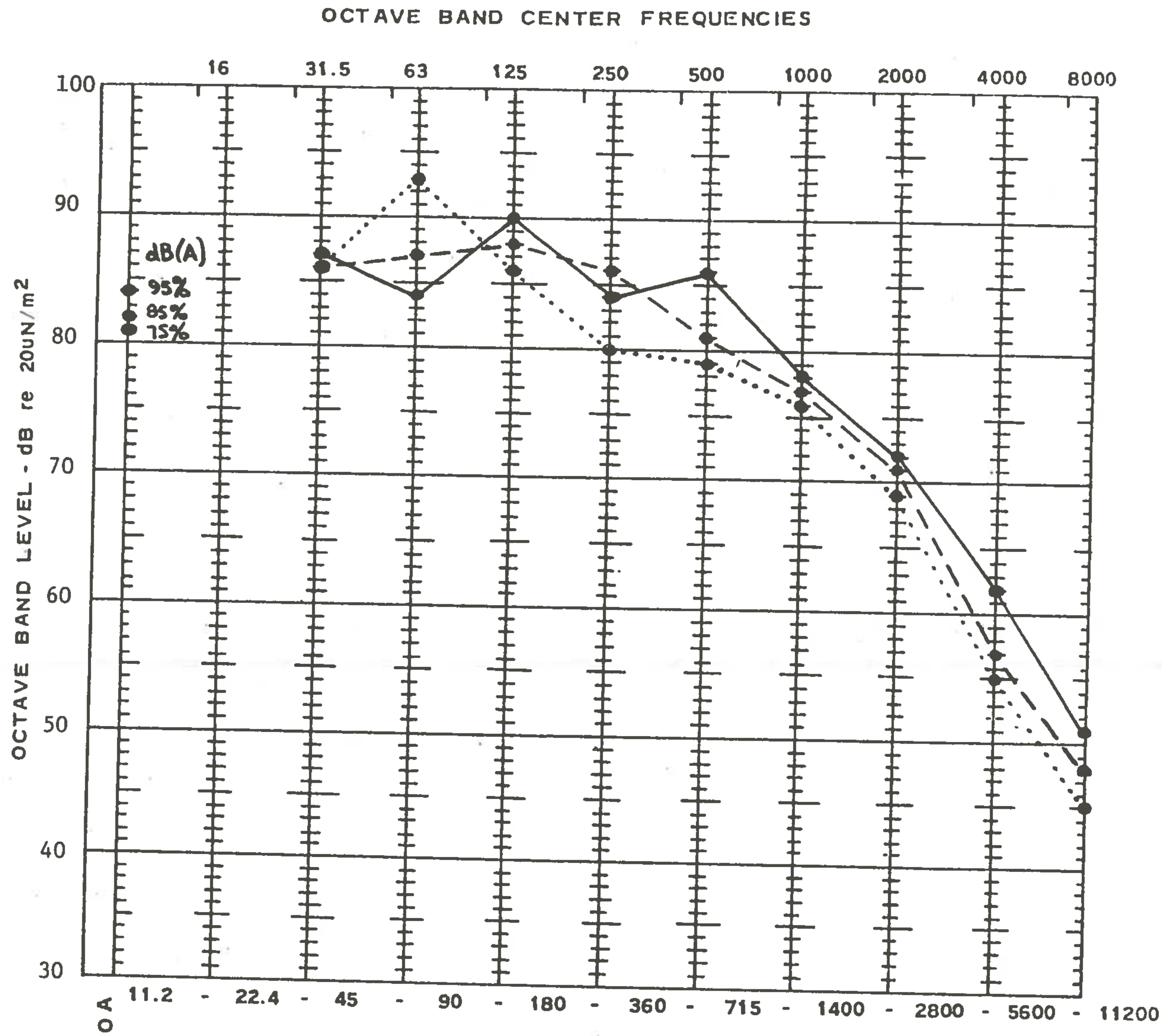
Interior Noise Measurements
Moving Bus

Driver's Ear Position

Condition - Sound Attenuation Kit No. 1

●·······● 75% Engine Speed
●— — —● 85% Engine Speed
●———● 95% Engine Speed

Figure F.4-16



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

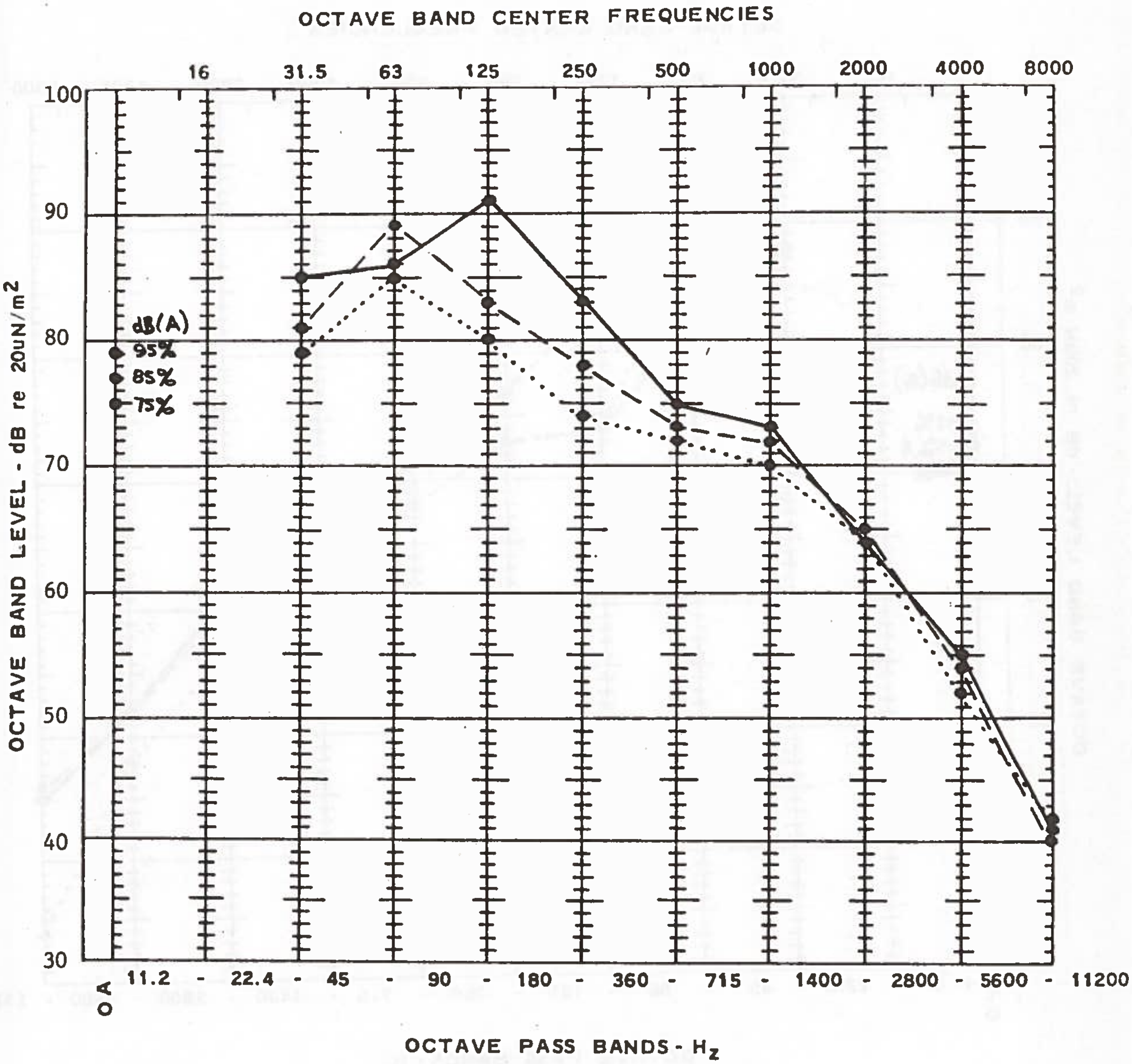
Interior Noise Measurements
Moving Bus

Center of Rear Seat

Condition - Sound Attenuation Kit No. 2

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.4-17



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements
Moving Bus

Mid-Coach Seat

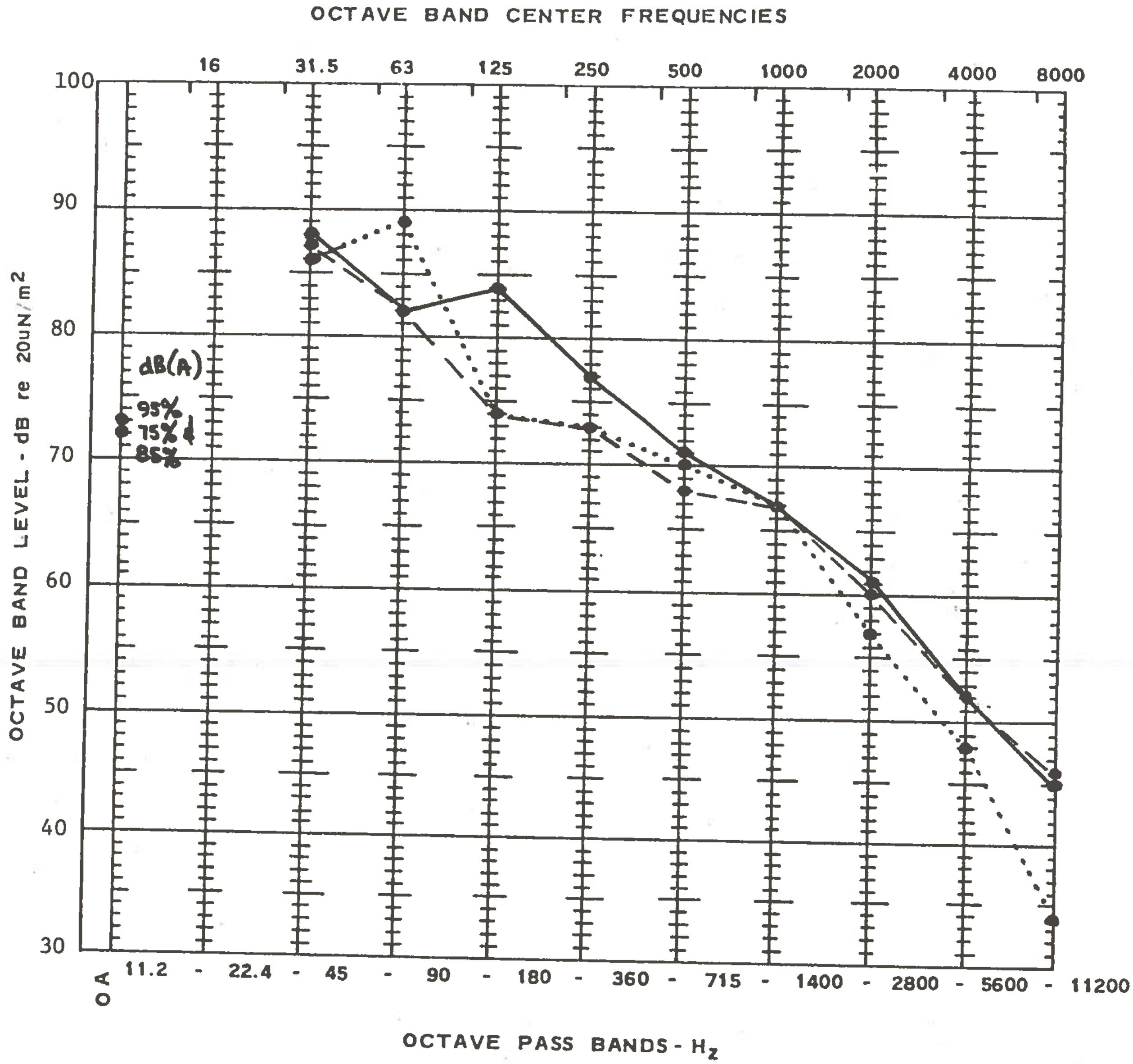
Condition - Sound Attenuation Kit No. 2

●·······● 75% Engine Speed

●— — —● 85% Engine Speed

●———● 95% Engine Speed

Figure F.4-18



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

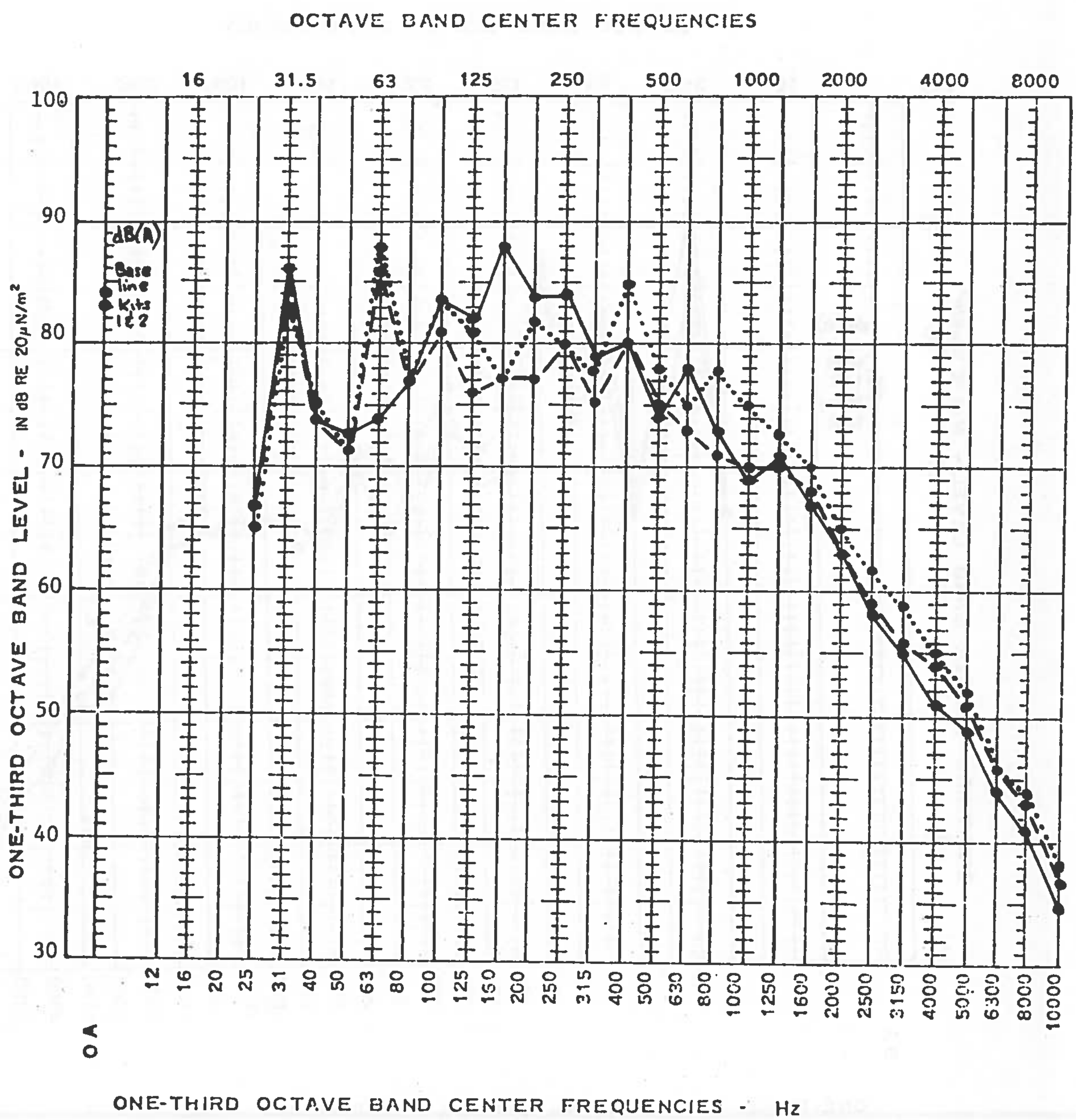
Interior Noise Measurements
Moving Bus

Driver's Ear Position

Condition - Sound Attenuation Kit No. 2

75% Engine Speed
85% Engine Speed
95% Engine Speed

Figure F.4-19



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements

Center of Rear Seat

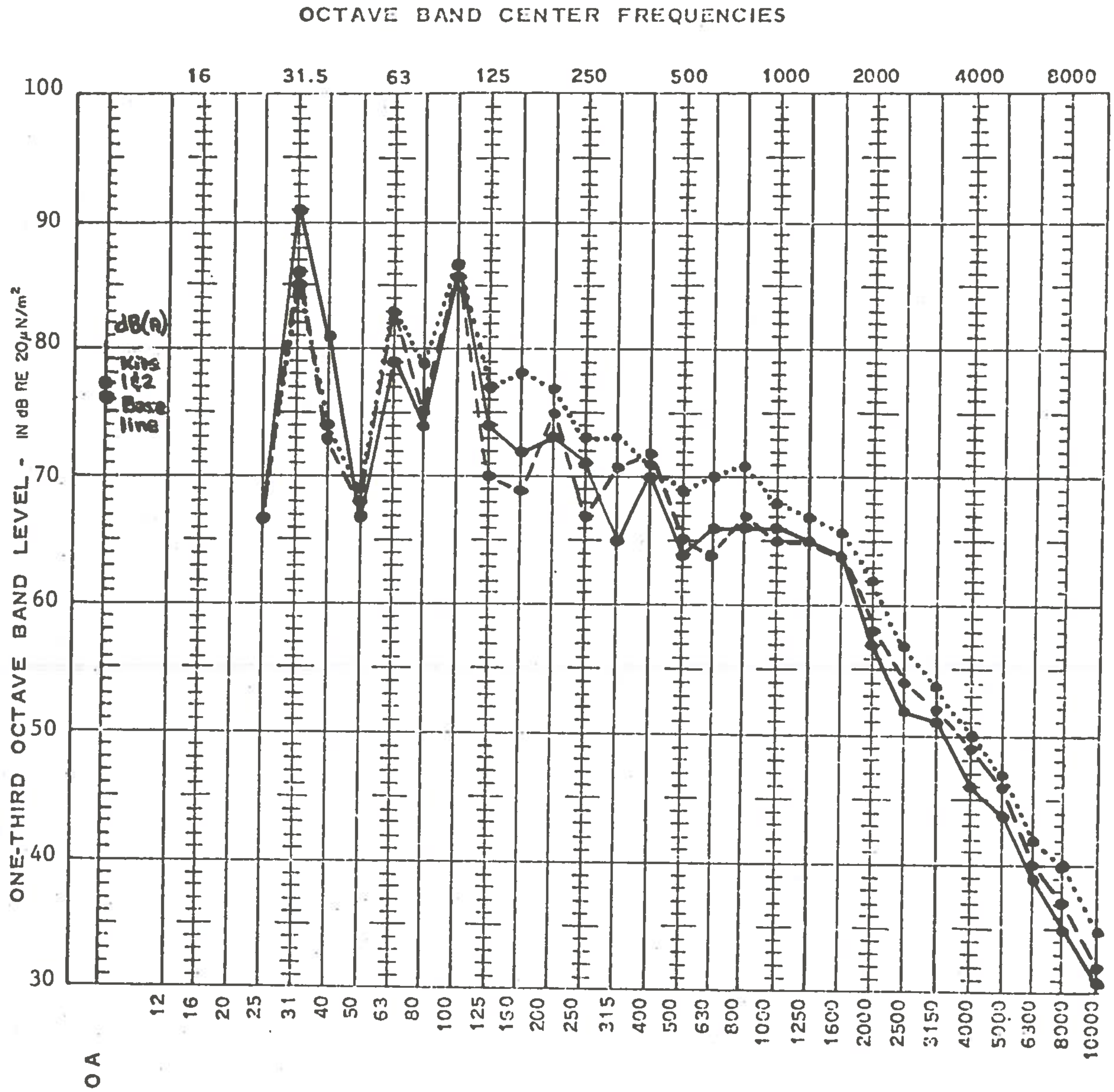
Stationary Bus - Engine Speed 95%

●———● **Baseline**

●— — —● Kit No 1.

●·······● Kit No. 2

Figure F.5-1



SOUND ATTENUATION KIT PROGRAM
35 Ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements

Mid-Coach Seat

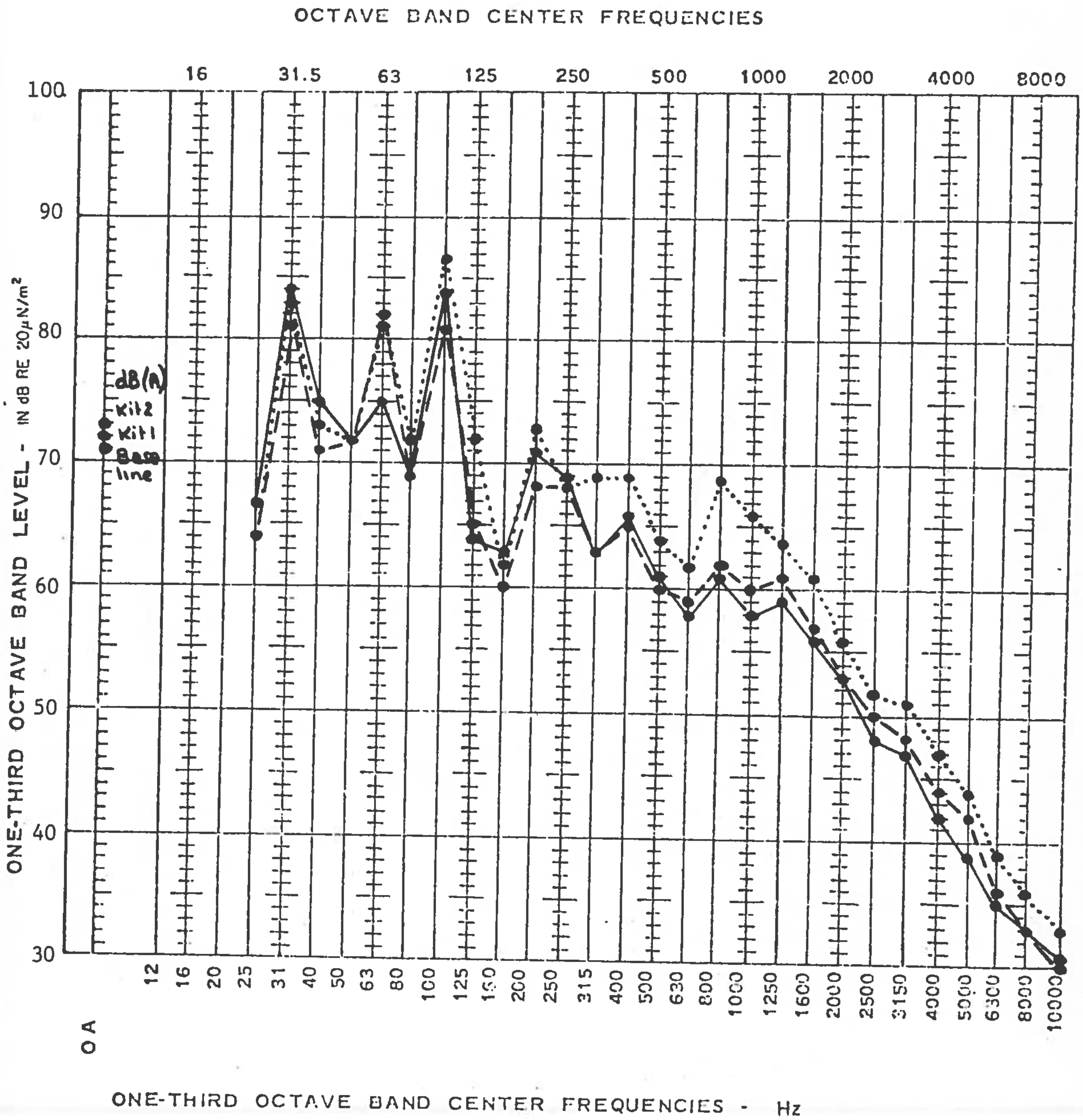
Stationary Bus - Engine Speed 95%

Baseline

Kit No. 1

Kit No. 2

Figure F.5-2



SOUND ATTENUATION KIT PROGRAM
35 ft. Flxible Bus - 6V71 Engine

Interior Noise Measurements

Driver's Ear Position

Stationary Bus - Engine Speed 95%

Baseline

Kit No. 1

Kit No. 2

Figure F.5-3

APPENDIX G

DYNAMOMETER TEST RESULTS

TABLE G-1 DYNAMOMETER TEST-SECOND BASELINE

VEHICLE WEIGHT @ TEST 27,245 LBS.

ENGINE 210 HP AT 2200 RPM - C-60 INJECTORS

TRANSMISSION 1ST GEAR 2.07 : 1

RATIO: 2ND GEAR 1.40 : 1

3RD GEAR 1.00 : 1

DIFFERENTIAL GEAR RATIO 4.71

AMBIENT TEMPERATURE °F 65° / 69% HUMIDITY

WIND VELOCITY — MPH DIRECTION —

TIRE SIZE 12.5 x 22.5

TIRE PRESSURE 82 FRONT 85 REAR

FRONTAL AREA ≈ 80 FT^2

TIME 2.35 PM

DYNO CHECK NO.	MPH	RPM	GEAR	HORSEPOWER	FUEL FLOW PPH	BACK PRESS	CONFIGURATION
1	40	1500	2ND	120	66	~~1.3~~ 2.6 "Hg	FAN 1000 RPM
2	60	1800	3rd	105	72	3.4 "Hg	
3	25	1850	1st	112	73	3.4 "Hg	
4	72	2100	3rd	DYNO FULLY UNLOADED	41	3.2 "Hg	FAN 1650 RPM
5	40	1500	2ND	120	62	2.6 "Hg	NO FAN
6	38	1500	2ND	114	62	2.6 "Hg	FULL FAN 1500 RPM

TEST COMMENTS: 2ND BASELINE OF BUS - ALL STD COMPONENTS - NO ACOUSTIC TREATMENT

NOTE 1st GEAR IS CONVERTER, 2ND GEAR IS LOCK-UP, 3rd GEAR IS OVERDRIVE

TEST DATA FORM
FLXIBLE PERFORMANCE TESTS

TEST ENGINEER: [signature]
DATE: Nov 08, 1974

TABLE G-2 DYNAMOMETER TEST - SAK #1

VEHICLE WEIGHT @ TEST 37,165 LBS.

ENGINE 210 HP AT 2200 RPM C-60 INJECTORS

TRANSMISSION 1ST GEAR 2.07 : 1

RATIO: 2ND GEAR 1.40 : 1

3RD GEAR 1.00 : 1

DIFFERENTIAL GEAR RATIO 4.71

AMBIENT TEMPERATURE °F 66° / 60% HUMIDITY

WIND VELOCITY — MPH DIRECTION —

TIRE SIZE 12.5 × 22.5

TIRE PRESSURE 81 FRONT 85 REAR

FRONTAL AREA ≈ 80 FT^2

TIME 2.15 PM

DYNO CHECK NO.	MPH	RPM	GEAR	HORSEPOWER	FUEL FLOW PPH	BACK PRESS	CONFIGURATION
1	38	1500 ~~1800~~	2ND	115	67	2.4"Hg	NOTE: FAN SPEED 1200 RPM IN AUTOMATIC MODE
2	62	1800	3RD	100	73	3.6"Hg	FAN @ 1200 RPM
3	26	1850	1ST	116	72	3.6"Hg	FAN @ 1650 RPM
4	72	2100	3RD	DYNO FULLY UNLOADED	48	3.6"Hg	
5	40	1500	2ND	120	60	2.8"Hg	NO FAN
6	38	1500	2ND	115	62	2.6"Hg	FULL FAN - 1500 RPM

TEST COMMENTS: WHEN THE FAN WAS APPLIED THERE WAS A LOSS OF 100 RPM IN ENGINE SPEED BETWEEN CHECK # 5 & 6.

SAK #1 TEST

TEST DATA FORM
FLXIBLE PERFORMANCE TESTS

TEST ENGINEER: [signature]
DATE: Dec 10, 74

TABLE G-3 DYNAMOMETER TEST - SAK #2

VEHICLE WEIGHT @ TEST 27,610 LBS.

ENGINE 210 HP AT 2200 RPM C-60 INJECTORS

TRANSMISSION 1ST GEAR 2.07:1

RATIO: 2ND GEAR 1.40:1

3RD GEAR 1:00:1

DIFFERENTIAL GEAR RATIO 4.71

AMBIENT TEMPERATURE ^{o}F ____________

WIND VELOCITY — MPH DIRECTION —

TIRE SIZE 12.5 x 22.5

TIRE PRESSURE 81 FRONT 85 REAR

FRONTAL AREA ≈ 80 FT^2

TIME 2:00 PM

DYNO CHECK NO.	MPH	RPM	GEAR	HORSEPOWER	FUEL FLOW PPH	BACK PRESS INCH HG	CONFIGURATION
1	39	1500	2ND	112	60.0	2.8	FUEL 7.12 LBS/GAL FAN: 1400RPM AUTO. MODE
2	60	1800	3rd	100	72.0	3.8	FAN 1600
3	24	1850	1st	110	70.0	3.8	FAN 1850
4	72	2100	3rd	DYNO FULLY UNLOADED	42.0	3.8	FAN 1200
5	39	1500	2ND	118	58.0	2.6	NO FAN
6	38	1500	2ND	105	62.0	2.6	FULL FAN ENGIN DROP 1350 100 HP/32 MPH

TEST COMMENTS:

SAK#2 TEST

TEST DATA FORM
FLXIBLE PERFORMANCE TESTS

TEST ENGINEER: [illegible]
DATE: Dec 13, 1974

APPENDIX H

VEHICLE FUEL CONSUMPTION TEST ROUTE

September 30, 1974

MONDAY THROUGH FRIDAY SCHEDULE

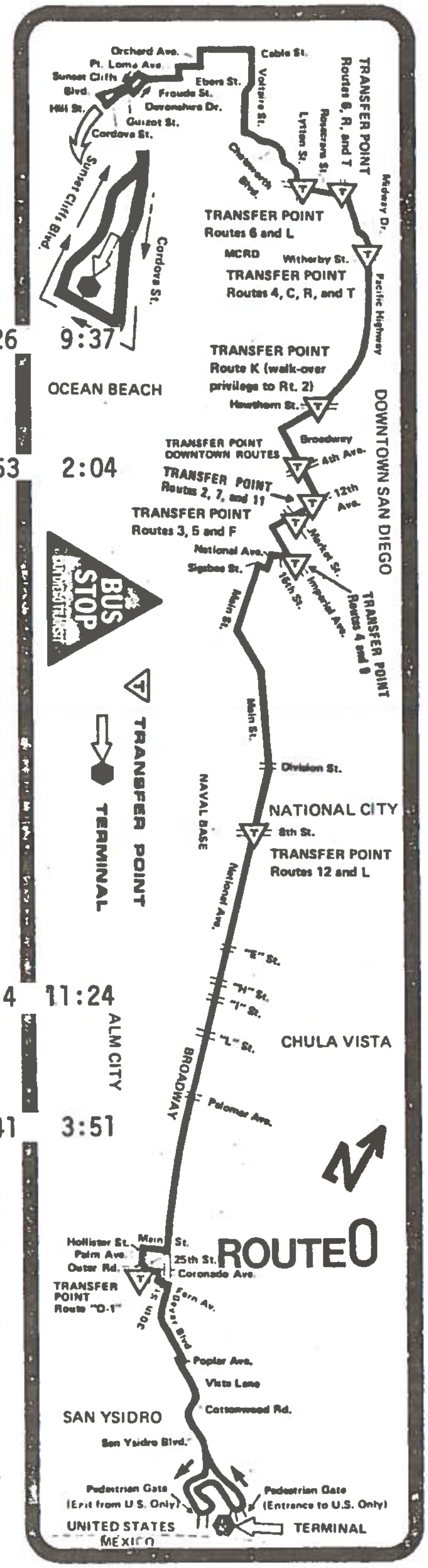
SAN YSIDRO TO CHULA VISTA NATIONAL CITY DOWNTOWN SAN DIEGO AND OCEAN BEACH

8:00	8:11	8:23	8:27	8:50	9:00	9:12	9:26	9:37
12:21	12:32	12:44	1:01	1:14	1:25	1:39	1:53	2:04

OCEAN BEACH TO DOWNTOWN SAN DIEGO NATIONAL CITY CHULA VISTA AND SAN YSIDRO

9:47	9:58	10:12	*10:25	*10:35	*10:48	*11:02	11:14	11:24
2:09	2:20	2:34	2:50	3:00	3:15	3:29	3:41	3:51

* These trips connect with the Rt. "O-1" bus going to Otay Mesa



ROUTE O

San Diego Transit

APPENDIX I

REPORT OF INVENTIONS

A diligent review of the work performed under this contract has revealed no innovation, discovery, improvement or invention.