EPA 550/9-77-203

NOISE EMISSION STANDARDS
FOR TRANSPORTATION VEHICLES

PROPOSED MOTORCYCLE NOISE EMISSION REGULATIONS

BACKGROUND DOCUMENT

November 1977

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF NOISE ABATEMENT AND CONTROL
WASHINGTON, D.C. 20460

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UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF NOISE ABATEMENT AND CONTROL

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FOREWORD

This background document was prepared in support of the U.S. Environmental Protection Agency's Proposed Noise Emission Regulations for New Motorcycles and New Motorcycle Replacement Exhaust Systems. These Regulations have been proposed pursuant to the mandate of Congress as expressed in The Noise Control Act of 1972 (86 Stat. 1234).

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SECTION I

INTRODUCTION

Section 1

INTRODUCTION

Statutory Basis for Action

Through the Noise Control Act of 1972 (86 Stat. 1234), Congress established a national policy "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." In pursuit of that policy, Congress stated in Section 2 of the Act that "while primary responsibility for control of noise rests with State and local governments, Federal action is essential to deal with major noise sources in commerce, the control of which requires national uniformity of treatment." As part of that essential Federal action, subsection 5(b)(1) requires the Administrator of the Environmental Protection Agency (EPA), after consultation with appropriate Federal agencies, to publish a report or series of reports identifying products (or classes of products) which in his judgement are major sources of noise. Further, Section 6 of the Act requires the EPA to publish proposed regulations for each product identified as a major source of noise and for which, in his judgment, noise standards are feasible. Such products fall into various categories, of which transportation equipment (including recreational vehicles and related equipment) is one.

Identification of Motorcycles as a Major Noise Source

Pursuant to the provisions of subsection 5(b)(1), the Administrator on May 20, 1975,[1] published a report identifying new motorcycles as a major source of noise. As required by Section 6, EPA is required to prescribe standards for the noise emissions of new motorcycles which are requisite to protect the public health and welfare, taking into account the magnitude and conditions of use of new motorcycles, the degree of noise reduction achievable through the application of best available technology, and the cost of compliance.

In accordance with the authorities granted in Sections 3, 6, and 10 of the Act, EPA may establish performance standards for specific components of those products which have been identified as major sources of noise. Replacement exhaust systems, which are noise sensitive components of motorcycles, have, in the judgment of the Administrator, been found to warrant separate regulatory treatment as part of EPA's noise abatement strategy for new motorcycles.

[1] Federal Register; 40FR 23105, May 28, 1975.

Labeling

Provisions for requiring the labeling of products identified as major sources of noise are contained in Sections 6 and 13 of the Noise Control Act. Labeling of motorcycles will provide notice to buyers that the product is sold in conformity with applicable regulations, and will also make the buyer and user aware that the motorcycle possesses noise attenuation devices which should not be removed or tampered with. Labeling will also be of assistance to enforcement officials in determining compliance with applicable laws and ordinances.

Preemption

After the effective date of a regulation for noise emissions from a new product, Section 6 of the Noise Control Act requires that no State or political subdivision thereof may adopt or enforce any law or regulation which sets a limit on noise emissions from such new products, or components of such new products, which is not identical to the standard prescribed by the Federal regulation. Subsection 6(e)(2), however, provides that nothing in Section 6 precludes or denies the right of any State or political subdivision thereof to establish and enforce controls on environmental noise through the licensing or the regulation or restriction of the use, operation, or movement of any such product or combination of products.

To assist in controlling motorcycle noise, State and local authorities are encouraged to enact and enforce noise regulations for motorcycles and replacement exhaust systems which complement Federal regulations, as well as regulations controlling the use and operation of motorcycles in areas where they are deemed to be necessary.

Study Approach

In June 1974 EPA published a preliminary study report which examined motorcycle quieting technology and the costs of applying such technology.[2] This study provided the Agency with an initial assessment of the feasability of motorcycle noise control, from which the Agency's regulatory options could be further considered. Shortly after the major noise source identification of motorcycles by the Administrator, EPA initiated further research studies of quieting technology, cost and economic impacts, and environmental impacts, to be used in assessing the various Federal noise regulatory alternatives for this product.

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[2] Control of Motorcycle Noise, Volume I, Technology and Cost Information. EPA publication 550/9-74-001A

During the course of these studies, all major motorcycle manufacturers, many smaller ones, and a number of manufacturers of replacement exhaust systems were visited by representatives of the Agency and its contractors. These visits were made for the purposes of collecting technical data and information, and to allow the industry the opportunity to become familiar with and participate in EPA's regulatory process.

Information and data collected from various sources by EPA and its contractors which were used by the Agency in assessing motorcycle quieting technology, compliance costs, and health and welfare impacts are presented in this document.

Public Participation

Throughout the development of this regulation an effort has been made to allow all groups and organizations who have an interest in, or may be directly affected by motorcycle noise standards, the opportunity to participate in the rulemaking process. This public participation effort has included meetings with concerned state, county, and city officials, as well as with motorcycle user groups, industry associations, and motorcycle dealers. Advance copies of a draft Notice of Proposed Rulemaking (NPRM) and selected sections of the supporting background document were distributed to manufacturers and interested government officials several months prior to publication of the NPRM to allow additional time for analysis and comment. Appropriate officials in all 50 states were contacted by telephone, and informational mailings were sent and follow-up contacts made for the purpose of obtaining viewpoints and opinions from these officials. Ongoing attempts to coordinate Federal, state, and local motorcycle noise control actions are being made by the Agency.

Outline and Summary of the Background Document

Section 1. Introduction

Section 2. Industry Description. General information on motorcycles, motorcycle manufacturers, exhaust system manufacturers, and the structure of the industry is given in this section.

Section 3. Sound Level Test Procedures. This section contains a discussion of existing noise measurement methodologies for motorcycles, and a presentation of EPA's proposed procedure for use in regulatory compliance testing.

Section 4. Sound Level Data Base. Sound levels of motorcycles and replacement exhaust systems which were obtained using various test procedures are presented in this section.

Section 5. Public Health and Welfare Analysis. An analysis of current impacts of motorcycle noise, and impacts expected as a result of various regulatory options is described in Section 5.

Section 6. Sound Reduction Technology. A discussion of motorcycle sound reduction feasability is contained in subsection 6.1. Subsection 6.2 presents an analysis of the various engineering techniques involved in controlling noise from motorcycle noise subsources.

Section 7. Costs of Compliance. This section provides estimates of the costs involved in applying these techniques to quiet motorcycles and replacement exhaust systems to various not-to-exceed regulatory levels.

Section 8. Economic Impact Analysis. Estimates of the economic impacts of various regulatory options on the manufacturing industry, on specific firms, on employment and on other economic measures are contained in this section.

Section 9. Environmental Effects. In this section the effects of motorcycle noise regulations on air and water pollution, energy and natural resource consumption, and land use patterns are considered.

Section 10. Alternatives to Federal Regulation. This section contains a discussion of the various alternatives for controlling motorcycle noise other than a Federal new product standard.

Section 11. Enforcement. The various enforcement actions open to EPA in ensuring compliance with Federal motorcycle noise regulations are discussed in Section 11.

Appendix A. Motorcycle Sound Level Test Procedures. Texts of the sound level test procedures discussed in Section 3 are presented in this appendix.

Appendix B. Test Sites and Instrumentation. Descriptions and photographs of the instrumentation and the test site locations used in performing EPA's motorcycle noise testing are found in this appendix.

Appendix C. Product Identification and Sound Levels. In this appendix are presented sound level data developed by EPA on individual motorcycles and replacement exhaust systems.

Appendix D. A synopsis of State, local and foreign laws applicable to motorcycle noise are contained in this appendix.

Appendix E. EPA's Operator and Passenger Exposure Testing Program is described in this appendix.

Appendix F. Motorcycle Demand Forecasting Model. This appendix describes the econmetric model used to forcast motorcycle demand.

Appendix G. Relation Between Standard Test Methodologies and and Representative Acceleration Conditions. The assessed relationship between motorcycle sound levels under rapid acceleration conditions (the proposed test procedure) and sound levels under representative unconstrained traffic acceleration conditions is detailed in this appendix.

Appendix H. Recent Motorcycle Sound Level Data. This appendix contains data developed in a test program conducted by EPA to gain additional data relating to the proposed test procedure and to investigate tachometer response characteristics. Operator ear and stationary test data are also presented.

Appendix I. Refinement of Motorcycle Testing Procedure. The testing procedure which was published in draft form for comment was refined prior to the publication of the proposal on the basis of the data described in Appendix H, and on manufacturer-supplied information. The analyses behind these refinements are described in this appendix.

SECTION 2

INDUSTRY DESCRIPTION

Section 2

INDUSTRY DESCRIPTION

2.1 Product Definition

For the purposes of the EPA motorcycle noise regulation all motorcycles which are designed and marketed for on-road operation are considered to be "street" motorcycles, subject to noise standards for street motorcycles. This category includes:

Street and highway motorcycles

On-road/off-road combination motorcycles

Enduro motorcycles intended for limited street operation

Minicycles intended for street operation

Motor-driven cycles

This street motorcyle category encompasses vehicles having the following characteristics:.

(1) Approximately 50 to 1200c.c. engines, developing from 1 to 100 horsepower

(2) Two-stroke, four-stroke and rotary engines

(3) One to six cylinders

(4) Liquid, fan and air cooling sytems

(5) Two and three wheels

(6) Light to heavy weight

(7) Shaft and chain drive

(8) Manual and hydraulic torque converter automatic transmission

For the purposes of the EPA noise regulation all motorcycles which are designed and marketed for off-road and off-road competition use, with the exception of motorcycles designed and marketed solely for use in closed-course competition events, are considered to be "off-road" motorcycles. This off-road motorcycle category includes:

- o Off-road, trail, and cross-country motorcycles
- o Enduro motorcycles not intended for street operation
- o Minicycles not intended for street operation
- o Trials motorcycles
- o All-terrain motorcycles not intended for street operation

This off-road category encompasses vehicles having the following characteristics:

(1) 50 to 500c.c. engines

(2) Two-stroke and four-stroke engines (great majority two-stroke)

(3) Single cylinder

(4) Air cooled

(5) Two and three wheels

(6) Light weight

(7) Chain drive

(8) Manual, centrifugal clutch and continuously variable (belt) automatic transmission

For the purposes of the EPA noise regulation all motorcycles designed and marketed solely for use in closed-course competition events are considered competition motorcycles and are not subject to EPA noise control standards. They are, however, subject to labeling provisions of the motorcycle noise regulation. This competition category includes:

Competition motocross motorcycles

Road Racing motorcycles

Oval and dirt track motorcycles

Two and three wheeled tractors are not considered to be motorcycles for the purpose of the EPA motorcycle noise regulation. Electric and battery-powered motorcycles are not subject to the provisions of the regulations.

Mopeds are two-wheeled motor vehicles intended for use on streets and roads. These vehicles, which are popular in Europe and Asia and which have been recently introduced into the U.S., have the following features:

(a) Not more than 50c.c. engines

(b) Not more than 2 horsepower

(c) Top speed less than 30 m.p.h.

(d) Pedal-assisted

These vehicles typically have low sound levels (see Section 4), and experience in other markets indicates that likely U.S. purchasers of mopeds would not be expected to modify their vehicles to any great extent. For these reasons, EPA's motorcycle noise regulation does not extend its applicability at this time to mopeds. Relevant information on mopeds is included in Table 2-1.

2.2 New Vehicle Manufacturers

More than 30 different manufacturers from all over the world sell full sized 2-wheel motorcycles in the U.S. The manufacturers described in Cycle Magazine's 1976 Buyer's Guide are listed in Table 2-2.

A partial list of three-wheeled motorcycle manufacturers is provided in Table 2-3.

Manufacturers of mini-bikes/minicycles are listed in Table 2-3. These manufacturers were listed in Cycle Magazine's 1976 Buyer's Guide, along with the full-sized motorcycle manufacturers.

Almost all foreign motorcycle manufacturers have companies in the U.S. distributing their products. The four major Japanese companies have wholly owned subsidiaries located in Southern California. Most of the smaller manufacturers are represented by independent distributing firms who represent their brand under contractual arrangements.

Table 2-1 MOPEDS

Introduced into the U.S. in 1975
    1975 sales: 25,000
    1976 sales: 75,000 (MBA estimate)

Features:
- (A) 1-2 hp
- (B) 50c.c. 2-stroke single cylinder engine
- (C) Top speed less than 30 m.p.h.
- (D) Pedal assisted for acceleration from complete stop
- (E) Automatic transmission (centrifugal clutch or direct drive)
- (F) Bicycle-type frame, brakes
- (G) 60-100 pounds, 120-200 m.p.g., $300-$500

Sound levels:
    65-75 dB(A) at 50 feet (full throttle/top speed)
    73 dB(A) ISO procedure

Manufacturers:
    Approximately 15 currently importing to U.S.--mostly bicycle manufacturers

Marketing:
    85% sold through bicycle dealerships

Annual Mileage:
    Europe: 2500-3000 miles annually
    U.S.: Insufficient experience

State Regulations:
    Twenty-two states separately define mopeds as a separate vehicle; remainder classify as motorcycle

Federal Regulation:
    NHTSA: same as motorcycle except for brakes, lighting and turn signal requirements

Source: Motorized Bicycle Association

Table 2-2

MANUFACTURERS OF FULL SIZED 2-WHEEL MOTORCYCLES (Partial List)

BRAND/MANUFACTURER	COUNTRY
Benelli/Moto Benelli	Italy
BMW	West Germany
Bultaco	Spain
Can-Am/Bombardier	Canada
Carabela	Mexico
Cheetah	U.S.
DKW/Hercules	West Germany
Ducati	Italy
Greeves	United Kingdom
Harley-Davidson	U.S./Italy
Hodaka/Pabatco	U.S.
Honda	Japan
Husqvarna	Sweden
Indian	U.S./Taiwan
Jawa/CZ	Czechoslovakia
KTM/Penton	Austria
Kawasaki	Japan
La Verda	Italy
MV Agusta	Italy
Maico	West Germany
Montesa	Spain
Moto Guzzi	Italy
Moto Morini	Italy
MZ	East Germany
NVT	United Kingdom
Ossa	Spain
Rokon	U.S.
Suzuki	Japan
Yamaha	Japan

Primary Source: Cycle Magazine, "1976 Buyer's Guide".

Table 2-3

THREE WHEELED MOTORCYCLE MANUFACTURERS (Partial List)

BRAND	MANUFACTURER
Dunecycle	Allied Mechanical Products Division of Tower Industries Santa Fe Springs, California
Explorer	Explorer International Owosso, Michigan
Heald	Heald, Inc. Benton Harbor, Michigan
Honda	Honda Motor Company Japan
Muskin	HPE/Muskin Corporation Subsidiary of Amcord, Inc. Colton, California
MTD	MTD Products, Inc. Cleveland, Ohio
Pacesetter	Pacesetter Enterprises, Inc. Cascade, Iowa
Speedway	Speedway Products, Inc. Mansfield, Ohio
Tri-Sport	Promark Norwald, Ohio
-	BMB
-	Central State Tool and Die Company

Table 2-3

MINIBIKES/MINICYCLES MANUFACTURERS (Partial List)

Arco	Honda
Benelli	Kawasaki
Carabela	Montesa
Cestad	Muskin
Fox	Suzuki
Heald	Yamaha

Source: Cycle Magazine "1976 Buyer's Guide".

Along with motorcycle manufacturers there are a few other U.S. companies that are involved to some extent in the OEM (original equipment manufacturer) segment of the market. These are companies which supply major components such as exhaust systems and engines to the motorcycle manufacturers. Representative companies in this category are:

Company	Component	Motorcycle
Nelson Industries	Mufflers	Harley-Davidson
Skyway	Mufflers	Hodaka
Briggs & Stratton	Engines	Heald
Tecumseh	Engines	Cheetah, Heald
Wisconsin	Engines	Heald

Most of these companies are not entirely dependent on the motorcycle industry. Their products are sold to manufacturers in other industries such as automobiles, lawn mowers, snowmobiles, and so forth.

The remainder of the new motorcycle industry description is oriented primarily toward the manufacturers of full sized, 2-wheel motorcycles, since this segment is by far the largest element in the industry in terms of number of units sold.

2.2.1 Market Shares and Sales

The new motorcycle manufacturing segment of the industry is characterized by a small number of manufacturers which have significant sales in the U.S., and a large number of manufacturers with very limited sales in the U.S. Available sales and market share data for each of the companies are listed in Table 2-4. Total industry sales figures since 1967 are shown in Figure 2-1.

The five leading manufacturers (Honda, Yamaha, Kawasaki, Suzuki and AMF/Harley-Davidson) have 93 percent of the market, based on numbers of new motorcycles registered. This is an approximation because an estimated 30 percent of all motorcycles sold are not registered; however market share inaccuracies are not likely to be great because all five sell the types of models that are likely to be unregistered. Of the individual brands, the largest share of the market is held by Honda, which has 40 percent of the market, followed by Kawasaki - 17.2 percent, Yamaha - 16.2 percent, Suzuki - 12.8 percent, Harley-Davidson - 6.9 percent, NVT Motorcycles (Norton, Triumph) - 1.2 percent, and BMW - 1.0 percent.

All other manufacturers combined share approximately 5 percent of the market, and none individually has a share of over 1 percent. Approximately 17 companies have less than 0.1 percent. These figures may be slightly understated since many of the companies with limited U.S. sales specialize in off-road models which are generally not registered. Market share trends for the five largest companies in the past few years are shown in Figure 2-2. In 1975, Kawasaki, Suzuki, and Harley-Davidson increased market shares, while Honda and Yamaha market shares declined.

The distribution of sales ranges has a similar dispersion. Honda's annual retail sales in the U.S. are estimated to be over $500 million. Sales for each of the four other leading manufacturers are estimated to be between $100 million and $500 million. Two manufacturers have annual sales estimated at between $10 to $50 million. All other companies are estimated to have less than $10 million in annual retail sales in the U.S.

Market shares for product categories defined by engine displacement size are shown in Table 2-5. Honda is the leader in all categories except for the minibike/minicycle category. Harley-Davidson is ranked second in the 750c.c. and above category with 24.6 percent of this market segment, compared with Honda's 41.4 percent and Kawasaki's 18.8 percent.

Table 2-4

MOTORCYCLE MANUFACTURER SALES AND MARKET SHARE DATA: 1975

RANK	Brand Manufacturer	Location/Mfg. Location(s)	Approx. Annual Retail Sales Range ($M)*	Percentage of New Registration **	Cum Percentage
1.	Honda	Japan	500+	40.2%	40.2%
2.	Kawasaki	Japan	200-300	17.2	57.4
3.	Yamaha	Japan	200-300	16.2	73.6
4.	Suzuki	Japan	100-200	12.8	86.4
5.	Harley-Davidson	U.S., Italy	100-200	6.9	93.3
6.	Norton-Triumph	U.K.	10-50	1.1	94.4
7.	BMW	Germany	10-50	1.0	95.4
8.	Bultaco	Spain	Less than 10	0.5	95.9
9.	Husqvarna	Sweden	"	0.5	96.4
10.	Can-Am/Bombardier	Canada	"	0.4	96.8
11.	Hodaka	U.S./Japan	"	0.3	97.1
12.	JAWA/CZ	Czechoslovakia	"	0.3	97.4
13.	Moto Guzzi	Italy	"	0.3	97.7
14.	Benelli	Italy	"	0.1	97.8
15.	Ducati	Italy	"	0.1	97.9

* U.S. Motorcycle Sales Only (estimate).

** Based on 1975 data for number of new motorcycles registered (R. L. Polk Registration Data).

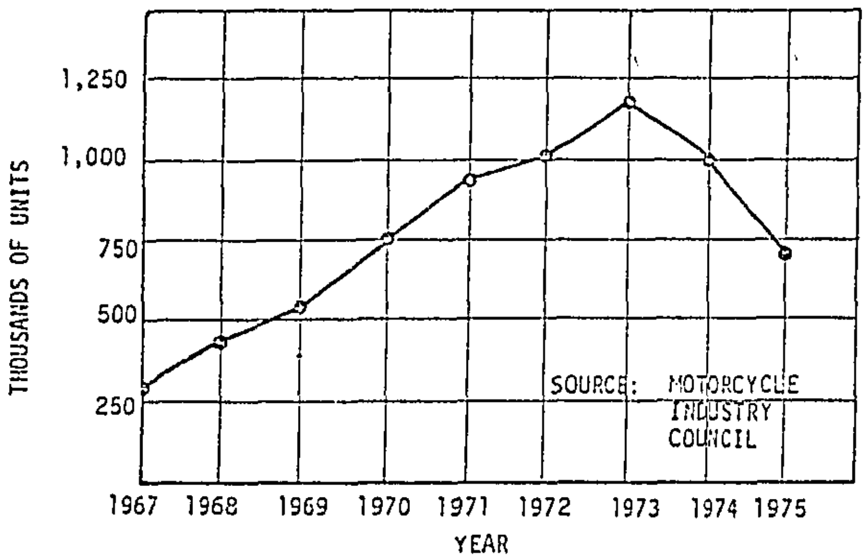

FIGURE 2-1. NEW MOTORCYCLE SALES, 1967-1975

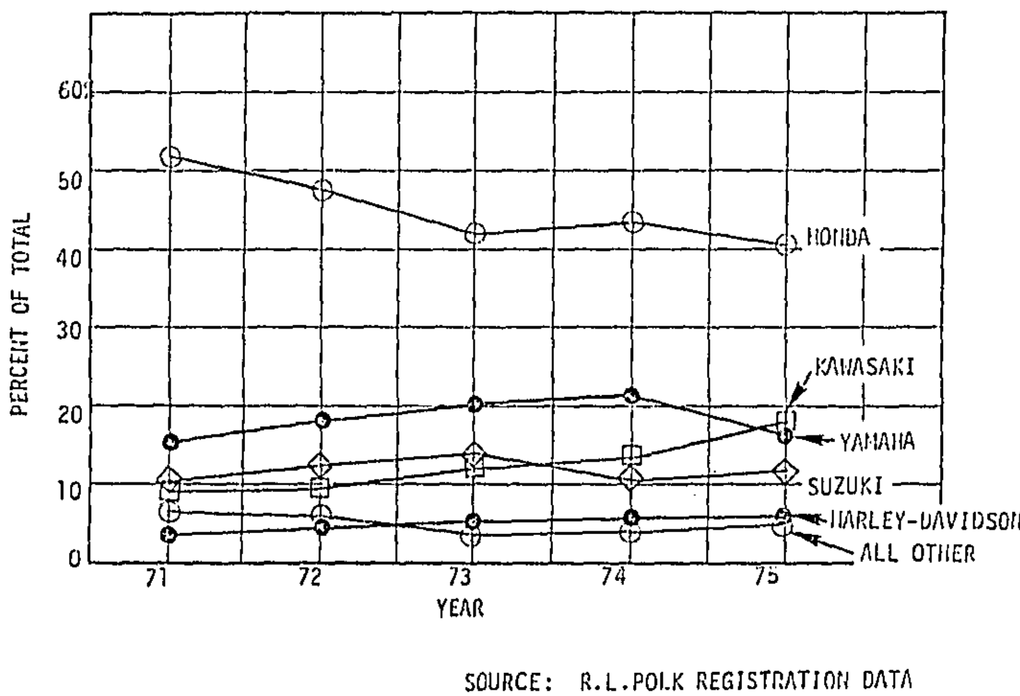

FIGURE 2-2. MAJOR MANUFACTURER'S MARKET SHARE OF REGISTERED MOTORCYCLES

Table 2-5 MARKET SHARE BY PRODUCT CLASS*

RANK SIZE	Minibikes/ Minicycles		50-99c.c.		100-169c.c.	
	Manufacturer	Pct.	Manufacturer	Pct.	Manufacturer	Pct.
1.	Yamaha	31.2	Honda	58.9	Honda	34.3
2.	Kawasaki	20.2	Yamaha	19.0	Yamaha	21.5
3.	Honda	14.3	Suzuki	8.1	Kawasaki	20.8
4.	Indian	12.7	Kawasaki	8.0	Suzuki	18.2
5.	Harley-Davidson	5.0	Harley-Davidson	5.5	Harley-Davidson	2.3
6.	Chaparral	4.7	Benelli	0.5	Hodaka	2.2
7.	Cushman	4.2			Can-Am	0.6
8.	Rockford	1.9			JAWA	0.1
9.	Rupp	1.8			Benelli	0.05
10.	Benelli	1.1			Bultaco	0.05
11.	Steen	0.4			Husqvarna	0.05
12.	Premier	0.3				
13.	Pacesetter	0.1				
14.	Speedway	0.1				
15.	Other	2.0				

*Market share as determined by R. L. Polk New Motorcycle Registration Data. Non-registered motorcycles are not accounted for in this tabulation.

RANK SIZE	170-349c.c.		350-749c.c.			
	Manufacturer	Pct.	Manufacturer	Pct.	Manufacturer	Pct.
1.	Honda	31.7	Honda	45.8	Honda	41.4
2.	Yamaha	23.5	Yamaha	20.8	Harley-Davidson	24.6
3.	Suzuki	22.2	Kawasaki	19.3	Kawasaki	18.8
4.	Kawasaki	14.2	Suzuki	12.6	BMW	4.1
5.	Harley-Davidson	4.9	Bultaco	0.8	Suzuki	4.1
6.	Can-Am	1.7	BMW	0.4	Norton	2.8
7.	Bultaco	1.1	JAWA	0.1	Moto Guzzi	2.6
8.	JAWA	0.3	Husqvarna	0.1	Yamaha	1.1
9.	Husqvarna	0.3	Norton Triumph	0.1	Ducati	0.5
10.	Benelli	0.1	Benelli	-		

*Market share as determined by R. L. Polk New Motorcycle Registration Data. Non-registered motorcycles are not accounted for in this tabulation.

2.2.2 Product Lines

There are major differences in the product lines offered by the manufacturers. The four major Japanese manufacturers and Harely-Davidson offer models in every category (see Table 2-6). Honda again is the leader with 38 different models in all size and function categories. Harley-Davidson has 13 models, but 7 are in the large (over 750c.c.), street model category. Most of the other manufacturers have model lines that are limited to some extent. Many of the others specialize in either large street motorcycles or small and medium sized dual-purpose or off-road motorcycles. More manufacturers sell small and medium dual-purpose and off-road motorcycles than any other category.

Most models in the large street motorcycle category and almost all Honda models have 4-stroke engines. Kawasaki and Yamaha have both 2-stroke and 4-stroke models. The other manufacturers rely principally on 2-stroke engines. Two manufacturers have models with rotary engines (Suzuki and DKW). A list of engine types by manufacturer is provided in Table 2-7.

A list of the three most popular models for each of the major Japanese motorcycle manufacturers is provided in Table 2-8.

2.2.3 Motorcycle Prices

In general, European motorcycles, particularly in the street motorcycle category, have higher retail level prices than those of major Japanese or U.S. brands. Figure 2-3 shows a comparison of prices versus engine displacement size for various street models listed in Peterson's 1975 Motorcycle Buyer's Guide. In the street category, European manufacturers generally offer a limited number of models at premium prices.

Comparisons of prices for off-road motorcycles are more difficult to make because of the multitude of specialized functions off-road motorcycles have. However, the Japanese brands are typically 10 to 20 percent less in price for equivalent sized off-road models.

2.2.4 Typical New Motorcycle Manufacturers

Manufacturers of full sized motorcycles can be classified in the following manner:

- Major Japanese Motorcycle Manufacturers
- Major U.S. Motorcycle Manufacturer - AMF/Harley-Davidson
- U.S. Motorcycle Manufacturers with Limited U.S. Sales
- Foreign Manufacturers with Limited U.S. Sales

Table 2-6

MOTORCYCLE MANUFACTURERS PRODUCT LINE BY PRODUCT CATEGORY

Manufacturer	STREET-LEGAL					OFF-ROAD			
	Under 100cc	100-169cc	170-349cc	350-749cc	750cc & Over	Under 100cc	100-169cc	170-349cc	350-749cc
Benelli/Moto Benelli			X	X	X				
BMW				X	X				
Bultaco				X			X	X	X
Can-Am/Bombardier		X	X				X	X	X
Carabela							X	X	X
Cheetah									
Ducati					X				
Greeves								X	X
Harley-Davidson		X	X		X				
Hercules									
Hodaka/Pabatco						X	X	X	
Honda	X	X	X	X	X	X	X	X	
Husqvarna							X	X	
Indian		X	X					X	
Jawa/Cz								X	
KTM							X	X	X
Kawasaki	X	X	X	X	X	X	X	X	
LaVerda				X	X				
MV Agusta					X				
Maico							X	X	X
Montesa			X				X	X	X
Moto Guzzi					X				
Moto Morini				X					
MZ									
NTV				X	X				
Ossa								X	X
Penton							X	X	X
Rokon								X	
Suzuki	X	X	X	X	X	X	X	X	
Yamaha	X	X	X	X	X	X	X	X	X

Primary Source: Cycle Magazine, "1976 Buyer's Guide".

Table 2-7

ENGINE TYPES BY MANUFACTURER

BRAND/MANUFACTURER	ENGINE TYPE(S)
Benelli/Moto Benelli	4-stroke/2-stroke
BMW	4-stroke
Bultaco	2-stroke
Can-Am/Bombardier	2-stroke
Carabela	2-stroke
Cheetah	4-stroke
DKW/Hercules	2-stroke*
Ducati	4-stroke
Greeves	2-stroke
Harley-Davidson	4-stroke/2-stroke
Hodaka/Pabatco	2-stroke
Honda	4-stroke/2-stroke
Husqvarna	2-stroke
Indian	2-stroke
CZ/Jawa	2-stroke
KTM	2-stroke
Kawasaki	2-stroke/4-stroke
LaVerda	4-stroke
MV Agusta	4-stroke
Maico	2-stroke
Montesa	2-stroke
Moto Guzzi	4-stroke
Moto Morini	4-stroke
MZ	2-stroke
NVT	4-stroke
Ossa	2-stroke
Penton	2-stroke
Rokon	2-stroke
Suzuki	2-stroke/4-stroke*
Yamaha	2-stroke/4-stroke

*Excluding one model with rotary engine.

Table 2-8

MAJOR JAPANESE MANUFACTURER'S BEST SELLING

NEW MOTORCYCLE MODELS

Honda

1. Honda CB-750 (Street)
2. Honda CB-360 (Street)
3. Honda CB-550 (Street)

Kawasaki

1. Kawasaki KZ-400 (Street)
2. Kawasaki 900 Z-1 (Street)
3. Kawasaki 350 (Street)
4. Kawasaki KS-125 (Enduro)

Yamaha

1. Yamaha XS-650 (Street)
2. Yamaha DT-125 (Enduro)
3. Yamaha DT-250 (Enduro)

Suzuki

1. Suzuki TS-250 Savage (Enduro)
2. Suzuki GT-550 Indy (Street)
3. Suzuki GT-380 Sebring (Street)

Source: Motorcycle Dealer News

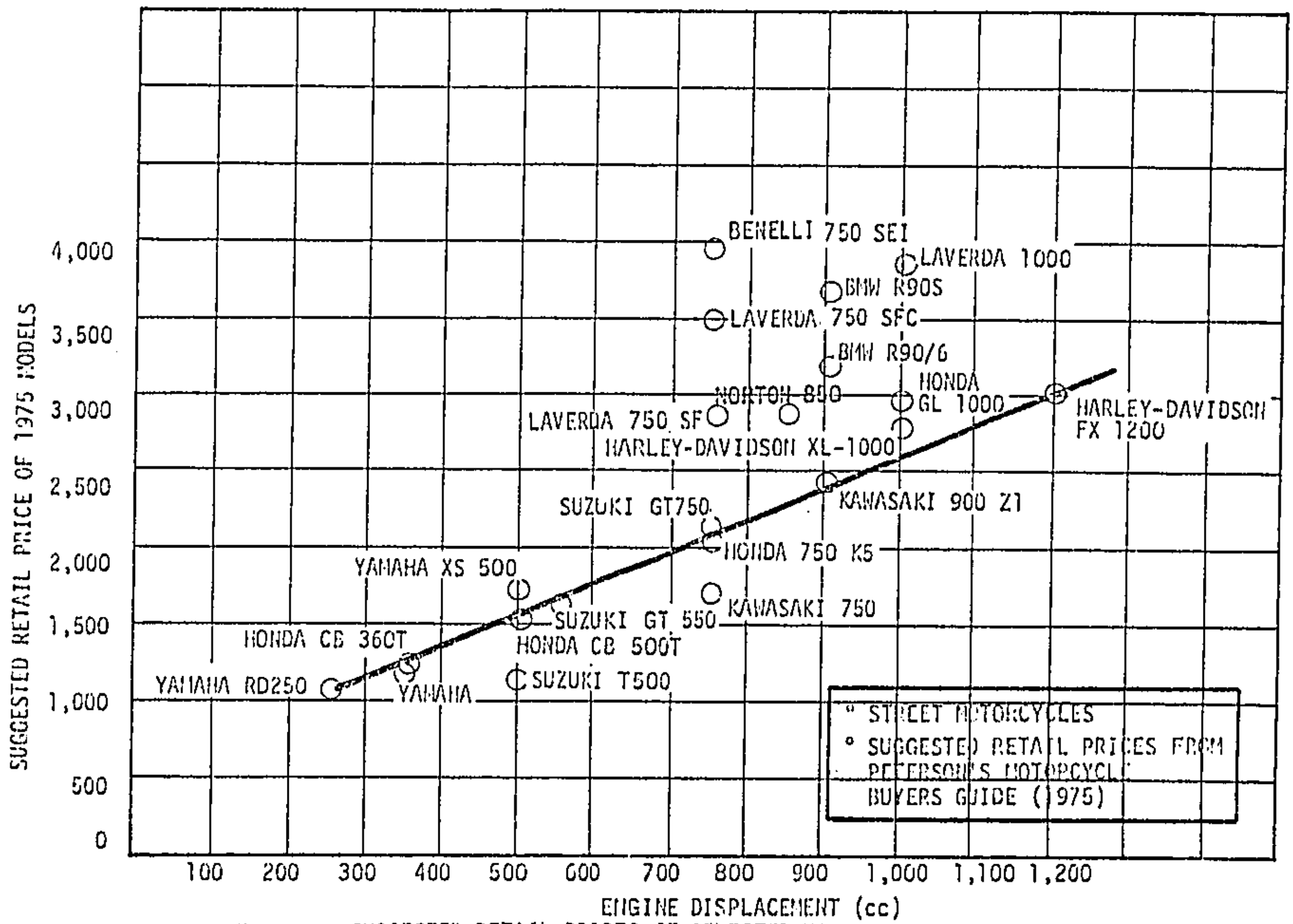

FIGURE SUGGESTED RETAIL PRICES OF SELECTED MODELS VS. ENGINE DISPLACEMENT SAE

FIGURE 2-3. SUGGESTED RETAIL PRICES VS ENGINE DISPLACEMENT SAE

A major motorcycle manufacturer is defined as having U.S. retail level sales of motorcycles and parts of $100M or over annually. Manufacturers with "limited" sales have less than $100M in U.S. sales (measured at the retail level) annually. Most in this category have less than $10M in annual sales. The categories are defined in this manner because economic impacts on typical firms in each category are likely to be significantly different. Each category is described in more detail in the following paragraphs.

Major Japanese Motorcycle Manufacturers

Major motorcycle manufacturers defined here are those Japanese companies with over $100 million in annual U.S. retail sales. The four companies (Honda, Kawasaki, Yamaha, Suzuki) are all very large industrial concerns, of which motorcycles are a major or significant component of total company operations. Data indicating the financial size and strength of these companies are provided in Table 2-9.

There is some variation in the proportionate level of motorcycle-related sales in each company. Honda is the world's largest motorcycle manufacturer, and 40 to 50 percent of total corporate revenues come from motorcycle sales. Kawasaki and AMF are essentially large conglomerates; motorcycle-related sales for these two companies are an estimated 10 to 20 percent of total corporate revenues. Suzuki and Yamaha are smaller companies, and have a much larger proportion (50 percent or more) of their total sales coming from the motorcycle business.

Approximately 20 to 40 percent of total Japanese motorcycle production is exported to the U.S. Kawasaki's U.S. sales are proportionately higher than this average, while Suzuki's are somewhat lower.

Characteristics of a major Japanese motorcycle manufacturer are shown in Table 2-10. On the average, each Japanese firm produces one million motorcycles annually, of which approximately 27 percent are exported to the U.S. At the retail level, these motorcycles are worth approximately $250M. Production capacities of the companies range from 40,000 units per month and up.

TABLE 2-9

MAJOR MOTORCYCLE MANUFACTURERS FINANCIAL DATA

COMPANY	COUNTRY	INDUSTRY	SALES ($000)	ASSETS ($000)	NET INCOME ($000)	STOCK-HOLDERS EQUITY $000	EMPLOYES	WORLD* RANKING 1974	1973	SOURCE
KAWASAKI HEAVY[1,2] INDUSTRIES	JAPAN	SHIPBUILDING INDUSTRIAL MACH MOTORCYCLES	1,980,137	2,710,376	37,741	289,082	39,560	95	80	1
HONDA MOTOR[3]	JAPAN	MOTORCYCLES AUTOMOBILES FARM MACH.	1,791,098	1,431,416	49,433	336,134	18,845	109	101	1
BMW[4] (BAYERISCHE MOTERN WERKE)	GERMANY	AUTOMOBILES MOTORCYCLES	964,929	619,881	16,261	227,631	25,805	205	148	1
SUZUKI[1,4] MOTORS	JAPAN	AUTOMOBILES MOTORCYCLES	638,716	469,486	7,254	94,823	9,600	294	236	1
YAMAHA MOTOR	JAPAN	MOTORCYCLES REC. VEHICLES	566,550	312,273	10,953	87,347	8,165		298	2
AMF/HARLEY DAVIDSON	U.S.	MOTORCYCLES LEISURE PRODS. IND. PRODUCTS	1,020,302	807,703	22,126	287,522			N.A.	3

1. Fiscal year ending March 31, 1975.
2. Includes pro-rated figures of subsidiaries that are more than 50 percent owned.
3. Fiscal year ending August 30, 1974.
4. Parent Company only.

* Ranked by sales; excludes U.S. companies.

** 300 Yen per dollar conversion rate used.

Source:

1. Fortune Magazine, August 1975.
2. Diamond Report, Japan **
3. AMF Annual Report, 1974.

Table 2-10 CHARACTERISTICS OF TYPICAL MAJOR JAPANESE MOTORCYCLE MANUFACTURER*

U.S. RETAIL SALES RANGE	$100M+
NO. OF FIRMS IN CATEGORY:	4**
ADMINISTRATIVE LOCATION:	Japan
MANUFACTURING LOCATION:	Japan***
PRODUCT LINE:	Motorcycles, Automobiles, Recreational Vehicles, Industrial Machinery
MOTORCYCLE PRODUCT LINE:	Full line of models for all product classes
TOTAL CORPORATION SALES:	$1,250M
ASSETS:	$1,230M
NET INCOME:	$ 150M
NET PROFIT MARGIN:	2%
STOCKHOLDERS EQUITY:	$ 201M
TOTAL MOTORCYCLE RELATED SALES****	
DOLLARS	N.A.
UNITS	1 M
MOTORCYCLE RELATED SALES, U.S.:	
DOLLARS	$ 261M
UNITS	0.27M
MARKET SHARE	22%
NO. OF EMPLOYEES:	8,000
MAXIMUM PRODUCTION CAPACITY:	40,000/Month and up

Source: Information from individual companies
N.A. - Not Available
*Based on 1974 data
**Honda, Kawasaki, Suzuki, Yamaha
***All manufacturing is done in Japan, Kawasaki has a facility in Lincoln, Nebraska that assembles certain models
****Retail level sales

Several features of Japanese financial practices and economic conditions should be noted. In general, Japanese companies are highly leveraged firms. The debt to equity ratios in the capital structure of a typical Japanese company is much higher than in U.S. firms. This makes Japanese companies more vulnerable in the event of downturns in business activity--large interest expenses can create cash flow problems. However, Japan has a central bank (Bank of Japan) that has very strong fiscal authority. The Bank of Japan can direct bank loans to companies with financial problems, which alleviates the hazards associated with high leverage to a great extent. However, if the condition is chronic, companies in Japan declare bankruptcy just as they do in the U.S. In general, profit margins of Japanese companies are lower than those of U.S. companies, but direct comparison is somewhat meaningless due to the differences in capitalization, as noted above. Because of the high degree of leverage, lower profit margins can nevertheless net the same return on owners investment as U.S. companies.

With regard to economic conditions, Japan has in the past few years experienced relatively higher inflation rates than other countries in the world, and this has diminished the competitive edge of Japanese companies to some extent. In 1975, the divergence decreased somewhat.

A brief profile of the major motorcycle manufacturers is provided in the following paragraphs.

Honda

The Honda Motor Company is located in Tokyo, Japan, and sells automobiles, motorcycles, and miscellaneous non-vehicular products. The company earned $49.4M in 1974 on sales of $1,791 million. Motorcycles sales accounted for 46 percent of the total sales, automobiles accounted for 35 percent of the total, and non-vehicular products sales made up the remainder.

Honda is the world's largest motorcycle manufacturer and has the largest share of the U.S. motorcycle market. In 1974, the company manufactured over 2 million motorcycles, an estimated 20 to 30 percent of which were exported to the U.S. Honda has a diverse product line with 38 models offered, ranging from 1000c.c road machines to 70c.c. mini-bikes. Almost all Honda models have four-stroke engines, although a few of the off-road models have two-stroke engines. The Honda Motor Company is relatively strong financially due not only to its large share of the motorcycle market, but also to the strength of its other major product line (automobiles).

The company has put a strong emphasis on R&D and has a separate wholly-owned subsidiary, Honda R&D Company, Ltd., which conducts research and development for both the automobile and motorcycle product lines. In recent years the company has put considerable emphasis on noise control research, and the company is well positioned in this area. Because of its size, financial strength, planning and research commitment and technical facilities, Honda is likely to experience the least adverse impact of any of the other companies in the industry. The only major disadvantage that Honda has is the number of models it carries in its product line. Each model, or possibly a smaller number of subset model categories, will require individual effort and time for noise control research and development.

Kawasaki

Kawasaki motorcycles are manufactured by Kawasaki's Engine and Motorcycle Group, which provides 20 percent of the corporation's total sales. This particular group is located in Akashi, Japan, and manufactures motorcycles, gas turbine engines, chemical machinery and industrial robots. The parent corporation, Kawasaki Heavy Industries, Ltd., is one of Japan's biggest industrial concerns, with total sales approaching two billion dollars.

Of the four major Japanese manufacturers, Kawasaki produces the lowest total number of motorcycles, but exports the highest percentage of its total production to the U.S. Kawasaki moved up to second in the U.S. motorcycle market in 1975, largely due to the popularity of two models introduced in 1974. These two models, 400c.c. and 900c.c. street cycles, now account for a significant portion of Kawasaki sales, although the company does offer a full range of street, combination and off-road bikes. Twenty-nine different models were manufactured for the U.S. market in 1975.

Kawasaki has a motorcycle assembly facility in Lincoln, Nebraska, but most motorcycle assembly, and all engine assembly is done in Japan. Approximately 200 employes are involved in the motorcycle manufacturing operations.

The company has a technical research laboratory equipped with sophisticated monitoring and diagnostic instruments. A noise research effort has been in progress several years, and Kawasaki's capability in this area (plant, equipment, personnel) seems well established.

Suzuki

Suzuki Motors is a leading manufacturer of motorcycles and light-weight automobiles with 2-stroke engines. Company sales increased from $467 million to $640 million between 1970 and 1974, an increase of 37 percent. Profits during this period declined some 34 percent, however, from $10.9 million to 7.2 million.

Suzuki exports approximately 30 models to the U.S., and sales are fairly well balanced in all categories of motorcycles, although street and dual purpose models account for the majority of sales. All of Suzuki's models have 2-stroke engines, with the exception of one model with a rotary motor and three 4-stroke street models which were introduced recently.

Yamaha

Yamaha Motor Company manufactures and sells motorcyles, motoped bicycles, snowmobiles, recreational boats, engines and swimming pools. In addition the company develops and operates recreational facilities. In 1955, the company separated from Nippon Gakki (a company that manufacturers musical instruments), and is now an independent operation.

A large proportion of the company's revenue comes from motorcycle sales. In 1974, the company manufactured slightly over one million motorcycles. Seventy-seven percent were exported, and approximately 20 to 30 percent were exported to the U.S.

Yamaha has extremely modern R&D facilities and equipment, and has a demonstrated capability for noise control research and design.

Major U.S. Motorcycle Manufacturer - AMF/Harley-Davidson

AMF/Harley-Davison is the only remaining major U.S. motorcycle manufacturer. The company was started in 1903, and has specialized in manufacturing large touring motorcycles. In 1968, the company was acquired by AMF, Inc., as part of AMF's extensive diversification effort. In 1975 AMF earned $32 million from sales of slightly over $1 billion. AMF products are primarily oriented toward the leisure and industrial products market; approximately 60 percent of sales and 50 percent of earnings come from leisure products.

A breakdown of revenues by class of product in AMF's 1975 annual report indicated that motorcycles and other travel vehicles provided $190.8M in revenues, or approximately 19 percent of AMF's sales. Motorcycles and motorcycle parts sales account for most of this revenue, estimated to be between $100 million and $200 million annually.

At the present time, the Harley-Davidson product line consists of seven large touring models, all of which are 1000c.c. or more, and six smaller lightweight models of 250c.c. or less. A sidecar option is available for the larger models. A very large part of U.S. motorcycle sales revenues comes from the larger models. In 1975, 74 percent of the Harley-Davidsons registered in the U.S. were 1000c.c. or larger.

A total of 51,263 Harley-Davidsons were registered in 1975, and nearly 38,000 of these were 1000c.c. or larger. The larger models average a retail price of $2800 or more; retail level sales for these models alone were in the neighborhood of $100M. Harley-Davidson's sales on a unit basis represented a 6.9 percent share of the market in 1975, based on registration data. Harley-Davidson's market share on a dollar basis is somewhat higher, since its product line is oriented toward the larger, more expensive motorcycles. Sales and financial characteristics of AMF/Harley-Davidson are shown in Table 2-11.

It should be noted that Harley-Davison actually consists of two relatively independent motorcycle manufacturing companies. The American division manufactures the large (1000c.c. or over) touring models. The wholly owned subsidiary in Varese, Italy designs and manufactures a line of smaller models. Its operation is therefore similar to some smaller U.S. companies which have manufacture motorcycles overseas. Since the operations are relatively independent, each will be described separately.

Harley-Davidson, U.S.

It is a consensus opinion in the motorcycle industry that Harley-Davidson has a unique niche in the market place. Buyers of the large Harley-Davidson models demonstrate considerable loyalty to the brand, and are relatively insensitive to design advancements and marketing campaigns of competing models. It is the only U.S. motorcycle manufacturer which has survived from the early 1900's to the present, resulting in the evolution of a very strong consumer tradition. As evidence, Harley-Davidson has increased its market share in spite of increased competition from major Japanese manufacturers in the large street motorcycle category. In fact, sales of the large models increased in 1974 and 1975, when sales of all other companies declined considerably. Figure 2-4 shows comparative sales trends. Part of the reason for Harley-Davidson's increase in sales in this period is a general consumer shift toward larger street motorcycles. Sales of street motorcycles 900c.c. and larger increased 240 percent in 1974 and 65 percent in 1975[1]. Price data in Table 2-12 show this trend occuring despite substantial increases in retail prices since 1973.

The strong brand loyalty that was indicated by industry sources to be characteristic of Harley-Davidson buyers would seem to accord Harley-Davidson certain advantages. It appears that Harley-Davidson sales are considerably less sensitive to both price increases and declines in real income than are other brands.

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1 Motorcycle Industry Council, "Manufacturers Shipment Reporting System".

Table 2-11

CHARACTERISTICS OF MAJOR U.S. MOTORCYCLE MANUFACTURING FIRM

(AMF/HARLEY-DAVIDSON)

CATEGORY:	U.S. Motorcycle related sales over 100M annually.
LOCATION:	Milwaukee, Wisconsin
CORPORATE PRODUCT LINE:	Leisure products (including motorcycles) Industrial products and machinery.
MOTORCYCLE PRODUCT LINE:	o Milwaukee, Wisconsin and York, Pennsylvania plants: large touring motorcycles (1,000c.c. and 1,200c.c.). o Varese, Italy plant: small and intermediate sized street, street/trail combination, and competition motorcycles.
TOTAL CORPORATION SALES:	$1,004,697,000
NET INCOME:	$ 32,133,000
NET PROFIT MARGIN:	3.2%
ASSETS:	$ 779,470,000
STOCKHOLDER'S EQUITY:	$ 297,698,000
MOTORCYCLE AND TRAVEL VEHICLE SALES:	$ 190,794,000
MOTORCYCLE RELATES SALES, U.S.	
DOLLARS:	$ 100,000,000+ (3)
UNITS REGISTERED (TOTAL)	51,263 (4)
1000C.C. AND OVER:	37,987 (74%)
UNDER 1000C.C.:	12,504 (24%)
C.C. NOT SPECIFIED:	774 (2%)
MARKET SHARE:	6.9%
NO. OF EMPLOYES, MOTORCYCLE RELATED:	3,300

Source: (Except otherwise indicated) AMF Annual Report, 1975.

(1) Based on 1975 data.

(2) Harley-Davidson AMF's largest manufacturing subsidiary.

(3) Motorcycle sales make up a very large percentage of motorcycle and travel vehicle sales, but exact percentage not available

(4) R. L. Polk, New Motorcycle Registration Data, 1975. Motorcycles 1000c.c. and above made up 77% of total registration.

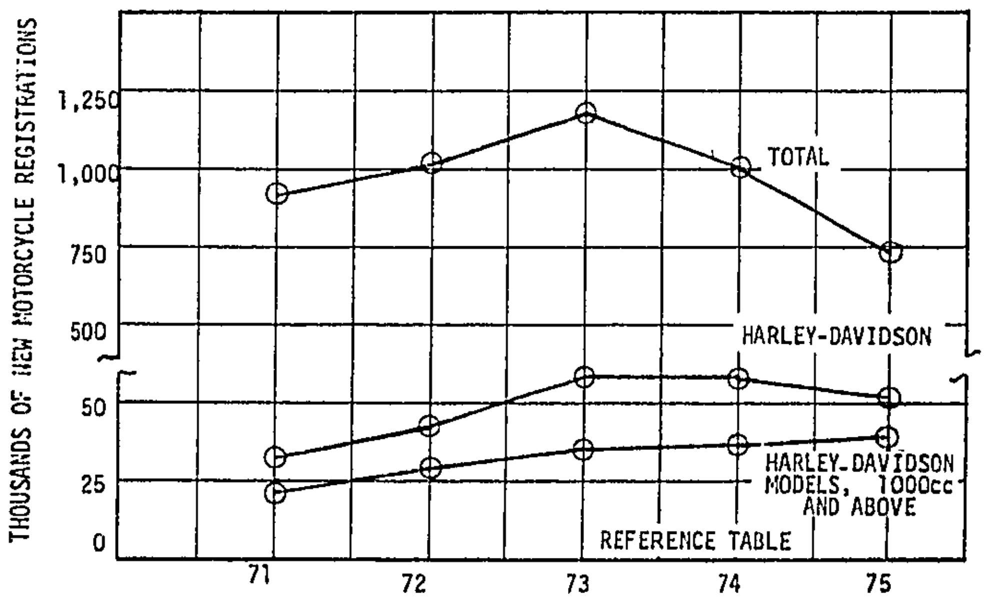

FIGURE 2-4. HARLEY-DAVIDSON NEW MOTORCYCLE REGISTRATION DATA

AMF/HARLEY-DAVIDSON SUGGESTED RETAIL PRICES

	1973	1974			1975		
C.C.	3/15/72	10/27/73	2/18/74	7/15/74	8/11/74	2/25/75	4/21/75
125	$ 565	$ 635	$ 660	$ 749	—	$ 770	—
175	—	$ 795	$ 825	$ 930	—	$ 930	—
250	—	—	—	$1,130	—	$1,168	—
1000	$2,182	$2,338	$2,440	—	$2,735	—	$2,767
1200	$2,482	$2,795	$2,819	—	$3,244	—	$3,330

Source: AMF/Harley-Davidson's Reply to Motorcycle Exhaust Emission ANPRM

Brand loyalty to Harley-Davidson motorcycles appears to arise from several factors. Large Harley-Davidsons feature a longitudinal 45° V-Twin engine with common crank pin; a unique design in today's motorcycle market. This engine configuration provides Harley-Davidson motorcycles with low centers of gravity, narrow profile, and powerful low-end torque. It also features a low frequency asymetrical exhaust note that is unique and which has customer appeal. In addition, the V-Twin engine provides specialized styling for these motorcycles. The manufacturer believes that this unique "sound" and appearance must be retained to preserve demand for Harley-Davidson motorcycles.

Engines and parts for the large motorcycles are manufactured in Harley-Davidson's Milwaukee, Wisconsin facilities, and are assembled in a York, Pennsylvania plant. Approximately 3,300 people are directly employed in the production of motorcycles, parts, and accessories. Harley-Davidson indicates that another 25,000 people are indirectly affected to some extent at supplier plants, distribution and sales locations, and Harley-Davidson dealerships. Harley-Davidson is more vertically integrated than most other manufacturers, in that it makes many of the parts and components which other manufacturers normally buy from suppliers.

Typically, Harley-Davidson's primary manufacturing facilities and equipment are older than most of its competitor's, in part because the basic engine design and manufacturing processes have remained relatively stable over the years. In its 1974 annual report AMF indicated that Harley-Davidson was having difficulty in meeting demand. For this reason, AMF has been spending considerable amounts for plant and equipment needed to raise production capacity and modernize manufacturing processes. In its 1975 annual report, AMF indicated that Harley-Davidson had doubled its engineering staff, partly to meet new design requirements for exhaust and noise emission controls.

From a cost standpoint, Harley-Davidson suffers a disadvantage in view of the fact that Harley-Davidson's production base is 50,000 units per year, as compared to the typical 270,000 units per year of its major competitors. Period costs such as R&D and depreciation are thereby allocated over lesser number of units. This disadvantage is tempered by the fact that Harley-Davidson has a lesser number of models to manage, and that its product line is composed of strictly large street motorcycles which can sustain larger cost increases than smaller models on a relative basis.

Harley Davidson - Italy

This division produces the smaller lightweight models. The product line is composed of small and intermediate sized (250c.c. or less) street and combination (dual purpose) motorcycles. Approximately 12,500 of these models were registered in 1975. The Varese operation falls more into the category of a small U.S. or foreign manufacturer, and so the description of a typical manufacturer with limited U.S. sales applies to this subsidiary. Small Harley-Davidsons have recently been introduced to the non-U.S. market. Non-U.S. sales now account for a third to one half of Varese's production.

U.S. Motorcycle Manufacturers with Limited U.S. Sales

The U.S. motorcycle companies with limited shares of the U.S. market include Chaparral, Cheetah, Fox, Heald, Indian, Pacific Basin Trading Company (PABATCO, distributor of Hodaka motorcycles) and Rokon. The extent of manufacturing and assembly in the U.S. varies from company to company. For example, Rokon buys various components from foreign manufacturers, but 60 to 90 percent of its motorcycles and mototractors (depending on which model) are manufactured or assembled in the U.S. Pacific Basin Trading Company (PABATCO) designs and markets Hodaka motorcycles in the U.S., but the actual manufacturing is done in Nagoya, Japan by the Hodaka Industrial Company. The Hodaka Company is essentially PABATCO's subcontractor. Indian motorcycles are designed and marketed in the U.S. but the manufacturing is done by Indian's wholly owned subsidiary, located in the Nantz Export Processing Zone, Taiwan. Chaparral minicycles are designed and marketed in the U.S., but manufactured in Taiwan (similar to the Indian operation). Fox minicycles are primarily manufactured and assembled in the U.S., but use components from other countries, such as Sachs motors from Germany.

Table 2-13

CHARACTERISTICS OF TYPICAL SMALL U.S.

MOTORCYCLE MANUFACTURERS

RETAIL SALES RANGE:	Less Than $10M
NO OF FIRMS IN CATEGORY:	10 - 20 (Est.)
ADMINISTRATION LOCATION:	U.S. (Typically Great Lakes area)
MANUFACTURING LOCATION:	Either U.S. or Foreign
PRODUCT LINE:	Limited number of specialty models
TOTAL MOTORCYCLE RELATED SALES**	
DOLLARS:	$4.1M
UNITS:	11,000
MARKET SHARE:	Less Than 1.0%
ASSETS:	$2M
NET PROFIT MARGIN:	Generally Negative
NET WORTH:	N/A
NO. OF U.S. EMPLOYES, MOTORCYCLE RELATED:	20

Source: Information from representative companies.

**Almost all companies in this category have all or very large part of revenues coming from motorcycle business.

N/A - Not Available

A typical U.S. company is relatively young and small (less than $2-3 million in assets), manufactures 11,000 units and has annual sales in the $4M range. Net earnings in 1975 were negative or marginally in the black because demand for new motorcycles was considerably down in 1975. U.S. employment for the companies ranges from 2 to 34 employees. Employment of manufacturing subsidiaries or subcontractors is generally less than 100. The small U.S. company's product line is generally limited to minicycles, or small motorcycles (typically less than 185c.c.) that are intended for off-road or dual purpose use. Characteristics of a typical U.S. company with limited sales is shown in Table 2-13. A brief description of some of these companies is contained in the following paragraphs.

Chaparral

Chaparral is a small company that manufactures 80c.c. and 100c.c. minicycles. The motorcycles are designed in the U.S., but are assembled in Taiwan. The engines are manufactured in Japan.

Cheetah

Cheetah makes two trail recreation models that use 7hp and 5hp Tecumseh engines. Production on the two models has been shut down due to a shortage in parts. The motorcycles and engines are manufactured and assembled in the U.S.

Fox

Fox manufacturers 4 minicycle models. Two of the models use 133c.c. Tecumseh engines and the other two use German Sachs engines. With the exception of the Sachs engines, most of the manufacturing and assembly is done in the U.S. The company also manufactures motocross bicycles.

Heald

Located in Benton Harbor, Michigan, Heald manufactures garden tractors, roto-tillers and two and three wheel motorcycles in kit form. Approximately 75 percent of sales are motorcycle-related. The motorcycles are recreational trail models which use Tecumseh, Briggs and Stratton, Wisconsin and J.L.O. engines. Sales are primarily by mail order.

Indian

The Indian Motorcycle Company is a small U.S. firm that is located in Southern California. Manufacturing is done by a wholly owned subsidiary located in Taiwan. Seven models are manufactured - a 100c.c. street machine, and 125c.c. and 175c.c. street, dual purpose and trail models. All are 2-stroke. Approximately 50 percent of Indian's sales are in the U.S.; the remainder are exported. Indians are sold through distributors and manufacturer's representatives. The company indicates it is in a precarious position because of pending exhaust emission control regulations which are more difficult to control on 2-stroke motorcycles.

Pacific Basin Trading Company (PABATCO)

PABATCO is located in Athena, Oregon and markets Hodaka motorcycles, primarily small (250c.c. and less), 2-stroke motocross and off-road motorcycles. Hodakas are manufactured in Nagoya, Japan by the Hodaka Industrial Company, which is essentially PABATCO's subcontractor. Over 90 percent of Hodaka's business is through PABATCO.

Rokon

Rokon is located in Keene, New Hampshire and manufactures mototractors and motorcycles. The mototractors are 2-wheel drive vehicles that are used for utility and agricultural work. The majority are exported. The motorcycles are 2-stroke, 340c.c. off-road motorcycles with Sachs motors and torque converter transmissions. Motorcycles represent approximately 40 percent of Rokon's business. Many of the components of Rokon motorcycles come from other countries, but the final assembly and check-out is done in Rokon's New Hampshire facilities. Rokon manufactures approximately 500 to 1000 motorcycles per year.

At the present the following companies are no longer active in the motorcycle market: Rupp; Rockford; Bandit; and Bird Engineering. Speedway has been acquired by Fox.

Foreign Motorcycle Manufacturers with Limited U.S. Sales

There are approximately 25 foreign manufacturers with limited U.S. motorcycle sales. A typical company manufactures 20,000 units, of which 4,000 are exported to the U.S. This quantity represents less than one-half percent of the U.S. market, and is worth approximately $4M in sales revenues. The product line is typically limited and concentrated in certain product categories. For example, many of the Italian companies such as Ducati, LaVerda, Moto Benelli, Moto Guzzi, Moto Morini, and MV Agusta market large street motorcycles. BMW and NVT Motorcycles are two other companies that specialize in large street motorcycles. Most of the other companies specialize in small and intermediate sized (less than 350c.c.) off-road and combination motorcycles. Characteristics of a typical foreign motorcycle manufacturer with limited U.S. sales is shown in Table 2-14. Capsule descriptions of some of the companies are contained in the following paragraphs.

Table 2-14

CHARACTERISTICS OF TYPICAL FOREIGN MOTORCYCLE MANUFACTURER

WITH LIMITED U.S. SALES

RETAIL SALES RANGE:	Less Than $10M
NUMBER OF FIRMS IN CATEGORY:	25+
LOCATION:	Europe, Taiwan, Mexico, Canada
PRODUCT LINE:	Motorcycles, Bicycles, Mopeds
MOTORCYCLE PRODUCT LINE:	Limited number of specialty models
TOTAL CORPORATION SALES:	N/A
ASSETS:	N/A
NET PROFIT MARGIN:	N/A
NET WORTH:	N/A
TOTAL MOTORCYCLE RELATED SALES	
DOLLARS:	
UNITS:	20,000
MOTORCYCLE RELATED SALES, U.S.	
DOLLARS:	$4M (Est.)
UNITS:	4,000
MARKET SHARE:	Less Than 1%
NO. OF EMPLOYES (U.S. DISTRIBUTOR):	40

Source: Information from individual U.S. distributors of foreign manufacturers.

N/A - Not Available

Benelli

Moto Benelli is an established Italian firm that is a subsidiary of DeTomaso Industries. Benelli markets 250c.c., 500c.c., 650c.c. and 750c.c. street motorcycles.

BMW

BMW is an extremely large manufacturer located in West Germany. Total corporation sales in 1974 approached $1 billion. Automobiles and large touring motorcycles are major product lines. According to registration data, BMW had a one percent share of the U.S. market in 1975, and ranked seventh among all manufacturers. BMW sells large touring motorcycles with horizontally opposed twin cylinder engines and shaft drive. Like Honda, BMW can make use of expertise and facilities developed for the automobile market.

Can-Am

Can-Am motorcycles are manufactured by Bombardier, Ltd., a large Canadian firm that also manufactures snowmobiles, industrial vehicles, all terrain tractors, and winter sport accessories and apparel. Can-Am specializes in high performance enduro and competition motocross motorcycles. Bombardier is presently making 10,000 motorcycles per year.

Hercules

Hercules are manufactured by DKW/Hercules, part of the Wankel-Fichtel-Sachs Manufacturing Group, which is one of Germany's largest manufacturers of motorcycles. The group is also a major supplier of engines to other motorcycle manufacturers. DKW makes enduro and off-road motorcycles primarily. DKW also markets a rotary engine model, although production of this model is relatively limited.

Husqvarna

Husqvarna is a large Swedish manufacturing company which produces engines, chain saws, appliances, sewing machines, as well as motorcycles. The company specializes in very high quality off-road cross country and competition models. Approximately 75 percent of Husqvarna's total production is exported to the U.S.

KTM

KTM sells strictly off-road motorcycles in the U.S. Sales in the Western U.S. were initiated in late 1975. The parent company is a medium sized Austrian company which manufactures motorcycles and bicycles.

LaVerda

LaVerda is an Italian motorcycle manufacturer that makes large street motorcycles. Product line is primarily in the 750-1000c.c. size range.

2.3 Aftermarket Industry

The structure of the aftermarket segment of the industry is entirely different from the new motorcycle market segment. The aftermarket industry is primarily domestic, as compared with the extreme international characteristics of the new motorcycle segment of the industry. There are an estimated 900 companies in the U.S. that are involved to some extent with manufacturing and distributing motorcycle aftermarket products[1]. The majority of these firms are relatively small, young companies. Most have motorcycle-related sales of less than $1 million per year and have been in business less than five years[1]. There is no single company or group of companies that dominate the market.

General Aftermarket Company

Firms in the motorcycle aftermarket industry can be classified as manufacturers only, manufacturers and distributors, and distributors only. The approximate number of companies in each classification are:

Manufacturers Only	270
Manufacturer/Distributor	279
Distributors Only	351

Source: Motorcycle Dealer News, "Industry Overview".

These companies are not all strictly motorcycle oriented; a significant number are diversified and involved in other industries. For example, some of the motorcycle aftermarket manufacturers are large automotive aftermarket companies which have expanded into the motorcycle market. Some firms also serve the snowmobile, boating, bicycle and other miscellaneous industries. In general, the smaller companies in the industry have a large or complete dependence on motorcycle product sales, and the large companies have a relatively small dependence on motorcycle sales.

[1] Motorcycle Dealer News, "Industry Overview".

Characteristics of typical aftermarket manufacturers are shown in Table 2-15. Data on some general characteristics of the aftermarket industry is present in Table 2-16.

A brief profile of manufacturers, manufacturer/distributirs and distributors is provided below, and summarized in Figures 2-5 and 2-6.

Manufacturers Only

Ninety percent of manufacturers-only firms characterize their sales as national in scope. The majority do much of their business through warehouse/distributor direct or through manufacturing representatives. Only 32 percent of the companies derive more than 70 percent of their business from the motorcycle industry. The majority (60 percent) have less than 20 percent of their sales coming from motorcycle products[1].

Manufacturers/Distributors

Seventy percent of the manufacturers/distributors derive more than 70 percent of their sales from motorcycle related business. In addition, 70 percent have less than $500,000 in annual motorcycle related sales. The manufacturer/distributors sell directly to dealers and accessory shops and to a lesser extent to other distributors[1].

Distributors

More than 60 percent of the distributors derive more than 80 percent of their sales from motorcycle related sales. However, 66 percent of the companies have motorcycle product sales of less than $500,000 per year. Most of the distributors are regional/local with only 16 percent of the companies considered to be national distributors.

In essence, the aftermarket segment of the industry is in the formative stage, with numerous small companies with specialized product lines or functions competing with each other. In addition, these companies are facing increased competition from the major motorcycle manufacturers who recognize the growth aspects in this industry. It is likely that some of the more marginal operations will fail, or be combined with other companies in the next few years. The emerging nature of the industry makes it more difficult to assess the likely impact of noise control programs on the aftermarket industry structure.

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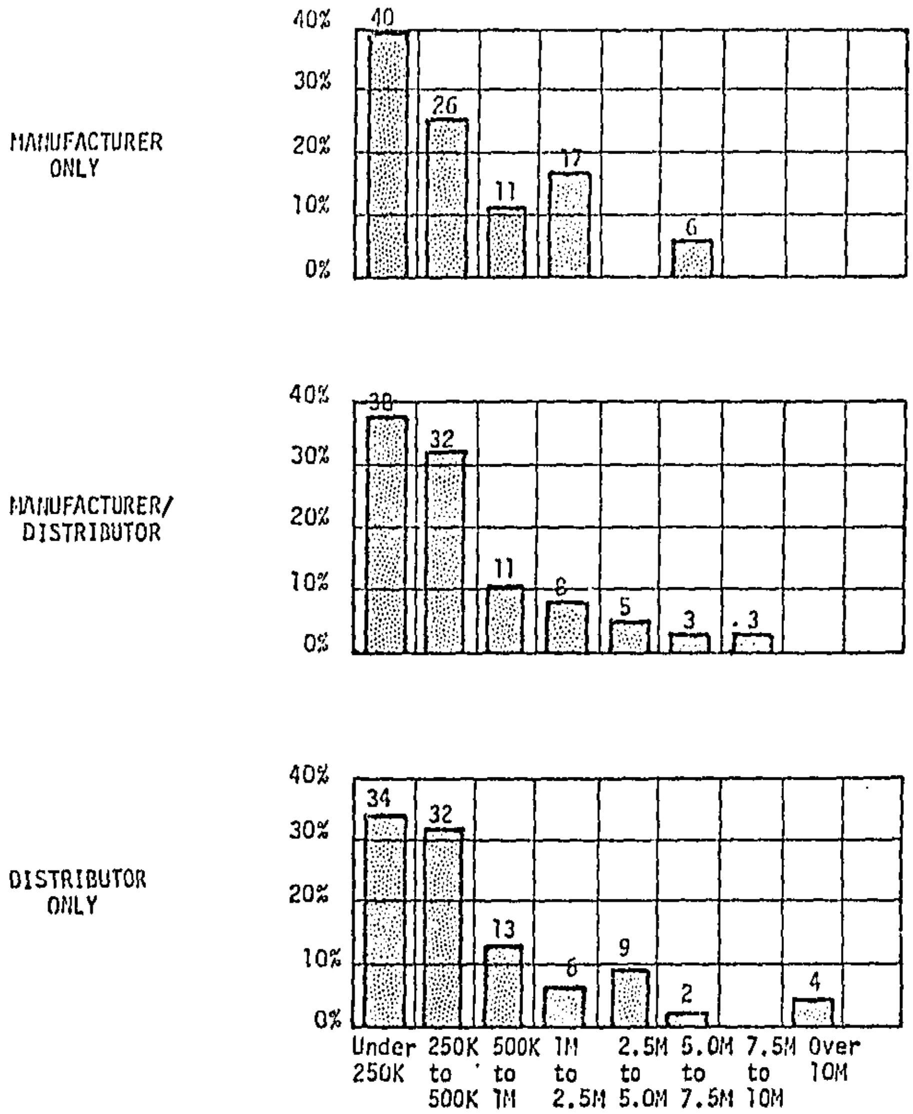
[1] Motorcycle Dealer News

Table 2-15

CHARACTERISTICS OF TYPICAL MOTORCYCLE
AFTERMARKET MANUFACTURER/DISTRIBUTOR

PRODUCT LINE:	Replacement Parts, Accessories, Apparel
CATEGORY:	Manufacturer Only
NO. OF FIRMS IN CATEGORY:	270
SALES:	$250,000
NO. OF EMPLOYES:	24 (median)
AGE:	4 years (median)
CATEGORY:	Manufacturer/Distributor
NO. OF FIRMS IN CATEGORY:	279
SALES:	$250,000
NO. OF EMPLOYES:	8 (median)
AGE:	5 years (median)
CATEGORY:	Distributor Only
NO. OF FIRMS IN CATEGORY:	351
SALES:	$250,000
NO. OF EMPLOYES:	5 (median)
AGE:	4 years (median)

Source: Motorcycle Dealer News



Source: Motorcycle Dealer News

FIGURE 2-5. AFTERMARKET FIRMS – ANNUAL REVENUES FROM MOTORCYCLE BUSINESS

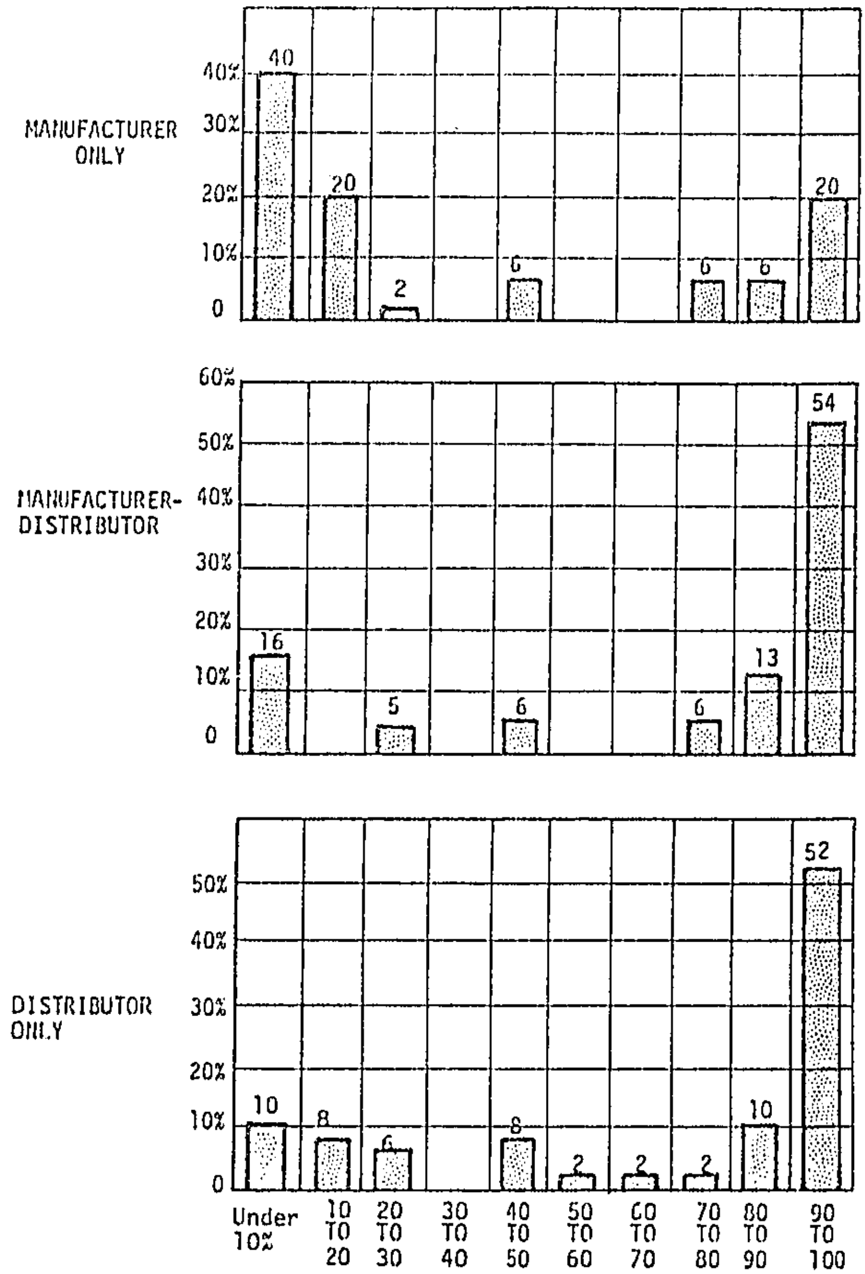


FIGURE 2-6. AFTERMARKET FIRMS - PERCENTAGE OF REVENUES FROM MOTORCYCLE BUSINESS

Exhaust Systems/Components Manufacturers and Distributors

The segment of the aftermarket that will be most directly affected by noise regulation are companies which manufacture and distribute exhaust system products - mufflers, exhaust pipes, expansion chambers, exhaust headers and so forth. There are over 160 companies in this group who are selling in a market that is estimated to be slightly over $30 million per year. Most are located in California. Average sales for manufacturing companies are estimated to be approximately $320,000. The leader in the industry is believed to sell between $2 and $3 million worth of exhaust system products per year. Exact distribution of sales in this subsegment of the industry is unavailable but the general nature is evident. The companies are relatively small and competing in a crowded market.

Based on a survey of 11 representative firms, a typical company in the exhaust system segment of the aftermarket manufactures 30,000 exhaust systems and components per year, has annual sales of $0.7 million, and nets 5 to 7 percent profit each year. Market shares range from 1 to 3 percent of the total. Total assets are approximately $300,000, but 60 to 75 percent of these assets are in inventory. Typical characteristics of exhaust system manufacturers shown in Table 2-17 are derived from manufacturer proprietary information.

Typically the president/owner of the company is also the designer of the exhaust systems and components, although one or two people may assist him in this function. Design emphasis is on styling, performance, and noise control; the priorities are dependent upon individual company philosophies. Noise control technical capabilities vary from company to company, although most use fairly standard noise control techniques, and the "cut and try" method for design advancements. Research facilities are generally non-existent or very limited.

Characteristics of consumer buying patterns for replacement parts and equipment, and projections of future market shares of replacement parts manufacturers and presented in Table 2-18 through 2-21.

Table 2-16

AFTERMARKET INDUSTRY CHARACTERISTICS

Total motorcycle aftermarket sales*

$1.8 billion

Number of U.S. aftermarket manufacturers

550 approximately

Exhaust system aftermarket sales

$30,663,000 retail

616,000 purchasers

862,000 units

$49.73 average per unit

Intake system aftermarket sales

$5,880,000 retail

840,000 purchasers

1,344,000 units

$7.00 average per unit

*Ziff-Davis Publishing Co., "Motorcycle Aftermarket Study" - 1974.

Table 2-17

CHARACTERISTICS OF TYPICAL MOTORCYCLE AFTERMARKET

EXHAUST SYSTEM MANUFACTURER

CATEGORY:	Aftermarket Exhaust System Manufacturer
NO. OF COMPANIES IN CATEGORY:	90+
LOCATION:	U.S., Predominately California
PRODUCT LINE:	Mufflers, Expansion Chambers, Headers
TOTAL COMPANY SALES:	$0.7M*
ASSETS:	$300K**
NET PROFIT MARGIN:	5 - 7%
NET WORTH:	N/A
TOTAL MOTORCYCLE EXHAUST RELATED SALES	
DOLLARS:	$0.7M
UNITS:	30,000
MARKET SHARE:	1 - 3%
NUMBER OF EMPLOYES, MOTORCYCLE RELATED:	40

Source: Information from sample of representative companies.

*Most companies derive most or all of their business from exhaust system sales.

**Generally 60 to 75 percent of assets is in inventories.

N/A - Not Available

Table 2-18

TIME OF PURCHASE OF MOTORCYCLE ACCESSORIES

ENGINE PARTS/HIGH PERFORMANCE MARKET

MONTHS AFTER MOTORCYCLE PURCHASE	SPECIAL SPROCKETS	EXPANSION CHAMBER	EXHAUST SYSTEM	SILENCER SPARK ARRESTERS
AT SAME TIME	21.0%	27.2%	36.0%	40.3%
1-2 MONTHS	15.6	9.5	6.6	11.7
5-7 MONTHS	24.1	12.2	7.2	6.4
8-12 MONTHS	21.0	12.6	11.2	6.3

NOTE: MOST OF THE NOTED ITEMS ARE PURCHASED WITHIN THE FIRST 2 YEARS AFTER PURCHASE OF A NEW MOTORCYCLE

Source: 1975 Motorcycle Market Study
Power-Robertson & Company

Table 2-19

OWNERS OF MOTORCYCLE ACCESSORIES

ENGINE PARTS/HIGH PERFORMANCE MARKET

AFTERMARKET ACCESSORY	% * TOTAL OWNERS	% HONDA OWNERS	% YAMAHA OWNERS	% SUZUKI OWNERS	% KAWASAKI OWNERS	% HARLEY OWNERS
SPECIAL SPROCKETS	11.8	9.6	19.7	21.3	16.9	16.8
EXPANS. CHAMBER	4.5	2.9	11.2	9.8	6.3	6.3
EXHAUST SYSTEM	10.9	12.6	8.3	9.7	6.0	25.0
SILENCER-SPARK ARRESTOR	4.9	3.9	8.7	9.8	7.1	7.1

NOTE: *OWNERSHIP OF INDICATED ITEMS BY PERCENTAGE OF MOTORCYCLISTS' QUESTIONED.

Source: 1975 Motorcycle Market Study
Power-Robertson & Company

Table 2-20

MANUFACTURERS OF MOTORCYCLE ACCESSORY ITEMS

CURRENT/FUTURE MARKET ANALYSIS

EXHAUST SYSTEMS

MAJOR BRANDS	CURRENT SHARE OF MARKET PERCENT	FUTURE SHARE OF MARKET PERCENT
HONDA	21.0	11.0
HOOKER	13.0	30.0
YAMAHA	5.0	—
SUZUKI	4.0	—
TORQUE	4.0	9.0
BASSANI	3.0	7.5
DUNSTALL	2.0	1.5
KAWASAKI	1.5	—
RUPP	.5	—
ALL OTHERS	46.0	41.0

Source: 1975 Motorcycle Market Study
Power-Robertson & Company

Table 2-21

MANUFACTURERS OF MOTORCYCLE ACCESSORY ITEMS

CURRENT/FUTURE MARKET ANALYSIS

EXPANSION CHAMBERS

MAJOR BRANDS	CURRENT SHARE OF MARKET PERCENT	FUTURE SHARE OF MARKET PERCENT
HOOKER	22	32
BASSANI	20	26
YAMAHA	8	3.5
SUZUKI	4	—
J & R	3	3.5
KAWASAKI	2	2.0
HONDA	2	—
ALL OTHERS	39	33

Source: 1975 Motorcycle Market Study
Power-Robertson & Company

2.4 Motorcycle Dealers

The major retail outlets in the motorcycle industry are dealers, motorcycle accessory shops, department store chains, discount stores, mail order firms and others (e.g., service stations). Dealers sell new and used motorcycles, and aftermarket products and services, while all the other outlets deal in the aftermarket only. Aftermarket parts and accessory retailing is done primarily by the dealers, who are responsible for 75 to 80 percent of total sales (refer to Table 2-22).

Table 2-22

SALES OF MOTORCYCLES, PARTS AND ACCESSORIES

BY TYPE OF OUTLET

OUTLET	PERCENTAGE OF TOTAL RETAIL SALES
Franchised Dealerships	75 - 80
Mail Order	10 - 12
Accessory Shops	6 - 8
Department/Discount Stores	6 - 8
Other	1 - 2

Source: Frost and Sullivan

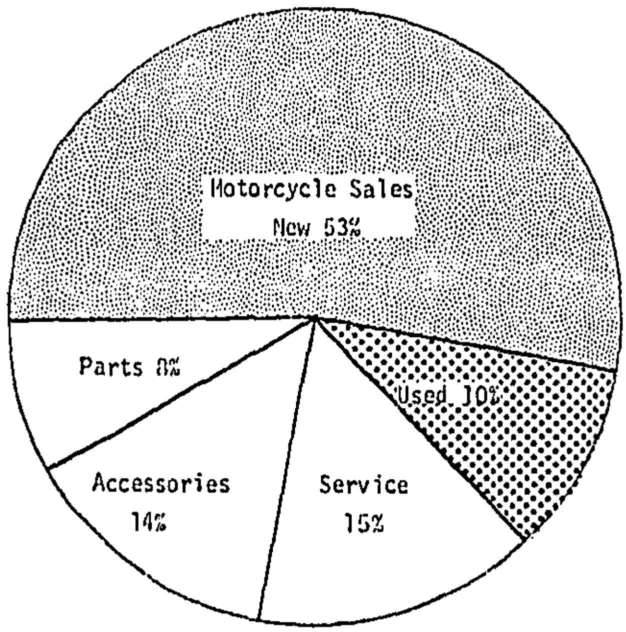
There are an estimated 7,000 to 8,000 independent franchised dealers in the U.S. selling motorcycles and aftermarket products and services. Most carry one brand of motorcycle exclusively, although a significant number carry more than one brand. Multiple brand representation is generally only for motorcycle manufacturers with a small specialized product line; the typical multiple brand dealer represents more than one of these types of brands to extend the range of models he can sell.

Slightly more than 50 percent of dealer sales are generated from new motorcycle sales, while accessories, parts and services sales make up almost 40 percent. The breakdown is as follows (reference Figure 2-7):

New Motorcycle Sales	53%
Used Motorcycle Sales	10%
Accessories	14%
Parts	8%
Service	15%
	100%

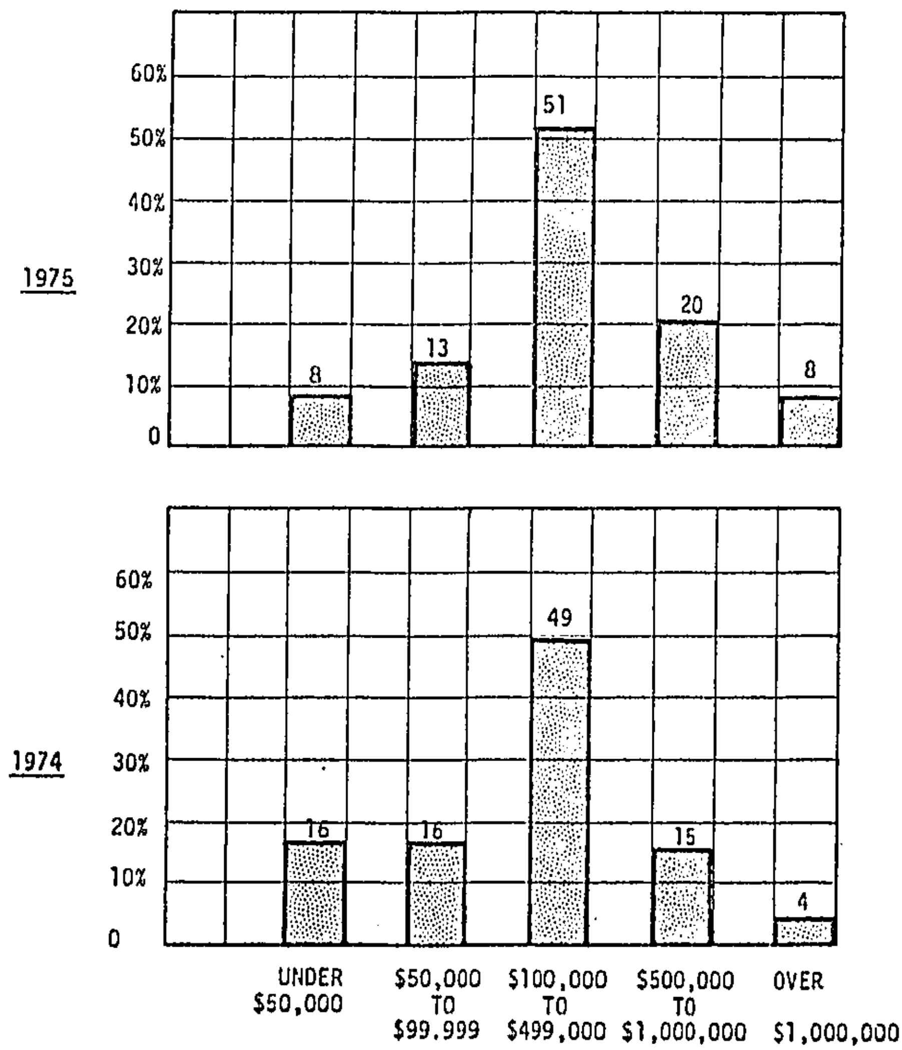
Average annual sales for motorcycle dealers is approximately $360,000. The distribution of dealers by total retail sales volume for 1974 and 1975 is shown in Figure 2-8. Approximately 50 percent of the dealers are in the $100,000 - $499,000 sales range. Dealers with sales under $50,000 per year went from 16 percent in 1974 to 8 percent in 1975, indicating that some of the marginal dealers folded as a result of the decline in demand for new motorcycles in 1975. Characteristics of a typical dealer are shown in Table 2-23.

The typical dealer has relatively small profit margin (3% before taxes), and relies heavily on short term financing for his inventory, which makes up a large proportion of his assets. When sales volume drops dealers are often stuck with a large inventory, and interest expense becomes critical. When this occurs, the dealers are forced to discount their prices, thereby reducing their profit margin even more. This process is especially damaging to the smaller dealers who are generally undercapitalized and have a low sales volume to support their operations.



Source: Motorcycle Dealer News

FIGURE 2-7. MOTORCYCLE DEALERS TYPICAL DISTRIBUTION OF RETAIL SALES, 1974



SOURCE: MOTORCYCLE DEALER NEWS

FIGURE 2-8. MOTORCYCLE DEALER REVENUES - FALL-OUT OF MARGINAL DEALER OPERATIONS

Table 2-23

CHARACTERISTICS OF TYPICAL FRANCHISED MOTORCYCLE DEALERSHIP*

CATEGORY:	Franchised Dealership
NO. OF FIRMS IN CATEGORY:	7,000 - 8,000
LOCATION:	U.S.
PRODUCT LINE:	New Motorcycles, Used Motorcycles, Parts, Accessories, and Services
ASSETS:	N/A (Primarily Inventory)
NET PROFIT MARGIN (AT):	3%
NET WORTH:	N/A
TOTAL MOTORCYCLE RELATED SALES	
DOLLARS:	$360,000/Year
UNITS:	190 New Motorcycles (median)
NO. OF EMPLOYES:	Equivalent of 5 Full Time

Source: Motorcycle Dealer News
Motorcycle Industry Council

*Based on 1974 Data

N/A - Not Available

2.5 Total U.S. Motorcycle Industry Employment

Total U.S. motorcycle industry employment is shown below:

Table 2-24

ESTIMATED U.S. MOTORCYCLE INDUSTRY EMPLOYMENT

INDUSTRY SEGMENT	NUMBER OF EMPLOYEES	SOURCE
New Motorcycle Manufacturers and Distributors	5,600	1
Aftermarket Manufacturers and Distributors	12,000*	2
Franchised Dealerships	35,000	2,3
Other Retail Outlets	5,000	4
Miscellaneous	2,000	
TOTAL	59,600	

Data derived from following sources:

(1) Information from various companies.

(2) Motorcycle Dealer News.

(3) Motorcycle Industry Council.

(4) Energy and Environmental Analysis, Inc., "Economic Assessment of Motorcycle Exhaust Emission Regulations".

* 1200 in aftermarket exhaust system manufacturing.

2.6 Motorcycle Warranties

Street motorcycles are often warranted against defects in materials and assembly for six months and a corresponding distance of travel. Shorter warranties (three months) and longer ones (one year) are also known. Off-road motorcycles are often warranted for three or six months, although semi-competition models often have no warranty. Pure competition motorcycles are almost never warranted. To EPA's knowledge formal warranties are extended on very few replacement exhaust systems, although many manufacturers will repair or replace obviously faulty products.

SECTION 3

SOUND LEVEL TEST PROCEDURES

Section 3

SOUND LEVEL TEST PROCEDURES

3.1 Application and Criteria

Existing noise test methodologies which have been either adopted, approved, or proposed in the United States or in other countries were examined for possible use in the EPA regulation. Several criteria were established to review these procedures and to provide a basis for possible refinement.

Ideally, a sound measurement procedure for new motorcycles should:

(a) Characterize the sound as perceived at the wayside in terms that relate to the impact of noise on humans.

(b) Characterize the sound during the most annoying mode(s) of operation commonly encountered in areas of impact.

(c) Measure sound levels on a comparable basis for all motorcycles in specified categories, as measured in the operating mode(s) identified above.

(d) To the extent possible, satisfy several practical requirements. Specifically, a testing procedure should be:

(1) Clear and easily understandable.

(2) Repeatable with a minimum of variation.

(3) Capable of being conducted with a minimum of meteorological and site-to-site variability.

(4) Insensitive to configuration options (such as gearing, sprocket ratios) which can result in variations of measured noise disproportionate to actual variations in vehicle noise.

(5) Free from ambiguous procedural situations requiring determinations which can affect the measured sound level.

(6) Minimally influenced by factors affecting vehicle performance, such as atmospheric conditions, rider weight, accessories, etc.

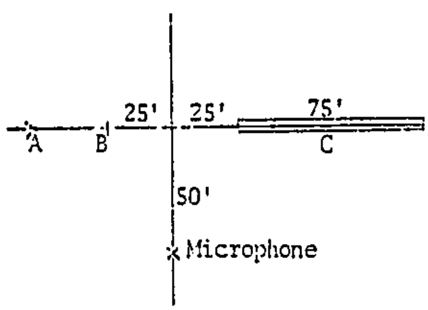
None of the existing in-use or proposed procedures, in their present form, satisfied the above criteria to the extent desirable in the intended applications. Accordingly, variations of these procedures designed to eliminate certain shortcomings of the existing procedures were explored. A description and critique of each procedure appears on the following pages.

3.2 Candidate Moving Vehicle Test Procedures

SAE J-331a (Moving vehicle acceleration test)

This test method, or variations of it, is the most commonly used noise measurement procedure for motorcycles sold in the U.S., and is the method for which the largest data base currently exists. It was therefore the baseline method to which other candidate procedures were compared. The procedure consists of approaching a marker at 30 mph or 60% of maximum rated RPM* (whichever is slower), accelerating at full throttle commencing at a point 25' before the microphone, and closing the throttle at a point 100' past the microphone, or when maximum rated RPM is reached (whichever occurs earlier). Second gear is used unless the vehicle travels less than 50' before reaching maximum rated RPM, in which case third gear is used. Six measurements on each side are taken, the highest and lowest discarded, and the reported level is the average of four readings within 2 dB(A) of each other on the loudest side.

The full text of the procedure is presented in Appendix A.



A. Approach at 30 mph or 60% RPM (the slower).

B. Accelerate in 2nd gear unless 100% RPM reached before zone C, in which case use 3rd gear.

C. Close throttle at 100% RPM or at end of zone C (the earlier).

*As used in this report, "maximum rated RPM" means the engine speed at which "peak brake power" (as defined in SAE Standard J-245) is achieved. Percent rpm is in reference to maximum rated RPM as 100%.

Critique:

(a) The highest sound level achieved during a given test occurs at different distances from the microphone for different motorcycles. This means that for some motorcycles the highest sound level is measured, while for others the measured level could be substantially less than the maximum. This variable is influenced by horsepower, gear ratio and sprocket ratios. Data on distance variability are presented in Appendix C, Table C-11. To a certain extent, this variability accounts for the differences in normal operation of high and low powered motorcycles. However, it also results in significant difference in measured levels among motorcycles having almost identical characteristics.

(b) Some motorcycles, particularly the larger vehicles, do not reach maximum rated RPM. In such cases, not only is maximum noise not developed, but also, the highest sound level generated is at a point where the vehicle is furthest from the microphone. Data on percent RPM attained are also contained in Appendix C, Table C-11.

(c) Due to vehicle and test variables, motorcycles of the same make and model are not necessarily tested in the same gear. This could result in a situation where a motorcycle was tested by the manufacturer using one gear, and verified by a government agency using a different gear. The measured levels could be substantially different in the two cases.

(d) Different size sprockets are available as options on most motorcycles, and are readily interchanged by the user. The 50 foot minimum distance criterion makes the J-331a test sensitive to sprocket ratio. Thus, the manufacturer could select a sprocket ratio which gives most favorable results under this procedure, and supply to the user other sprockets for various use applications. The practice of changing sprockets is widespread, particularly in off-road or combination street/off-road motorcycles. The important point here is that changing sprockets does not necessarily affect substantially the actual generated noise, but can have major effect on the measured level in the J-331a test.

(e) The procedure does not provide for the testing of motorcycles with automatic transmissions.

(f) The procedure does not provide for the situation when, even in 3rd gear, the vehicle does not travel the stipulated distance.

(g) Atmospheric conditions which affect power output will affect closing RPM and/or vehicle position in relation to the microphone (in addition to affecting sound power generated).

(h) Vehicle closing conditions (RPM and/or position) are affected by rider weight, accessories weight, wind, and wind resistance.

(i) This test procedure has the advantage of being independent of tachometer dynamic characteristics for larger motorcycles (approximately 400-500 cc).

CHP Variation of J-331a (Moving vehicle acceleration test)

The California Highway Patrol (CHP) adopted the J-331a method for type approval, with two variations:

(a) If maximum rated RPM is reached before 30 mph, or if a 50 foot acceleration distance is not attained, the next higher gear is to be used. (Other stipulations of J-331a apply.)

(b) Four instead of six measurements are required on each side of the vehicle and the average of the two highest readings (within 2 dB(A) of each other) on the loudest side are reported.

States which have adopted the CHP method are California, Colorado, Floria and Oregon. States and cities which have adopted the J-331a method are Maryland, Washington, Grand Rapids, Chicago and Detroit (Detroit requires only two measurements on each side of the vehicle).

The full text of this procedure is presented in Appendix A.

Critique:

(a) Variation "a", above, will primarily affect the smaller motorcycles, obviates certain test operation difficulties that may result in over-revving, and may be more representative of operational conditions for these vehicles. Variation "b", based on test experience with measurement consistency, should have no significant effect, and results in a simpler test procedure.

(b) The other shortcomings identified in the J-331a procedure critique remain in the CHP variation of J-331a.

SAE J-986a (Moving vehicle acceleration test)

The J-986a procedure, although designed for passenger cars and light trucks, is prescribed in Canada for the testing of motorcycles.

Major differences, referred to J-331a, are:

(a) Approach is at 30 mph in all cases.

(b) Sole criterion for gear selection is that the lowest gear which will achieve the 50 foot acceleration distance shall be used.

(c) The end-zone is 100 ft. long, instead of 75 ft.

Full text of the procedure is presented in Appendix A.

Critique:

(a) The speed and gear selection stipulations are not suited to some motorcycles.

(b) The gear selection stipulation will result in full acceleration in 1st gear on the larger motorcycles, with attendant hazard factors.

SAE J47 (Moving vehicle acceleration test)

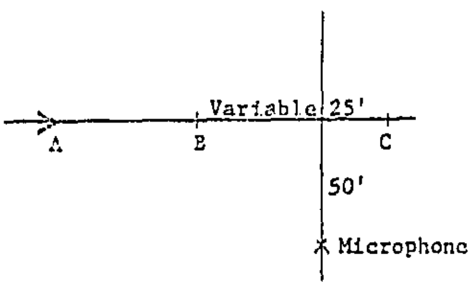
The J47 procedure was designed to measure the maximum noise potential of the vehicle. It differs from the J331a procedure in the following major respects:

(a) Instead of a variable end-point, a variable acceleration start-point is employed, such that all vehicles reach rpm for peak power at a point 25' past the microphone.

(b) The gear employed is the lowest gear that does not result in an accelerating distance of less than 50' (for many motorcycles, this will be first gear); however, when the above selected gear "results in a dangerous or unusual operating condition such as wheel spin, front wheel lifting, or other unsafe conditions, the next higher gear shall be selected...."

(c) Approach to the acceleration point is made at 60% rpm for peak power in all cases.

Reporting method is the same as the J331a. The full text is presented in Appendix A.



A. Approach at 60% rpm.

B. Accelerate in lowest gear such that BC is not less than 50'. If this results in unsafe condition, use next higher gear. By trial, point B is selected such that peak power rpm is reached at point C.

C. Close throttle at end point C, 25' past microphone point.

Critique:

(a) The J47 test provides a more consistent measures of vehicle maximum noie, since all vehicles reach peak power rpm at the same point in relation to the microphone.

(b) Since the above condition does not prevail in the J331a test, correlation between the two procedures cannot be expected, although maximum differences by motorcycle category may be developed.

(c) As with J331a, motorcycles of the same make and model are not necessarily tested in the same gear (due to vehicle and test variables). Gear selection is further based on a judgment as to whether operation in that gear is safe or not. However, in the J47 test the particular gear used is of secondary importance, since in this test all motorcycles reach peak power rpm at full throttle, and reach this condition at the same point in relation to the microphone. The effect of gear selection on measured levels was investigated during this study, with test results presented in <u>Table 3-1 (F76 procedure description)</u>.

(d) Since in the J47 test gear selection is of only secondary significance in relation to measured levels, then the matter oif sprocket options (discussed in citique of J331a) is also not critical.

(e) The safety aspects of the J47 testing procedure are such as to require a skilled rider familiar with the behavior of the particular motorcycle, and exercise of care in its operation.

(f) The procedure is less sensitive to factors affecting vehicle performance than is the J331a.

(g) The method has potential for precise correlation with a stationary vehicle dynamometer test, since power output together with position in relation to the microphone are defined.

The noise control regulations of Italy incorporate a noise test procedure which in essense is the J47. Approach conditions are not prescribed, the only stipulations being that 1st gear shall be used and that the vehicle shall develop rated power and rpm when the vehicle is at the microphone target point. Substitute methods of engine loading are permitted, such as grade or dynamometer.

ISO/R-362 (Moving vehicle acceleration test)

The International Standards Organization, (ISO) Recommendation R-362, "Measurement of Noise Emitted by Vehicles", was approved in May 1962 by the following ISO Member Bodies*.

Australia	France	Poland
Austria	Germany	Portugal
Belgium	Greece	Spain
Brazil	Hungary	Sweden
Canada	India	Switzerland
Chile	Ireland	United Kingdom
Czecholovakia	Israel	U.S.A.
Denmark	Netherlands	U.S.S.R.
Finland	New Zealand	Yugoslavia

The ISO/R-362 moving vehicle test procedure has since been incorporated into the regulations of the following countries:

France	Portugal
Luxemburg	Austria
Netherlands	United Kingdom
Norway	West Germany

Japan and Belgium have adopted a variation of the ISO/R-362 method. The Economic Commission for Europe (ECE) has adopted the ISO/R-362 method and has prescribed noise standards for various categories of motorcycles. Sweden and Australia have proposed revisions to the ISO/R-362.

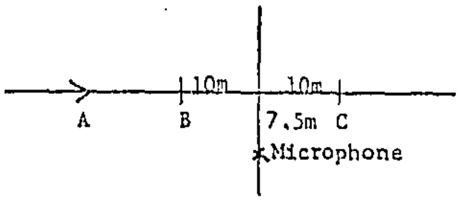
In the test, approach is made at 75% rpm for peak power or 50 km/h, (whichever is slower). 2nd Gear is used if the vehicle is fitted with a two-, three-, or four-speed gear box. If the vehicle has more than four speeds, 3rd gear is used. The throttle is fully opened at a point 10 m before the microphone point, and closed 10 m past the microphone point.

Provisions are included for the testing of vehicles with no gear box, and for vehicles with automatic transmission.

Two readings within 2 dB(A) of each other are required on each side of the vehicles, and the highest value reported.

Full text of the procedure is presented in Appendix A.

*"Approved" does not necessarily mean adoption into the regulations of that country.



A. Approach at 75% rpm or 50 km/h, whichever is slower.

B. Accelerate in 2nd gear for vehicles having up to four speeds, 3rd gear for vehicles having five or more speeds.

C. Close throttle.

Critique:

(a) The test is simple, and subjective determination of proper gear selection has been eliminated.

(b) A technical advantage is that acceleration termination is based on vehicle position, not RPM, thus eliminating errors in closing RPM reading or tachometer lag.

(c) The test was designed to be related to "normal town driving conditions".

(d) Peak power will be developed on some vehicles, but not on others; therefore, maximum sound level will be measured on some motorcycles, not on others.

(e) The problem associated with sprocket options, as discussed in critque of the J-331a procedure, is viewed as critical, and is not addressed.

(f) Some off-road motorcycles are geared sufficiently low that they will not travel the required 20 meters in the stipulated gear without exceeding maximum rated RPM.

(g) To meet their special requirements, or to eliminate certain problems encountered with the ISO/R-362 procedure, various countries have adopted or proposed modifications to the basic procedure. These are discussed below.

ISO/R362 Variations (Moving vehicle acceleration tests)

"Modified Method", Appendix A2 to ISO/R362-1964:

In this variation, the gear is selected which most closely results in a vehicle speed of 50 km/h at 75% rpm, and approach is made at 75% rpm. Itis further stipulated that if the vehicle has more than three speeds, first gear shall not be used.

"ISO/R362 Proposed Amendment", 1974:

In this variation, approach is at 75% rpm or 50 km/h (whichever is slower), except that if the speed corresponding to 50% rpm is less than 50 km/h, then entry shall be at the speed corresponding to 50% rpm. 2nd Gear is to be used, unless 100% rpm is reached before the end of the acceleration zone, in which case 3rd gear is to be used.

JASO Modification of ISO/R362:

This variation of the ISO/R362 procedure has been incorporated into the regulations of Japan and Belgium. Modifications to the basic ISO/R362 are in gear selection and approach speed:

	JASO	ISO/R362
Gear Selection	2nd gear: 2, 3-speed gr. box	2nd gear: 2, 3, 4-speed gr. box
	3rd gear: 4-speed gr. box	3rd gear: over 4-speed gr. box
	4th gear: over 4-speed gr. box	
Approach Speed	25 km/h: under 50 cc 40 km/h: 50-249 cc 50 km/h: 250 cc & over (or 75% rpm)	50 km/h (or 75% rpm)

"Second Draft Proposal", Revision of ISO/R362, May, 1975:

Major revisions, referred to the ISO/R362 procedure are:

(a) Vehicles haveing gear boxes of five or more speeds are to be tested in both 2nd and 3rd gears, and the reported value is to be arithmetic average of the two.

(b) The procedure for testing vehicles with automatic transmissions is revised and expanded.

Critique:

(a) The numerous variations of ISO/R362, dealing mainly with approach speed and gear selection, reflect the difficulty with this type of test (where approach conditions, but not termination conditions, are controlled) in arriving at a procedure that adequately characterizes the noise of a broad range of motorcycles.

(b) A very comprehensive study[1/] of motorcycle noise and test procedures conducted in Japan compared noise emissions of a group of motorcycles as measured by three variations of the ISO/R362 procedure (JASO, ISO, and ISO Proposed Amendment). These variations, differing only in approach speed and gear selection, yielded measured sound level variations up to 12 dBA, showing the criticality of these parameters on measured levels. This also indicates that a change in sprocket ratio will result in a change in measured sound level. (The Japanese investigators determined that the JASO modification of the ISO/R362 procedure yielded the best correspondence with average noise due to average acceleration, as related to Japanese urban traffic situations.)

F76 (Moving vehicle acceleration test)

While all of the foregoing test procedures can be considered as candidates for use in the proposed EPA regulations, all of these procedures were found to have shortcomings for new vehicle type approval. Shortcomings fall in one or more of the following areas:

(a) Safety; hazard in testing (J47)

(b) Ambiguity; measured level dependent on gear selection involving a subjective determination (J331a)

(c) Sprocket variables; measured level dependent on sprocket ratio which is readily changeable; change in measured level disproportionate to change in vehicle noise (J331a, ISO/R362)

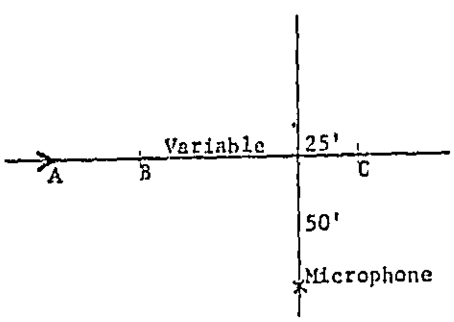
(d) Position variables; similar vehicles, differing only in gearing, having noise measured at different distances from the microphone, or at different rpm and power conditions (J331a, ISO/R362)

(e) Performance variables; atmospheric conditions, rider weight, or accessories affecting vehicle closing rpm and/or position (J331a, ISO/R362)

Representatives of the U.S. Suzuki Motor Corporation, and the California Highway Patrol, submitted preliminary drafts of test procedures designed to eliminate the above objections. These procedures, together with other candidate procedures, were evaluated and refined in the course of the study. The resulting procedure has been designated F76, and consists of the following:

Approach is made at 50% rpm. The throttle is smoothly and fully opened, commencing at a poin such that 75% rpm at full throttle is reached at a point 25 feet past the microphone target point, at which time the throttle is closed. Second gear is used, unless the accelerating distance is less than 25 feet, in which case progressively higher gears are used until the minimum 25 feet distance is attained. It is further specified that if use of second gear results in a road speed in excess of 100 km/h (62 mph), then first gear shall be used.

Full text of the procedure is contained in <u>Appendix A</u>.



A. Approach at 50% rpm.

B. Accelerate in 2nd gear from point B, selected such that 75% rpm is reached at point C. If BX is less than 25', use next higher gear. If speed at C is more than 62 mph, use 1st gear.

C. Close throttle.

Critque:

(a) Safety. The procedure does not require rapid opening of the throttle; mandatory requirement is that wide open throttle at 75% rpm be attained 25 feet past the microphone. No instances were encountered in the entire test program where use of first gear was required; in any case, use of first gear would not be hazardous under the prescribed operation of the throttle.

The procedure results in many off-road motorcycles being tested in third, and even fourth gear. Even in these higher gears, many off-road motorcycles will exhibit front wheel lift-off under rapid throttle opening. The procedure does not require this. Lift-off, however, is not hazardous with these vehicles when operated by an experienced rider; it is, in fact, a normal operational mode, used widely in the traverse of obstacles in rough terrain.

(b) Ambiguity. Tests conducted in the course of this study show that procedures which call for attainment of a specified condition of power and rpm at a specified location in relation to the microphone (such as J47, F76), are relatively insensitive to gear selection (Table 2-1).

(c) Sprocket variables. The relative insensitivity to gear selection in the F76 test shows that a change in sprocket ratio will have little effect on measured sound levels.

(d) Position variables. In the F76 test, the sound level, at the specified power and rpm conditions, is always measured at the same distance from the vehicle.

(e) Performance variables. As with the other test procedures the measured level in the F76 procedure will be affected by factors which affect sound power generated (such as relative air density); correction factors could be applied for this. In contrast with the J331a procedure, however, the F76 measured level is not affected by rpm/distance relationships associated with variations in power output.

(f) Methodology substitution. Since the F76 test is conducted under controlled conditions of power, rpm, and measurement distance, it can be deduced that the means used to load the engine is relatively unimportant. For example, the same result should be obtained on a grade, or on a suitable dynamometer, as long as the prescribed end-conditions are attained. (The Italian procedure, which is similar to the J47, permits

TABLE 3-1 EFFECT OF GEAR SELECTION ON MEASURED SOUND LEVELS

Bike No.	Category	Displ. (cc)	Δ dB(A) Using Next Higher Gear J331a	F76	J47
101	S	356		-0.2	
103	SX	123		-1.3	
109	X	248	-5.5		
119	S	398		-1.7	
126	S	184		-0.3	
123	SX	249			-0.6
127	S	738			-0.8
130	SX	98	-3.2		
131	S	371			-0.1
132	S	543			0.3
134	S	246		0.2	
135	SX	173	-1.6	-0.3	
146	X	246		-0.9	
*151	S	949	-1.7		
153	X	248		0.9	
155	SX	98	-0.9	0	
*160	S	736	-3.7		
161	SX	247	-1.1		
*166	SX	72	-2.6	1.0	
173	SX	397	-1.7		
181	SX	183	-3.3		
191	SX		-1.3		
197	SX	242	-4.0		

*Automatic Hi-Range vs. Low-Range

these substitutions in lieu of the prescribed acceleration test). In contrast, procedures such as the J-331a or the ISO/R-362 offer no possibility of such substitutions as equivalents.

(g) Tachometers. Tachometer lag time can have an important effect on the sound levels measured by F-976. Slow-responding tachometers will result in engine speeds higher than those specified in the procedure as occuring 25 feet past the microphone point. These higher engine speeds will result in erroneously high sound levels being measured.

While it is possible to derive a statistical transfer function between F-76 and J-331a (as has been done in the next section) it is not possible to predict, for a particular motorcycle, the F-76 level based on the J-331a level using this transfer function. The reasons for this are fundamental. For the smaller motorcycles, the J-331a level is dependent of where in the end-zone the vehicle reaches 100% RPM. If it reaches 100% RPM near the start of the end-zone, the F-76 level (75% RPM) will be lower; if it reaches it near the end of the end-zone, the two levels will be about equal (differences in power being cancelled by differences in distance). This in turn depends on gearing, and on which gear is used. In the case of the larger machines, the degree of equivalence is dependent on the value of the J-331a closing RPM. If the closing RPM is at a near 100%, the two levels will be near equal; if the closing RPM is well below 100%, the F-76 level will be higher. By making use of these factors, together with vehicle performance data, it would be possible to estimate F-76 levels for a particular motorcycle, based on the J-331a level.

For the aforementioned reasons, no close correlation should be expected between the F-76 levels and J-331a levels. It was considered of interest, nevertheless, to examine the degree of correlation, which is presented in Figures 3-1 and 3-2. The surprising correlation in the case of the off-road motorcycles is no doubt attributable to the fact that most of these are small displacement, low-geared machines, and therefore reach the acceleration end point near the microphone in both test procedures.

Note: In the initial drafts of this procedure, a 50 ft. minimum acceleration distance was stipulated and employed. Difficulties occurred in two areas--several of the smaller bikes could not attain the 50 ft. distance before reaching 75% RPM even in the highest gear; others (350 cc class off-road bikes) would not pull properly from 50% RPM in the gear required to attain the 50 ft. distance. For these reasons the 50 ft. minimum acceleration distance was changed (starting with bike No. 135) to 25 feet. The 25 ft. minimum distance stipulation presented no problems in the testing of any of the motorcycles employed in the total program.

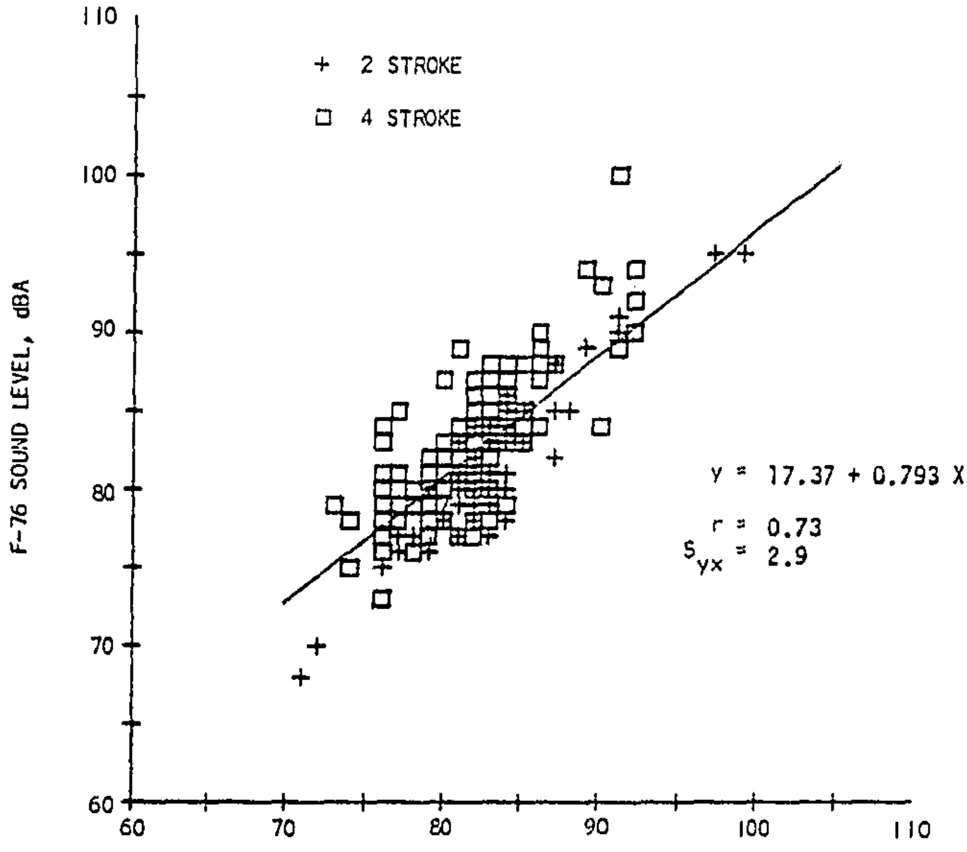


FIGURE 3-1 CORRELATION BETWEEN F-76 AND J331a TESTS, STREET AND COMBINATION STREET/OFF-ROAD '75-'76 YR. OF MFG. MOTORCYCLES

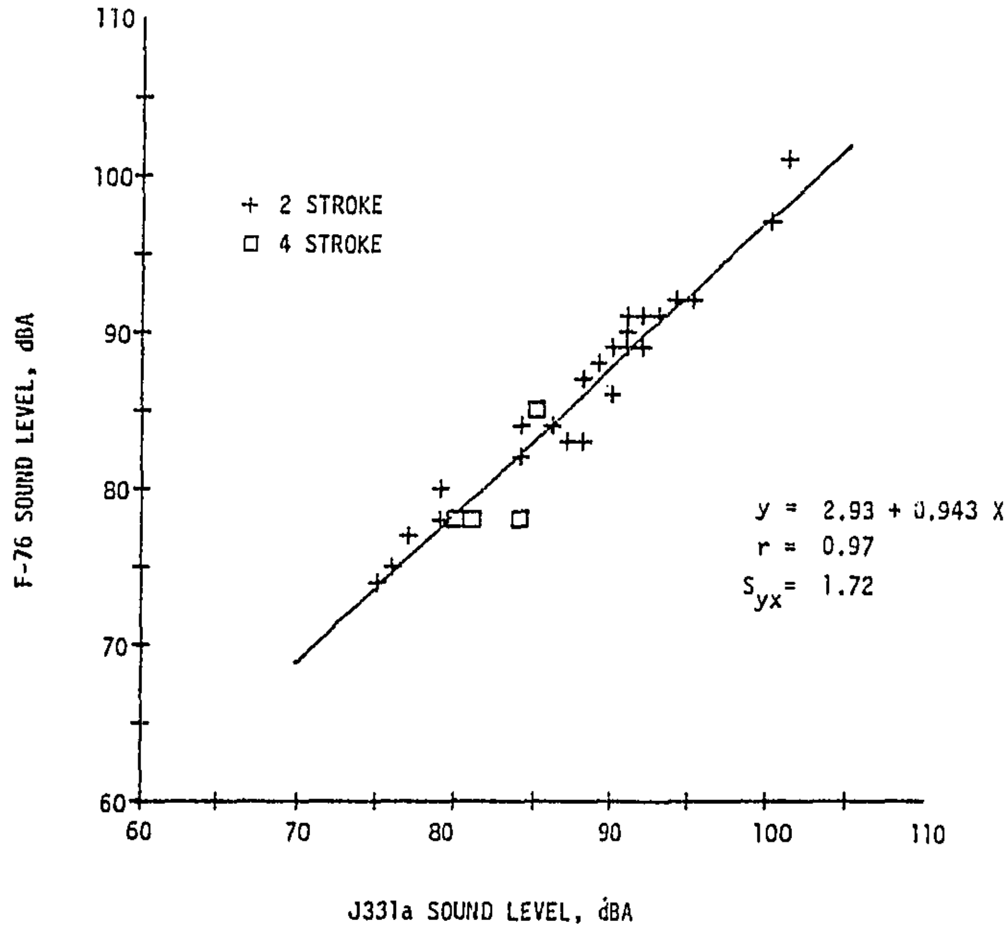


FIGURE 3-2 CORRELATION BETWEEN F-76 AND J331a TESTS, OFF-ROAD (ONLY) '75-'76 YR. OF MFG. MOTORCYCLES

F76a (Moving vehicle acceleration test)

In examining the noise emission data base (Section 4), in terms of J331a levels (Figure 4-1)*, and in terms of F76 levels (Figure 4-3)*, it is seen that the J331a method yields a regression line nearly flat (sound level independent of displacement), whereas the F76 method shows a definite upward slope of the regression line with displacement.

The reason for this is, of course, that in the J331a test the larger motorcycles pass through the measurement zone without reaching rated power rpm, whereas in the F76 test all vehicles are measured at 75% rpm. The ISO/R362 test is similar to the J331a tests is intentional, and recognizes the fact that both in constant speed and in accelerating modes the smaller machines will usually be operated closer to their maximum potential than will the larger machines. This is not only because of available horsepower, but also, in the small machines characteristically the torque curve is steep, favoring operation at high rpm, whereas in the large street machines the torque curve is relatively flat, resulting in acceptable performance at lower rpm's.

To take this factor into account, a variation of the F76 method, designated F76a, was investigated. The F76a procedure differs from the F76, in that instead of testing all vehicles at 75% rpm, the test rpm is a function of displacement. The rpm/displacement relationship developed in the study was:

y - 90	(0 -100 cc)	where y - % rpm
95 - .05x	(100-700 cc)	x - displacement, cc
60	(700+ cc)	

This relationship, shown graphically in Figure 2-3, yields a test rpm of 90% at 100 cc, reducing to 60% at 700 cc. Above 700 cc the closing rpm remains constant at 60%. Entering rpm is 50% or 20 percentage points below closing rpm, whichever is lower.

Basis of the F76a rpm/displacement relationship is the data collected in the course of the test program where a number of motorcycles were tested at more than one closing rpm. These data appear in Appendix C, and in Tables C-11 and C-12 and are summarized in Table 3-1 and Figure 3-4 in this Section.

*Figures pertaining to the noise emission data base are presented in Section 4.

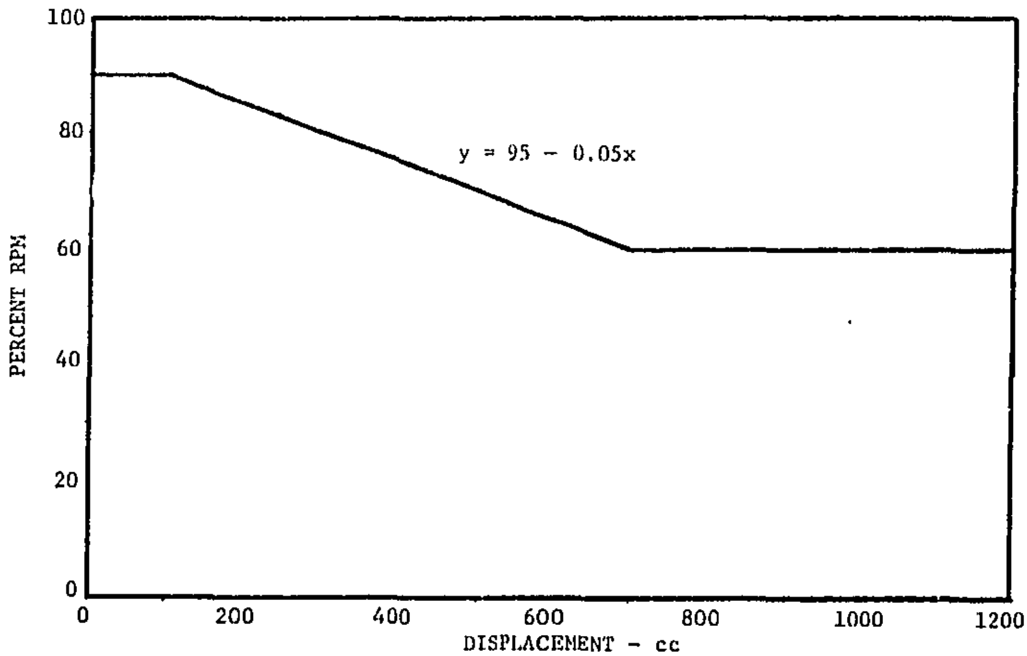


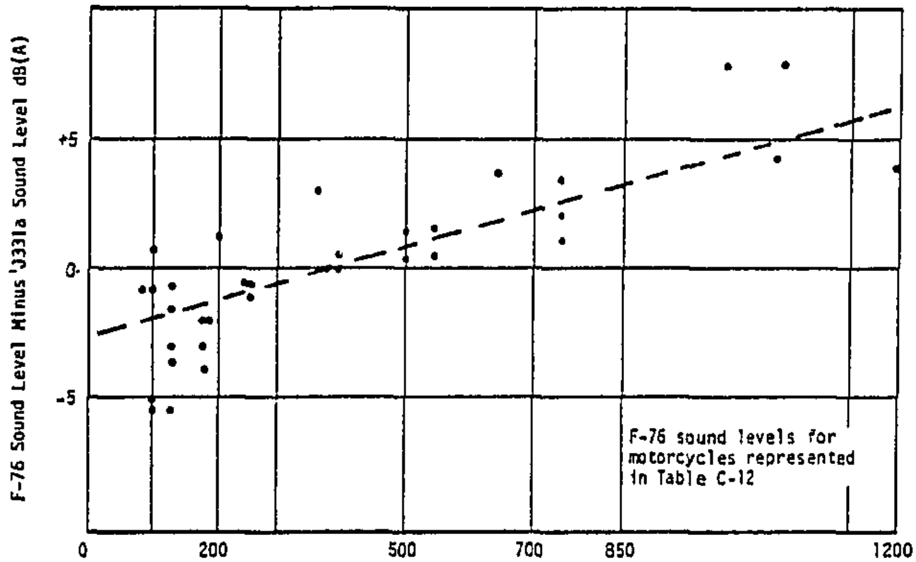
FIGURE 3-3. CLOSING RPM FOR F76a MOVING VEHICLE ACCELERATION TEST

TABLE 3-2. COMPARISON OF F-76a AND J-331a SOUND LEVELS

Displacement Range cc	Mean Sound Level, dB(A) F-76a	J-331a	Std. Deviation F-76a	J-331a	Number of Vehicles in Sample
100 - 125	80.8	80.9	2.57	2.62	10
175 - 250	80.8	80.9	1.73	2.34	8
350 - 400	82.5	81.1	1.77	3.55	6
550 - 750	82.3	81.9	1.38	0.71	6
900 - 1200	82.6*	80.6	1.91	3.58	4

The vehicles in this sample are unmodified '75 - '76 yr. of mfg. street and combination street/off-road motorcycles. The F-76a levels have been derived by interpolation or extrapolation of sound levels measured at RPM's other than the F-76a RPM. The J-331a levels are directly measured data.

*This small sample of 4 included two vehicles whose F-76 level was considerably higher than the average of other vehicles in this category.



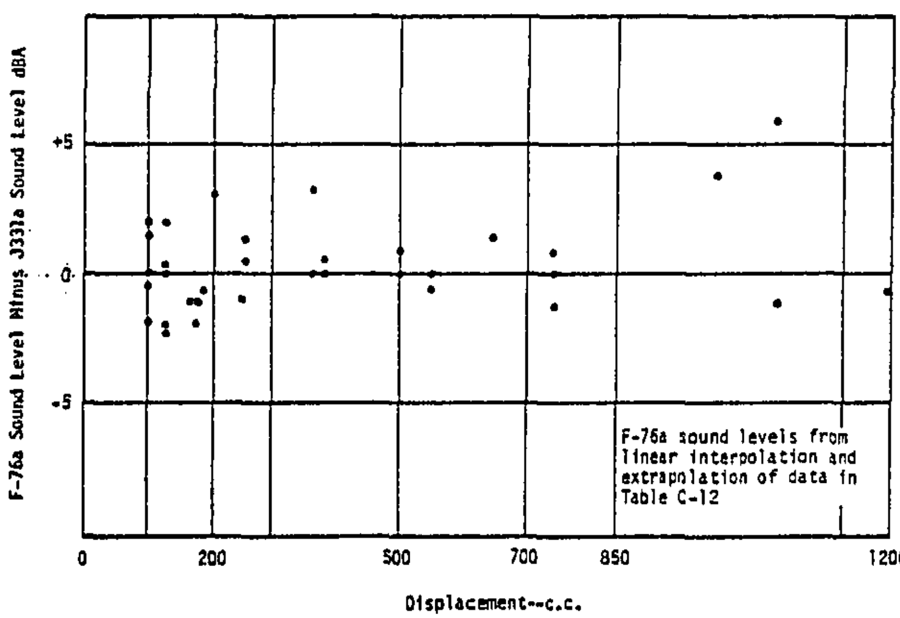


FIGURE 3-4. COMPARISON OF F76 AND F-76a SOUND LEVELS

Figure 4-5* shows the difference between F-76 and J-331a levels plotted against displacement, with the upward sloping regression line showing that statistically the F-76 level is higher than the J-331a level for large motorcycles, lower for small motorcycles. Referring again to Table 3-2, it is seen that while a larger statistical sample of F-76a test data desirable, the data indicate that if F-76a data were substituted for F-76 data, the regression line would not only be independent of displacement, but would also be numerically approximately equal to the J-331a levels on a statistical basis.

A curve of sound level vs. closing RPM for one motorcycle is shown in Figure 3-5.

A secondary advantage of the F-76a procedure over F-76 is that lower testing speeds result on the large motorcycles. In the F-76 test, speeds of up to 55 mph were encountered in this study. This would reduce to about 45 mph in the F-76a test. Manufacturer test data show tire noise of 66 dB(A) at 45 mph on a 750cc motorcycle, indicating that tire noise would not be a significant contributor to total vehicle noise in the F-76a test.

Text of the F-76a procedure is presented in Appendix A.

R-60 (Moving vehicle acceleration test)

With the same rationale basic to the F-76a test, a staff member of AMF Harley-Davidson submitted (prior to development of the F-76a test) a candidate moving vehicle acceleration test procedure designated R-60. The R-60 test is similar to the F-76a except that the closing RPM employed is the RPM corresponding to 60 mph in top gear (instead of 75% RPM for all vehicles). Entering RPM is 75% of the closing RPM.

A full text of the procedure is presented in Appendix A.

Critique:

(a) The procedure does not provide for the testing of vehicles which do not reach 60 mph; this difficulty could be eliminated by adding the stipulation that vehicles which reach 100% RPM before 60 mph shall be tested at 100% RPM.

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*Figures pertaining to the noise emission data base are presented in Section 4.

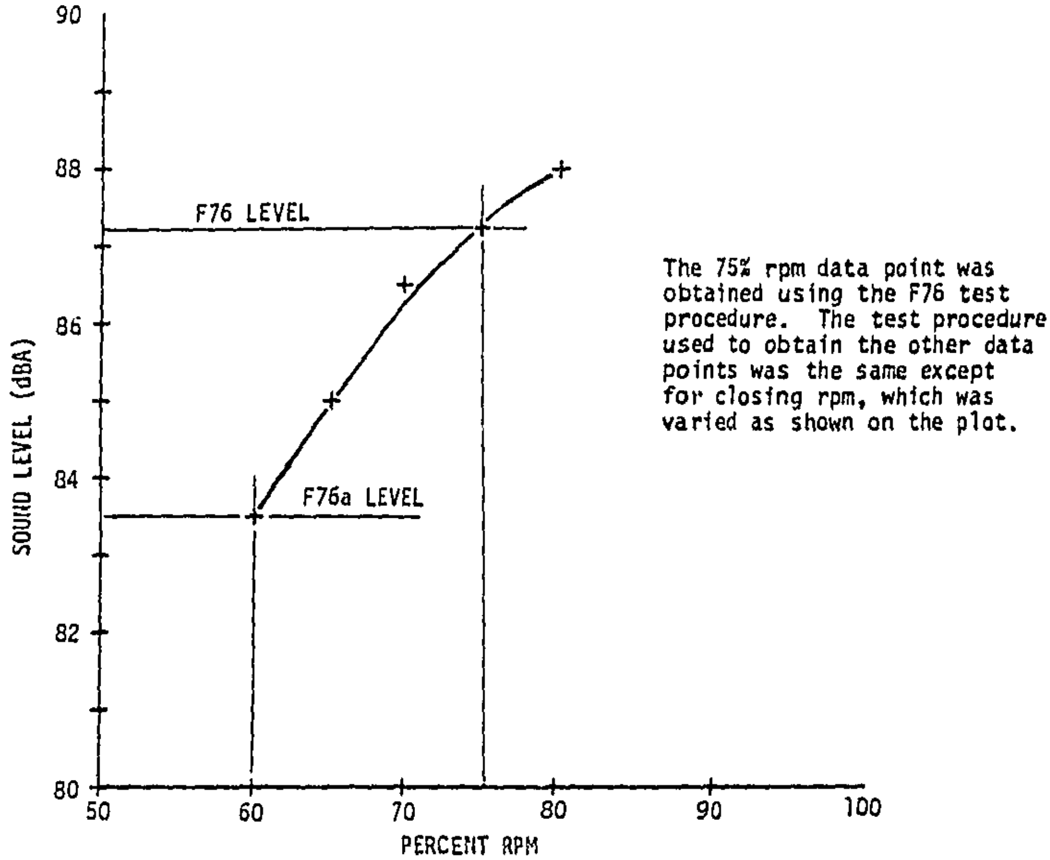


FIGURE 3-5 EXAMPLE OF SOUND LEVEL AS A FUNCTION OF PERCENT RPM (HARLEY XLH-1000)

(b) Similar vehicles, differing only in gearing, could be tested at substantially different RPM's yielding substantially different measured levels.

(c) Changing sprockets would result in testing at different RPM's, with resultant different measured levels.

(d) Some street motorcycles are capable of very high speeds. A motorcycle with a top speed of 135 mph would be tested at 44% RPM, a rather low test RPM.

(e) The F-76a procedure provides an alternative means of dealing with the different operational situations of the small and large machines, and avoids the difficulties appearing in the R-60 method.

F-77 (Full speed, full throttle, moving vehicle test)

In lieu of the ISO/R-362 acceleration test, Norway prescribes a full speed, full throttle pass-by test for mopeds. In the course of the study, this procedure was examined for motorcycles up to 100 cc; above that some vehicles reach excessive speeds.

This is a considerably simpler test to run than any of the other moving vehicle procedures, requires no tachometer or speedometer, and is representative of common operational conditions for the under-100 cc vehicles. It yields levels usually close to the J-331a levels, and can be expected to yield levels close to the F-76a test.

Full text of the procedure is presented in Appendix A.

Problem Areas: Moving Vehicle Test Procedures

(1) Automatic Transmissions

Automatic transmissions are coming into use increasingly in both street and off-road motorcycles, large and small. In the course of the study the following motorcycles with automatic transmissions were tested:

Street

Moto Guzzi V1000 Converter
Honda CB750A
Honda NC-50

Off-Road

Rokon 340 RT
Husqvarna 360 Automatic

Combination Street/Off-Road

Yamaha Chappy (minibike)

Mopeds

NTV Model ERB
Kreidler MP3
Vespa Ciao
Motobecane Mobylette
Velosolex 4600
Peugeot 103LVS.U3

Difficulty in varying degrees was encountered in testing the motorcycles with automatic transmissions. The Moto Guzzi V1000 and the Honda CB750a incorporate a high and low-range selection; low range produces significantly higher levels in the J-331a test. high-range use in the F-76 test results in excessive speed. For the F-77 test, however, high-range should be specified; otherwise the engine can over-rev.

The Rokon 340RT and the Husqvarna 360 Automatic present testing problems which were not resolved in the course of this study. The Rokon 340RT incorporates a variable ratio belt drive, the driving member acted upon by centrifugal forces, the driven member affected by reacting torque.

The drive ratio is determined by both engine rpm and torque demands. There are no selectable options for the rider, other than throttle position. The J-331a test procedure, as written, does not provide for the testing of vehicles with automatic transmissions. However, if the gear stipulation is ignored, what appears to be a meaningful J-331a test can be run. To run an F-76 test, however, an entirely different technique is required: the throttle must be opened very gradually in order not to immediately exceed 75% RPM; with some practice, vehicle speed can be smoothly increased such that 75% RPM at full throttle is attained at the required end point, with good consistency among the six passes. As discussed in Section 3.2, vehicles which reach 100% RPM near the end of the end-zone in the J-331a test exhibit near equal J-331a and F-76 levels. The Rokon 340RT fits this pattern, reinforcing the appropriateness of the above testing techniques.

The Husqvarna 360 Automatic incorporates four centrifugal clutches, with Sprague roller clutches which permit the lower geared centrifugal clutches to freewheel when the higher geared clutches engage. The J-331a test cannot be run, because 100% RPM is reached well before the start of the end-zone, and no rational criteria exists for regulating the throttle other than wide open. Within the time constraints of the study, no technique was developed which would achieve full throttle at 75% RPM at the prescribed point in relation to the microphone. Further analysis and testing will be required to develop a meaningful and repeatable test technique for this type of vehicle.

Based on the testing of two under-100 cc motorcycles, and six mopeds, no problems appear in testing the under-100 cc vehicles with automatic transmissions under the F-77 procedure.

(2) Tachometers

A major problem encountered throughout the test program was in obtaining engine RPM readings on motorcycles not equipped with tachometers. Portable tachometers used in the program included the Sanwa Model MT-03, the Rite Autotronics model 4036, and the Dynall Mode TAC 20. In most cases, one of these three tachometers could be made to function properly on the test vehicle, but none of these tachometers would work on all motorcycles. In some cases the testing of a motorcycle was abandoned because of inability to obtain proper functioning of the tachometer.

A vehicle manufacturer should have no difficulty in arriving at a suitable tachometer or other means of determining RPM for his particular line of vehicles; the problem exists primarily for the EPA and for after-market manufacturers, where universal application over many makes and models would be necessary. Fortunately, however, the steady-state accuracy of the tachometer (either the vehicle tachometer or a portable tachometer) can be readily verified simply by matching the engine firing frequency (as picked up by a wire placed in proximity to a spark plug lead) with a signal from a calibrated oscillator, the two signals being matched on an oscilloscope.

A second factor to be considered in the use of tachometers for moving vehicle acceleration tests is tachometer lag, and the ability of the rider to close the throttle at the correct RPM. This effect was evaluated in a previous study[2/], where results obtained using the vehicle tachometer were compared with results obtained using an electronic tachometer incorporating a "max. hold" mode (Emission Control Instruments, Precision Tachometer). In that study, when the rider performed J-47 tests on ten motorcycles using the vehicle tach for reference, the true RPM recorded by the electronic tach ranged from 1132 RPM high, to 356 RPM low, as compared to the intended RPM. When the J-47 tests were repeated with the closing RPM at the proper value established by the electronic tach, measured levels ranged from zero to 2 dB(A) lower.

Test methodologies such as the J-331a and the F-76 (as opposed to the ISO/R-362 type) are subject to both the problems of tachometer functional compatibility and lag, unless other methods are established to measure engine speed. The dynamometer method is free of these problems, since the tachometer can be incorporated into the dynamometer, and measuring conditions are steady-state.

3.3 Candidate Stationary Vehicle Test Procedures

F-50 (Stationary vehicle test)

The F-50 procedure is patterned after the ISO proposed draft, "Method of Control of Noise Emitted by Stationary Motor Vehicles," July 1974. The test consists of running the engine up to 50% RPM, unloaded, and measuring noise at a distance of 0.5 m from the exhaust outlet, on a line displaced 45° from the exhaust axis. The complete text of the procedure and also the ISO draft are presented in Appendix A.

Critique:

The F-50 levels, presented in Section 4, are relatively independent of displacement (Figure 4-7 and 4-8) and have been correlated with J-331a and F-76 levels in Figure 3-6 thru 3-9. The correlation is not sufficiently good as to permit the moving vehicle acceleration noise for a particular vehicle to be predicted from the stationary level. Major reasons for this are that the engine is not under load, and thus exhaust noise is not representative of the acceleration conditions, and because the throttle is only partially open, intake noise is not fully developed.

The test is nevertheless of potential value. Figures 3-10 and 3-11 show that in general an exhaust system change which produces higher moving vehicle sound levels also results in higher levels in the stationary test. The correspondence in this respect is sufficiently good that the method could be used for on-the-road enforcement against exhaust system tampering. The figures show that the method would be quite effective against flagrant violators, providing the OEM (original equipment manufacturer) value was known and labeled on the machine.

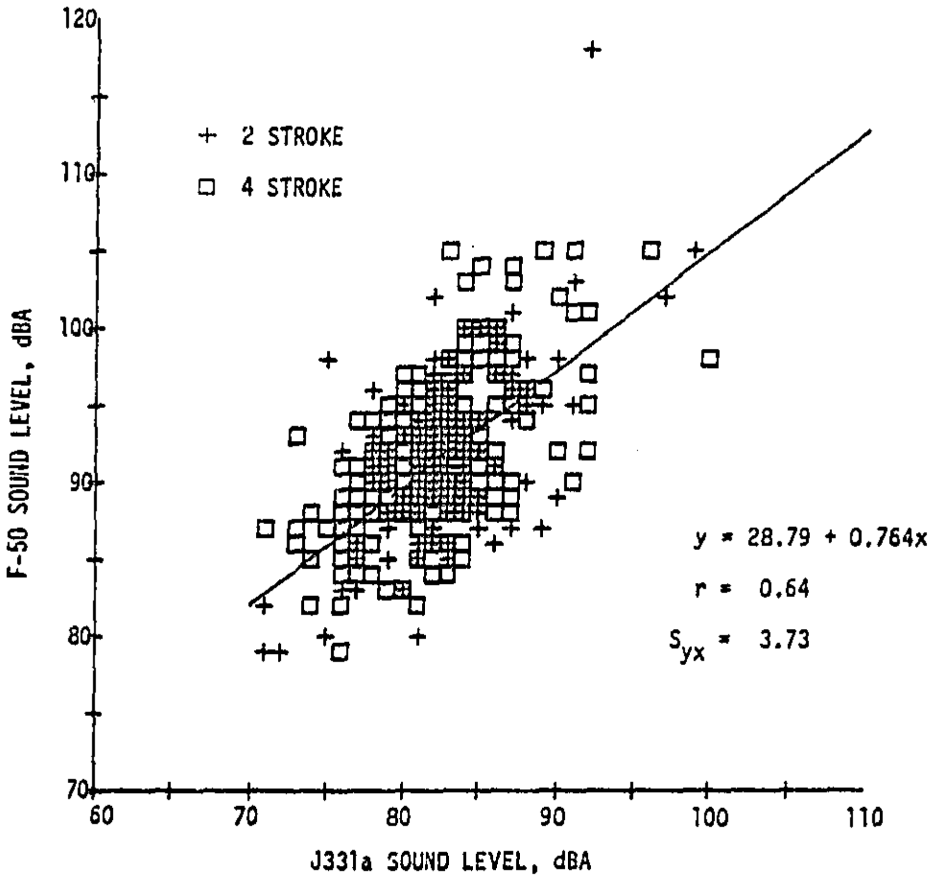


FIGURE 3-6 . CORRELATION BETWEEN F-50 AND J331a TESTS, 1969 - 1976 MODEL STREET AND COMBINATION STREET/OFF-ROAD MOTORCYCLES

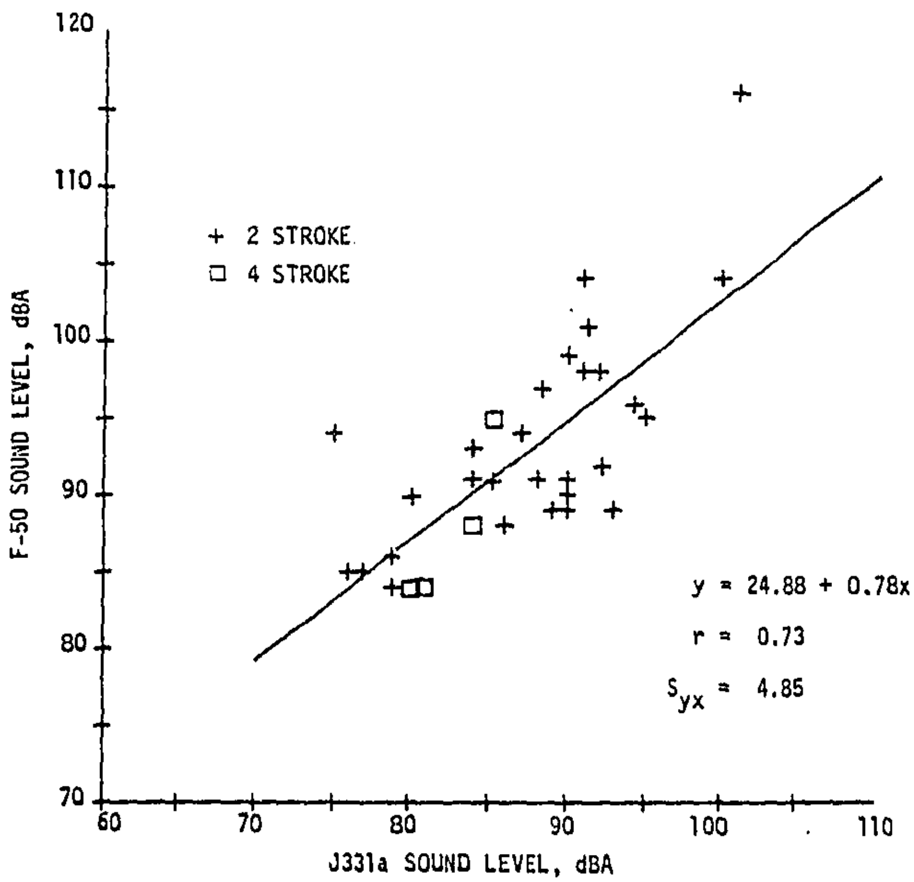


FIGURE 3-7 CORRELATION BETWEEN F-50 AND J331A TESTS, 1969 - 1976 MODEL OFF-ROAD (ONLY) MOTORCYCLES

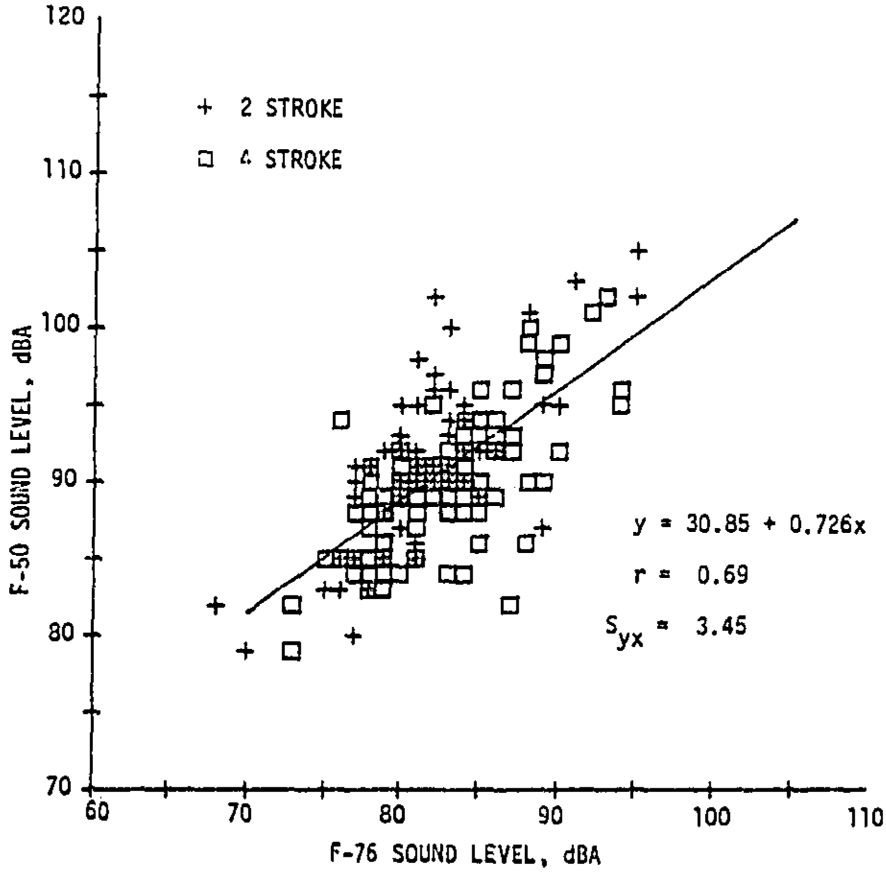


FIGURE 3-8 CORRELATION BETWEEN F-50 AND F-76 TESTS, 1969 - 1976 MODEL STREET AND COMBINATION STREET/OFF-ROAD MOTORCYCLES

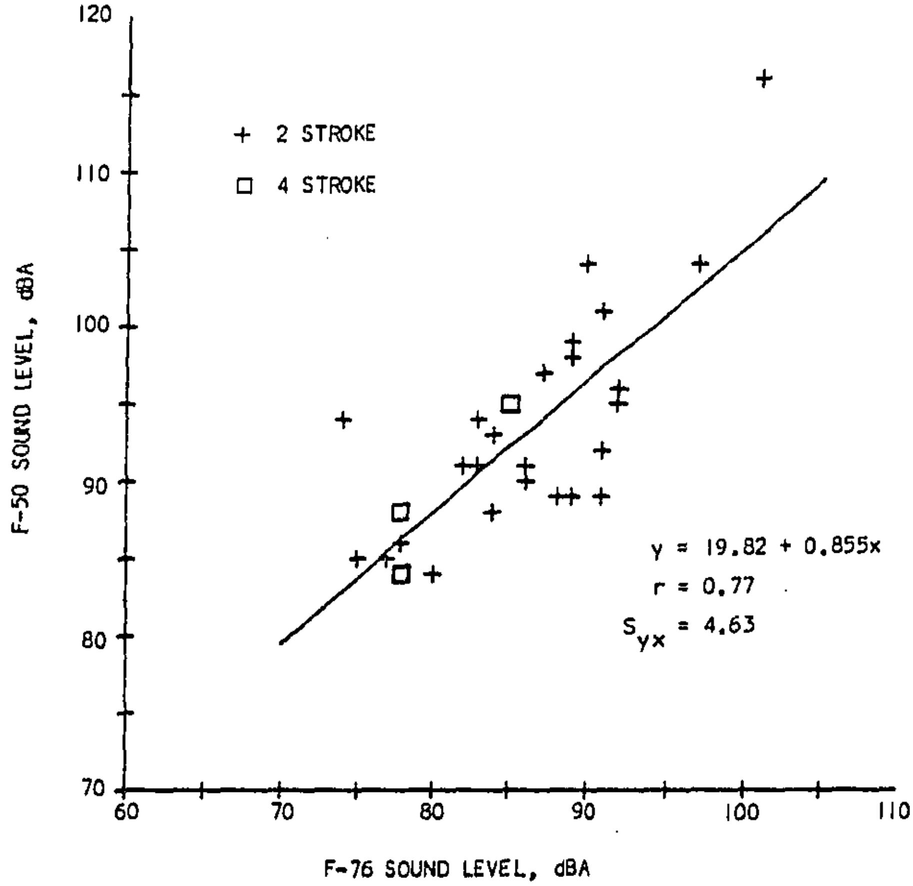


FIGURE 3-9 CORRELATION BETWEEN F-50 AND F-76 TESTS, 1967 - 1976 MODEL OFF-ROAD (ONLY) MOTORCYCLES

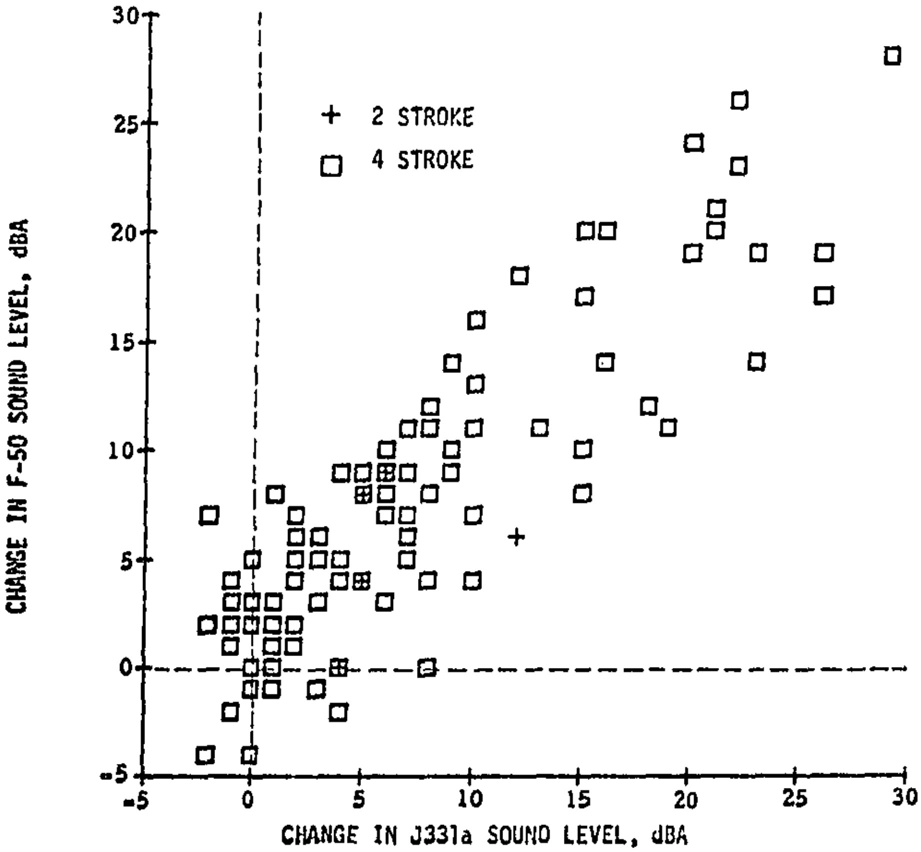


FIGURE 3-10 CORRELEATION BETWEEN CHANGE IN F-50 SOUND LEVEL COMPARED TO CHANGE IN J331a SOUND LEVEL, AFTERMARKET AND MODIFIED CONFIGURATIONS REFERRED TO ORIGINAL MANUFACTURE

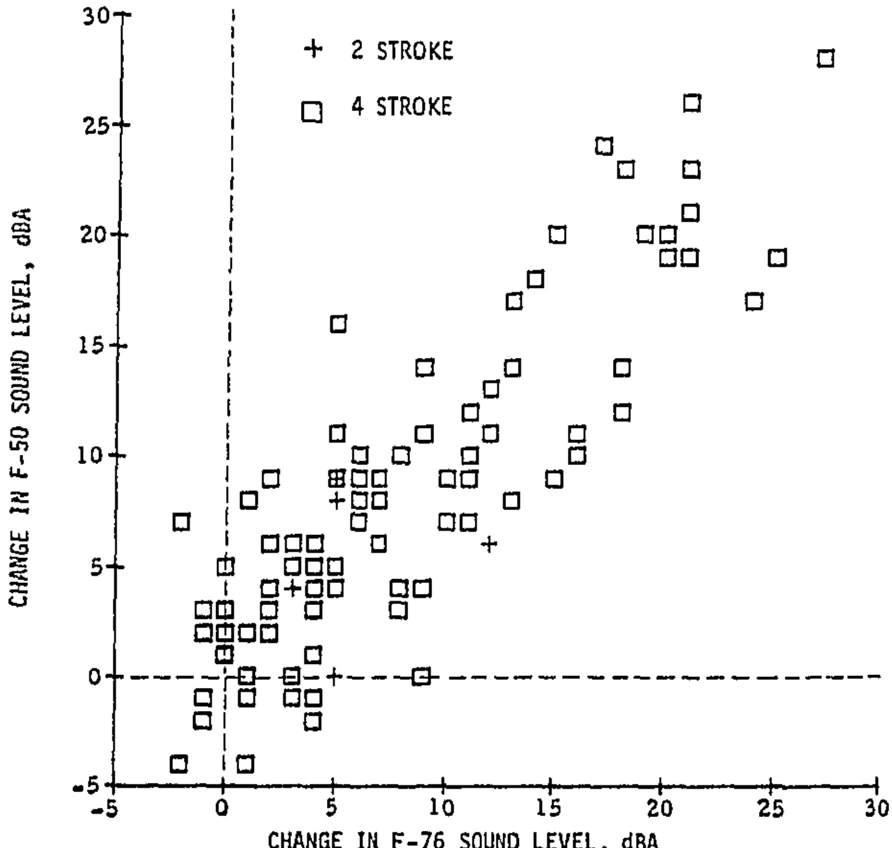


FIGURE 3-11 CORRELATION BETWEEN CHANGE IN F-50 SOUND LEVEL COMPARED TO CHANGE IN F-76 SOUND LEVEL, AFTERMARKET AND MODIFIED CONFIGURATIONS REFERRED TO ORIGINAL MANUFACTURE

A further alternative to the F-50 test, for use by the exhaust system manufacturer, could be the dyno-simulation of the moving vehicle test, as discussed later in this section.

Motorcycle Industry Council (MIC) Proposed Field Test Procedure for Sound Levels of Competition Motorcycles, Rev. 1-30-76

This procedure, the full text of which appears in Appendix A, is similar to the F-50 procedure, differing mainly in features which make it more convenient for application in competitive events. Test RPM is 50% red-line, alternatively 60% maximum rated RPM, or alternatively calculated from a formula as a function of stroke dimension.

Critique:

(a) The features of this procedure (which enhance its usefulness in the intended application) introduce a lack of precision not desirable in EPA applications.

(b) The procedure provides for the testing of motorcycles not having a "neutral" transmission position; this is accomplished by raising the rear wheel or removing the chain.

F-76 Dyno-Simulation (simulated moving vehicle acceleration test)

A cursory investigation of the feasibility of simulating moving vehicle acceleration tests on a dynamometer was conducted, using one motorcycle (Honda CB 750) and a Pabatco Dyno (made by Weda Instruments). This dynamometer is one of the lowest priced portable units commercially available, not specifically designed for noise testing, and not incorporating any quieting provisions (Figure 3-12). The motorcycle was successively fitted with seventeen different exhaust systems, which resulted in F-76 levels ranging from 82 to 98 dBA. For the dyno-simulated F-76 test, the dynamometer was set up at the test site at the F76 test track end point, with the microphone positioned as it would be for the actual F-76 test moving vehicle test. Sound level as measured at 75% RPM at full throttle was established, a procedure taking about 15 seconds. Figure 3-13 presents the correlation of results from this test and the actual F-76 moving vehicle test. Readings were taken only on the left side of the motorcycle, even though some of the exhaust systems were on the right side only; this because the dynamometer configuration precluded taking readings on the right side.

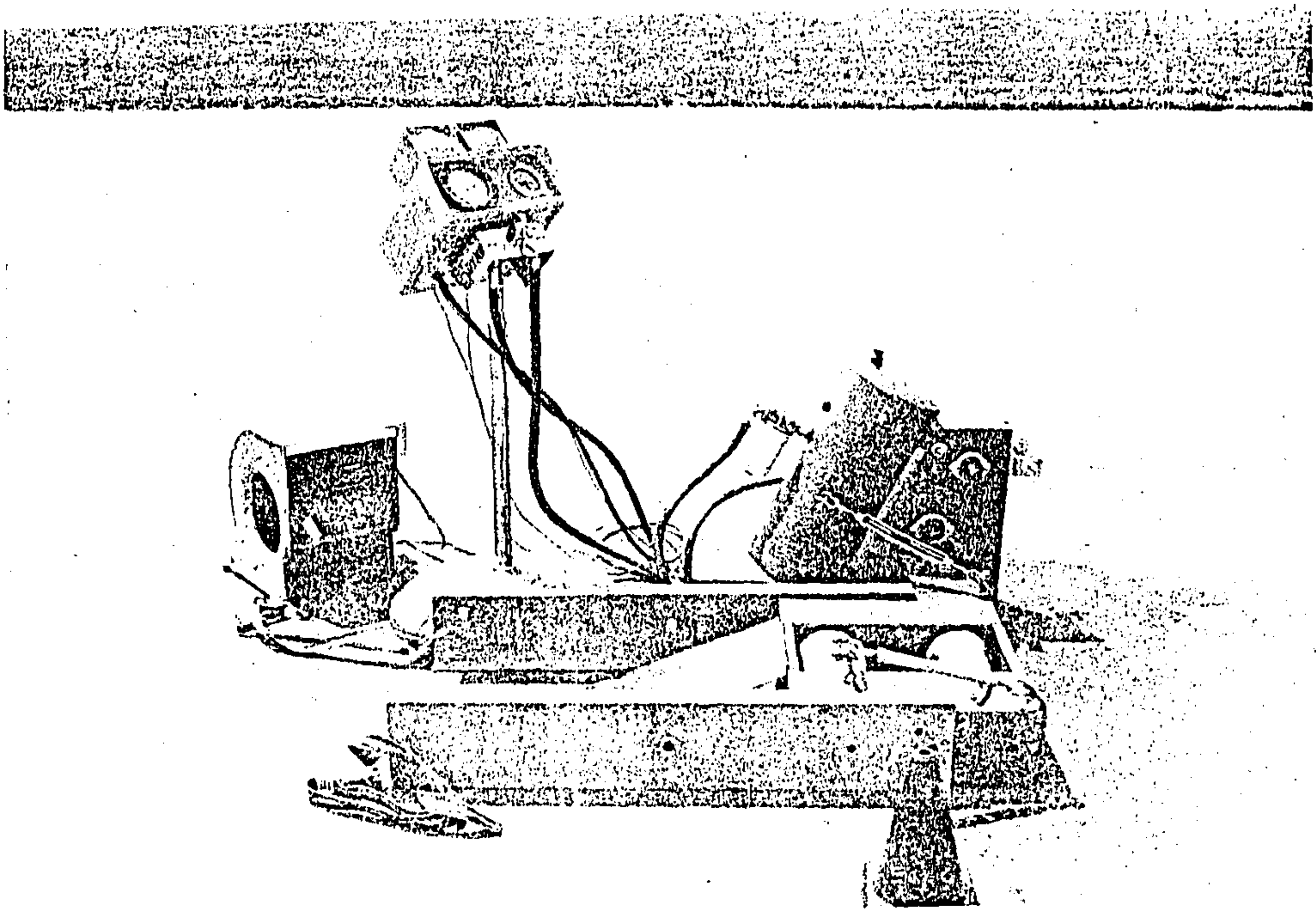


FIGURE 3-12 PABATCO DYNAMOMETER

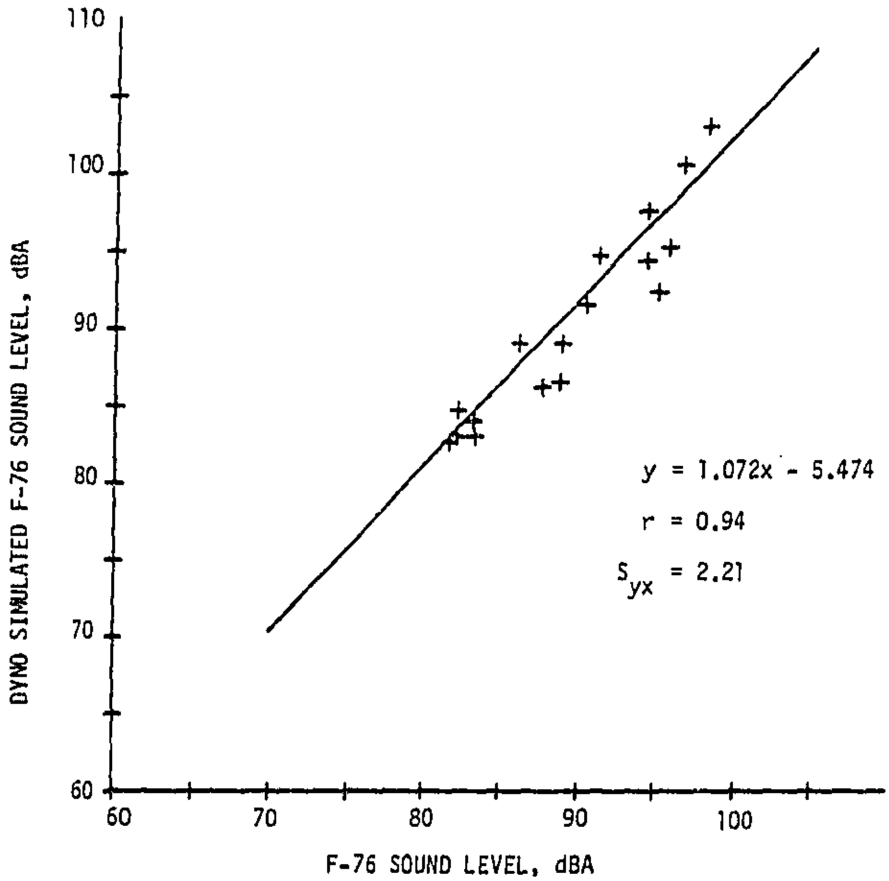


FIGURE 3-13 CORRELATION BETWEEN DYNO-SIMULATED F-76 TEST, AND ACTUAL F-76 MOVING VEHICLE TEST

Potential advantages of the dynamometer test method include:

- lower testing cost
- removal of schedule constraints due to weather
- greatly reduced area requirements
- no transportation of vehicles to and from test site
- greater accuracy by testing at a steady state condition rather than at a changing condition
- no problems with tachometer functioning, accuracy, or lag
- removal of testing variables such as throttle closure, distance determination
- removal of wind, weather, micro-meteorological variables
- minimization of site variables

As discussed in Section 3.2, dyno-simulation of the J-331a or ISO/R-362 test procedures is not feasible.

3.4 Measurement Distance Substitution

All of the noise emission data presented in this report were measured at a 50-foot distance (except the F-50 data, which were measured at 0.5 m), as delineated in the respective procedures. An investigation was made, however, to determine feasibility of taking measurements at 25 feet, and correcting the measured values to a 50-foot equivalent. Results of this investigation are shown in Table 3-3 and Figures 3-14 and 3-15; it is evident that no such conversion is possible in the case of an acceleration test (as opposed to a constant speed test).

The reason for the lack of correspondence between the 50-foot and 25-foot measurements was not investigated; it may be that the vehicle noise exhibits a changing polar pattern as the vehicle accelerates, such that a lobe changes in magnitude as it passes from one microphone to the other, or it may relate to a changing interference relationship (discussed in section 4.2) resulting from spectral changes as the vehicle moves past the microphones with changing RPM.

TABLE 3-3 RELATIONSHIP BETWEEN 25 FT. AND 50 FT. SOUND LEVEL MEASUREMENTS

BIKE NO.	DISPL. CC	ENGINE TYPE	DIFFERENCE BETWEEN 25 FT AND 50 FT SOUND LEVEL READINGS, dBA				
			J331a	F76	F77	P_{60}	55 MPH
101	356	4 S	5.6	6.2			
102	72	4 S	3.1	4.3			
103	123	2 S	5.0				
104	999	4 S	5.8	5.4			
105	736	4 S	7.6				
109	248	4 S	5.0				
110	124	4 S	1.6	1.9			
111	171	2 S		4.1			
112	99	4 S	2.1				
113	248	4 S	2.8				
114	99	2 S	3.5	4.1			
115	99	2 S	4.6	4.8			
117	99	2 S	3.1	3.8			
118	174	2 S		5.0			
119	400	2 S	4.0	6.0			
120	746	4 S	3.5				
140	828	4 S	4.5	5.4			
141	49	2 S			5.0		
142	744	4 S	6.3	7.2			
143	246	2 S	6.5	6.9			
145	981	4 S	5.1	5.3			
146	246	2 S	3.6	5.9			
146	246	2 S		5.3			
151	949	4 S	7.3	7.3			6.6
151	949	4 S	6.7				
152	336	2 S	5.5				4.7
155	98	2 S	4.6	4.1			
155	98	2 S	4.3				
156	72	2 S	3.5	4.6	5.3		
157	49	2 S			6.5		
158	898	4 S	5.8	8.1			6.6
159	750	4 S	5.4	6.1			7.0
160	736	4 S	4.4				
160	736	4 S	5.2				
160	736	4 S	6.9				
161	247	2 S	4.8	4.7			
161	247	2 S	5.9				
162	124	2 S	6.8	5.8			6.0
163	903	4 S	7.1	6.6		6.6	5.2

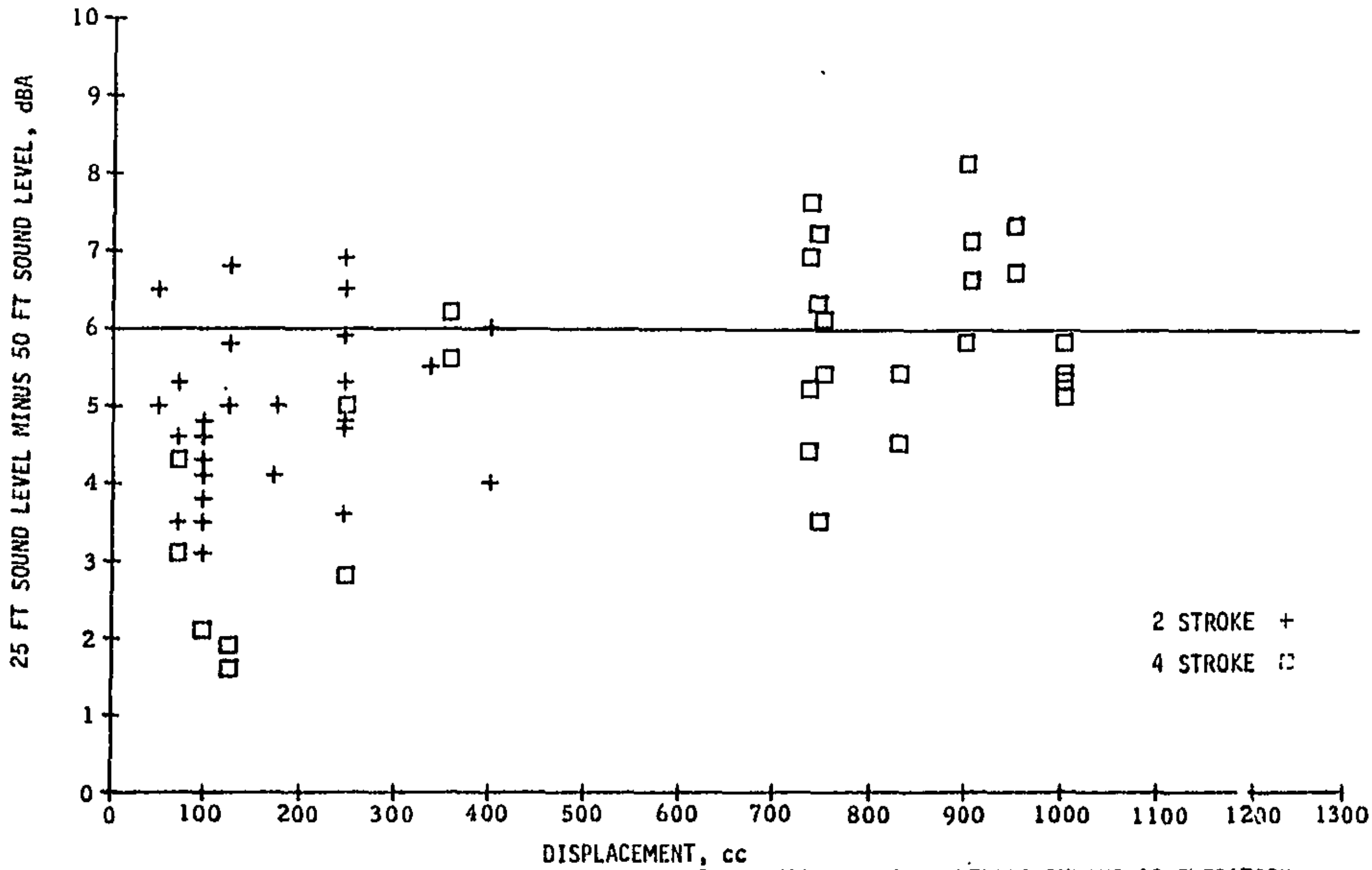


FIGURE 3-13 DIFFERENCE BETWEEN 50 FT AND 25 FT MEASURED SOUND LEVELS DURING ACCELERATION (J331a AND F-76) TESTS

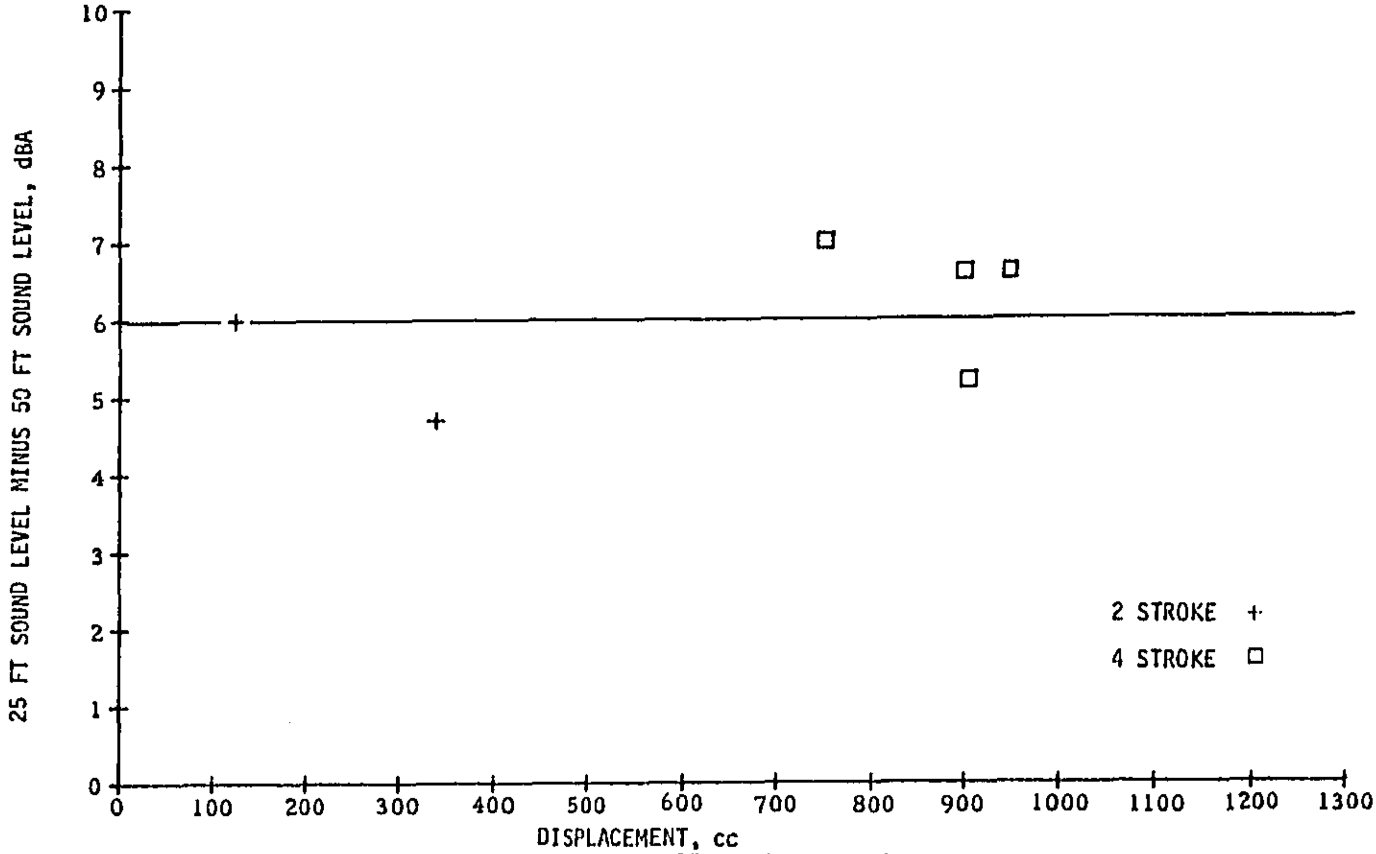


FIGURE 3-14 DIFFERENCE BETWEEN 50 FT AND 25 FT MEASURED SOUND LEVELS DURING CONSTANT SPEED (35 MPH AND 55 MPH) TESTS

SECTION 4

SOUND LEVEL DATA BASE

Section 4

SOUND LEVEL DATA BASE

4.1 Content and Format of the Data Base

The basic motorcycle sound level data base used for this regulation is presented in Appendix C. Sound data for the following are included:

(a) 159 new 1976 model year motorcycles (year of manufacture 1975 and 1976);

(b) 60 year of manufacture 1974 motorcycles in stock configuration;

(c) 257 in-service motorcycles in stock configuration, year of manufacture 1969-1973 (includes the data developed in the MIC motorcycle testing program);

(d) 43 in-service modified motorcycles, year of manufacture 1969-1976;

(e) 107 motorcycles with new aftermarket exhaust systems.

Motorcycles in group "a" above provide the best sound level baseline for assessing cost and economic impact of adoption of standards more stringent than 83 dBA (for street motorcycles) which is the standard currently in effect in some states (e.g., California). Street motorcycles manufactured prior to 1975 have been subject to less stringent standards and are therefore not representative of current technology applications and cost.

Off-road motorcycles in groups "a", "b", and "c" can be included in the baseline data for off-road category, since regulation of noise emissions from those vehicles has been very limited.

Motorcycles in group "a" through "d" provide a baseline for assessing environmental improvement that can result from regulation of the new vehicle, the aftermarket product, and user modifications.

Motorcycle aftermarket data, group "e", show the degree to which currently offered-for-sale aftermarket exhaust systems affect new vehicle noise emissions.

The total sample of vehicles, groups "a" through "e" above, were employed in the development and/or evaluation of test methodologies (Section 3) in the course of acquiring the data base.

The following makes and models are represented:

Benelli 750 SEI
BMW R90/6
BMW R90S
BMW R60/6
Bultaco 250 Alpina
Bultaco Frontera
Bultaco 350 Sperpa T
Bultaco Matador MK9
Bultaco 250 Pursang
Can Am 125 TNT
Can Am 250 TNT
Can Am 250 MX1
Carabela 125 Marquesa MX
Carabela 250 Centauro
Ducati DM750S
Garelli Moped
Harley FXE-1200
Harley FLH-1200
Harley SS125
Harley SS175
Harley SS250
Harley SX125
Harley SX175
Harley SX250
Harley XLH1000
Hodaka Road Toad
Hodaka 250
Honda CB 400F
Honda CB 500T
Honda CB 750A
Honda CB125S
Honda CB125S
Honda CB200T
Honda CB350F
Honda CB360T
Honda CB450
Honda CB550
Honda CB550F
Honda CB500T
Honda CB750
Honda CB750F
Honda CJ360T
Honda CL360
Honda CL450
Honda CR125M
Honda CT70
Honda GL1000
Honda MR50
Honda MR175
Honda MR125
Honda TL250
Honda XL70
Honda XL70K2
Honda XL100
Honda XL125
Honda XL175
Honda XL250
Honda XL350
Honda XR-75
Honda Z50A
Honda All Terrain
Honda CT90
Honda NC50
Husqvarna 360 Automatic
Husqvarna 360WRX
Indian MT175
Kawasaki 900Z1
Kawasaki KD80
Kawasaki KE125
Kawasaki KE175
Kawasaki KH 100
Kawasaki KH 250
Kawasaki KH 400
Kawasaki KM 100A
Kawasaki KT250
Kawasaki KV75
Kawasaki KV100
Kawasaki KZ400
Kawasaki KZ400D
Kawasaki KZ400S
Kawasaki KZ750
Kawasaki KZ900
Kawasaki KZ900LTD
Kreidler MP3
Laverda 750SF
Laverda 1000Three
Montesa 250 Enduro
Montesa Cota 123
Montesa Cota 247
Montesa Cota 348
Motobecane Mobylette Moped
Moto Guzzi 1000 Convert
Moto Morini 3 1/2
Moto Guzzi 850-T
Norton 860 Commando
NVT ERB Moped
Ossa Desert Phantom 250
Ossa 250 Pioneer
Ossa 350 Plonker
Peugeot 103 LVS V3
Rokon RT-340 11
Suzuki GT185
Suzuki GT380
Suzuki GT500T
Suzuki GT550
Suzuki GT750
Suzuki RE-5 Rotary
Suzuki RM125
Suzuki RV90
Suzuki TM75
Suzuki TS100
Suzuki TS185
Suzuki TS400A
Suzuki TS400S
Velosolex 4600 Moped
Vespa Ciao Moped
Yamaha Chappy
Yamaha DT100C
Yamaha DT175
Yamaha DT175C
Yamaha DT250
Yamaha DT250C
Yamaha DT400C
Yamaha DT650C
Yamaha MX125
Yamaha RD125B
Yamaha RD200B
Yamaha RD200C
Yamaha RD250
Yamaha RD350
Yamaha RD400C
Yamaha RS100B
Yamaha TX750
Yamaha TY80
Yamaha XS360C
Yamaha XS650B
Yamaha XS650C
Yamaha XT500C
Yamaha XT500
Yamaha YZ125C

The vehicle population tested encompasses street, off-road, and combination use motorcycles; 50 to 1200 cc displacement; 2-stroke, 4-stroke and rotary engines; 1, 2, 3, 4, and 6 cylinders; manual gear shift, automatic clutch, hydraulic torque converter, and centrifugal torque converter transmissions; a few mopeds are also included.

Test methodologies employed in acquiring the data base include the J-331a, F-76, and R-60 acceleration tests; the F-77 full-speed/full-throttle test for under-100 cc bikes; the F-50 stationary vehicle test; and a dyno-simulation of the F-76 test. These test procedures are described in Section 3 and detailed in Appendix A. Sound levels at 35 mph and 55 mph, constant speed pass-by, have also been obtained on a representative group of vehicles.

The sound level data base of new '75-'76 year of manufacture motorcycles is presented primarily in terms of J-331a, F-76, and F-50 noise measurements. The data base is presented graphically in Figures 4-1 thru 4-10, and in tabular detail in Appendix C. Format of the graphical presentations is as follows:

(a) J-331a levels vs displacement -- Figures 4-1 and 4-2

(b) F-76 levels vs displacement -- Figures 4-3 and 4-4

(c) Transfer function F-76:J-331a, by displacement category and overall -- Figures 4-5 and 4-6

(d) F-50 levels vs displacement -- Figures 4-7 and 4-8

(e) 35 mph steady speed levels vs displacement -- Figure 4-9

(f) 55 mph steady speed levels vs displacement -- Figure 4-10

Tabular detail of noise emissions presented in Appendix C includes not only that for new '75-'76 year of manufacture motorcycles, but also similar data for '69-'74 in-service motorcycles, motorcycles with modified exhaust systems, and data on aftermarket products. The tabular presentations include:

(a) Sound levels (J-331a, F-76, R-60, F-77, F-50, 35 mph, 55 mph) by displacement and use categories; new motorcycles, year of manufacture '75 and '76: Table C-4.

(b) Same data as Table C-4; by manufacturer: Table C-5.

(c) Sound levels (J-331a, F-76, F-77, F-50, 35 mph, 55 mph) by displacement and use categories; in-service motorcycles, year of manufacture '69-'74, in stock configuration: Table C-6.

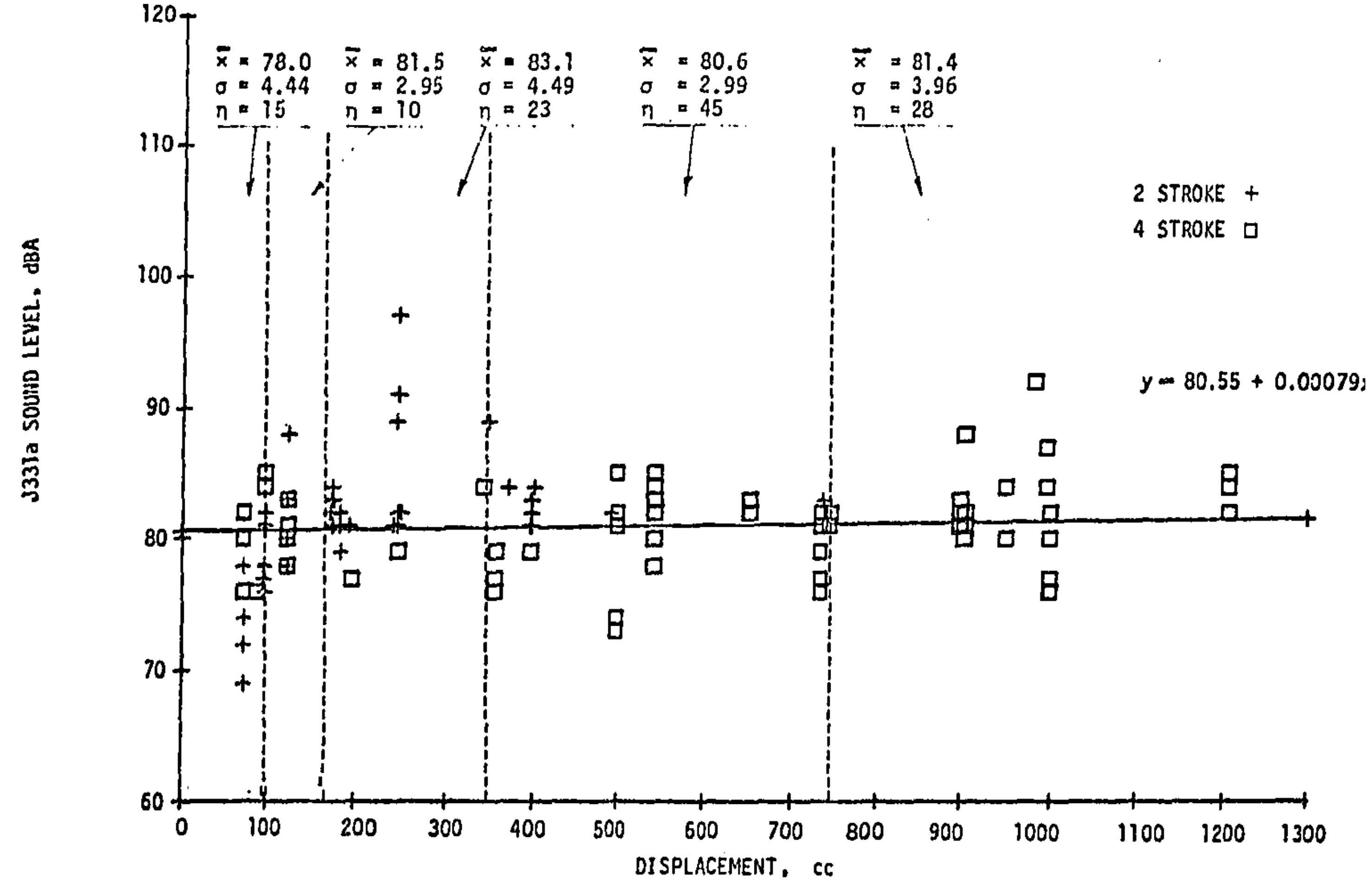


FIGURE 4-1 J331a SOUND LEVELS, STREET AND COMBINATION STREET / OFF-ROAD '75 - '76 YR. OF MFG. MOTORCYCLES

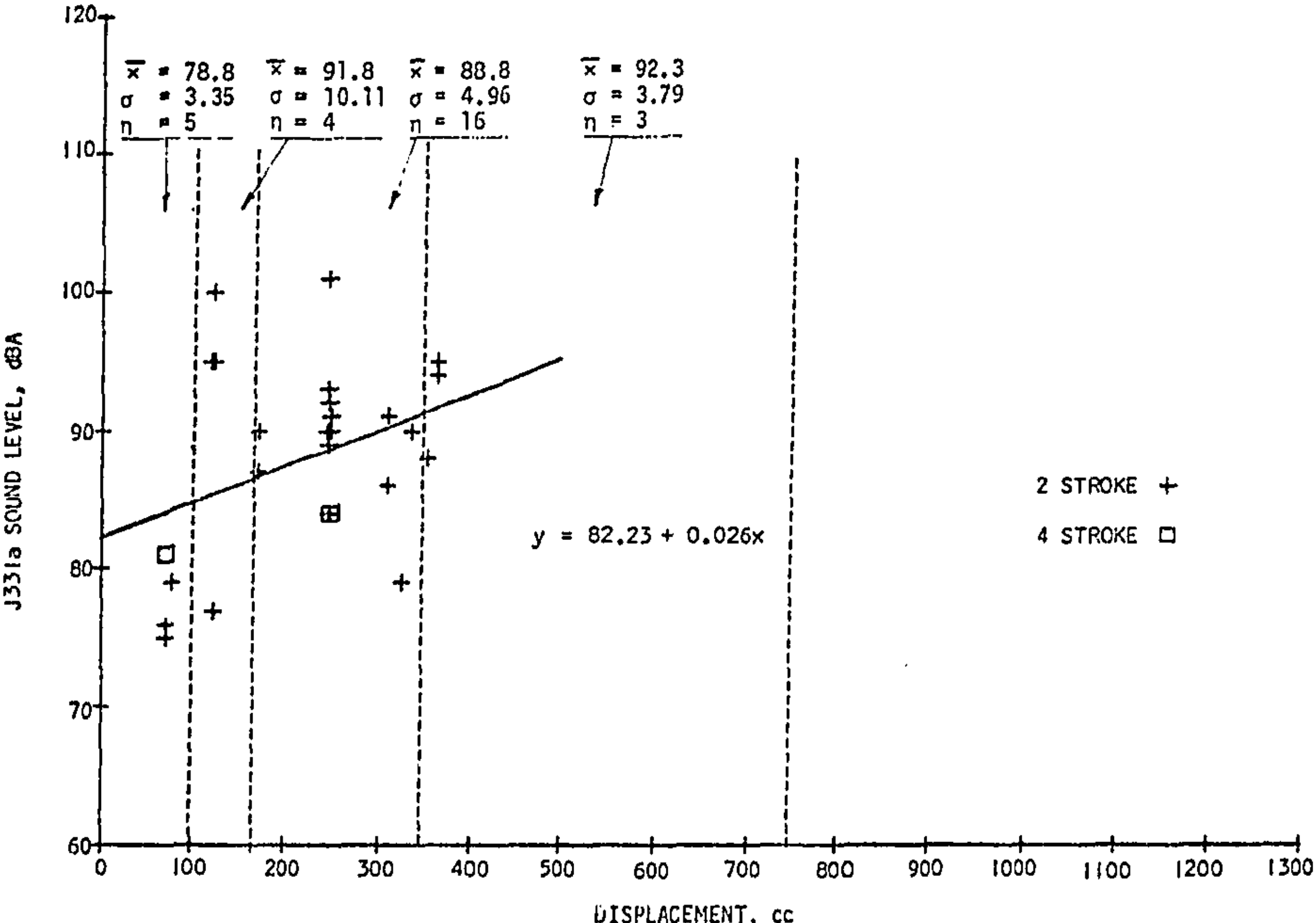


FIGURE 4-2 J331a SOUND LEVELS, OFF-ROAD (ONLY) '75-'76 YR. OF MFG. MOTORCYCLES

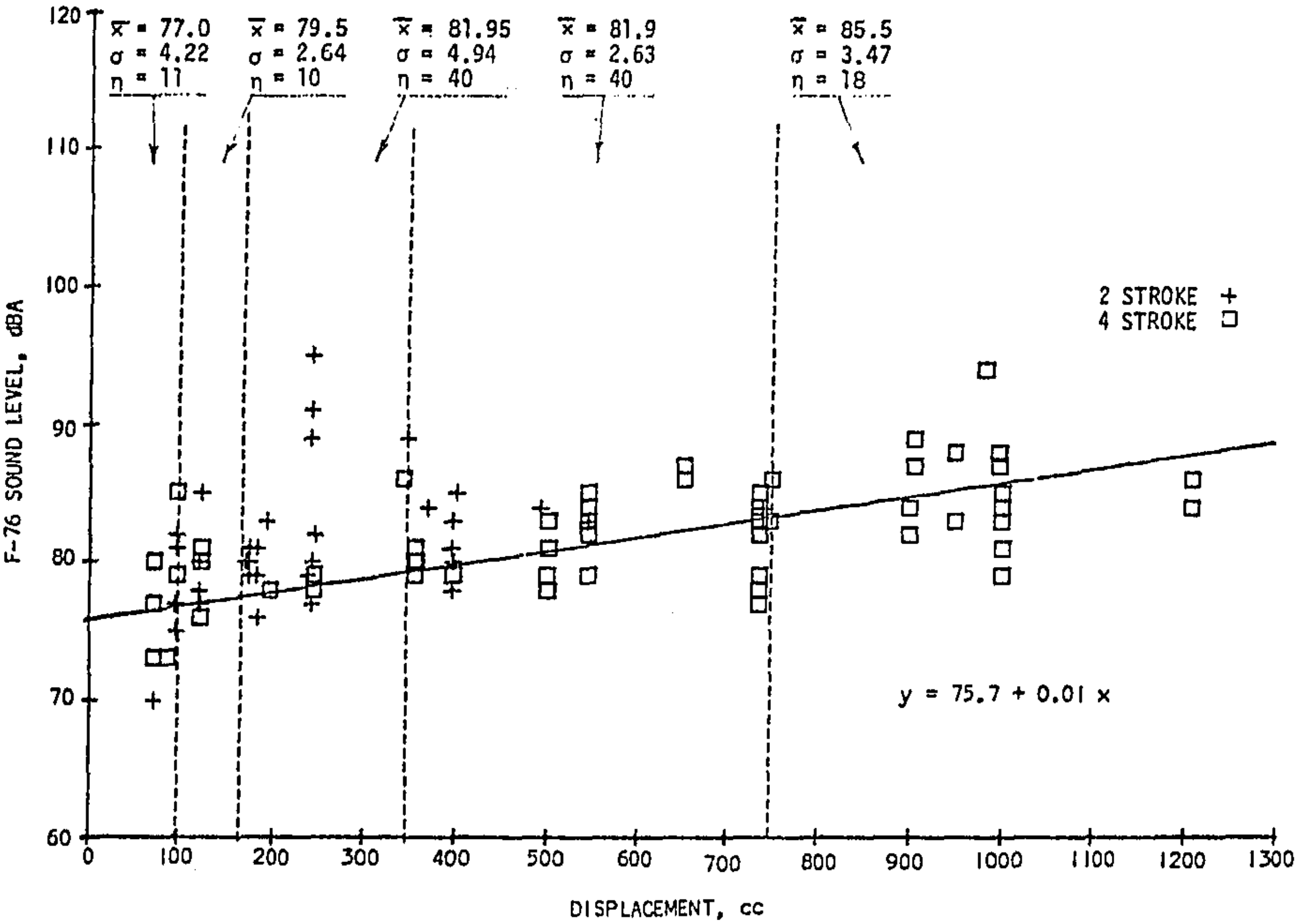


FIGURE 4-3 F-76 SOUND LEVELS, STREET AND COMBINATION STREET/OFF-ROAD '75 - '76 YR OF MFG MOTORCYCLES

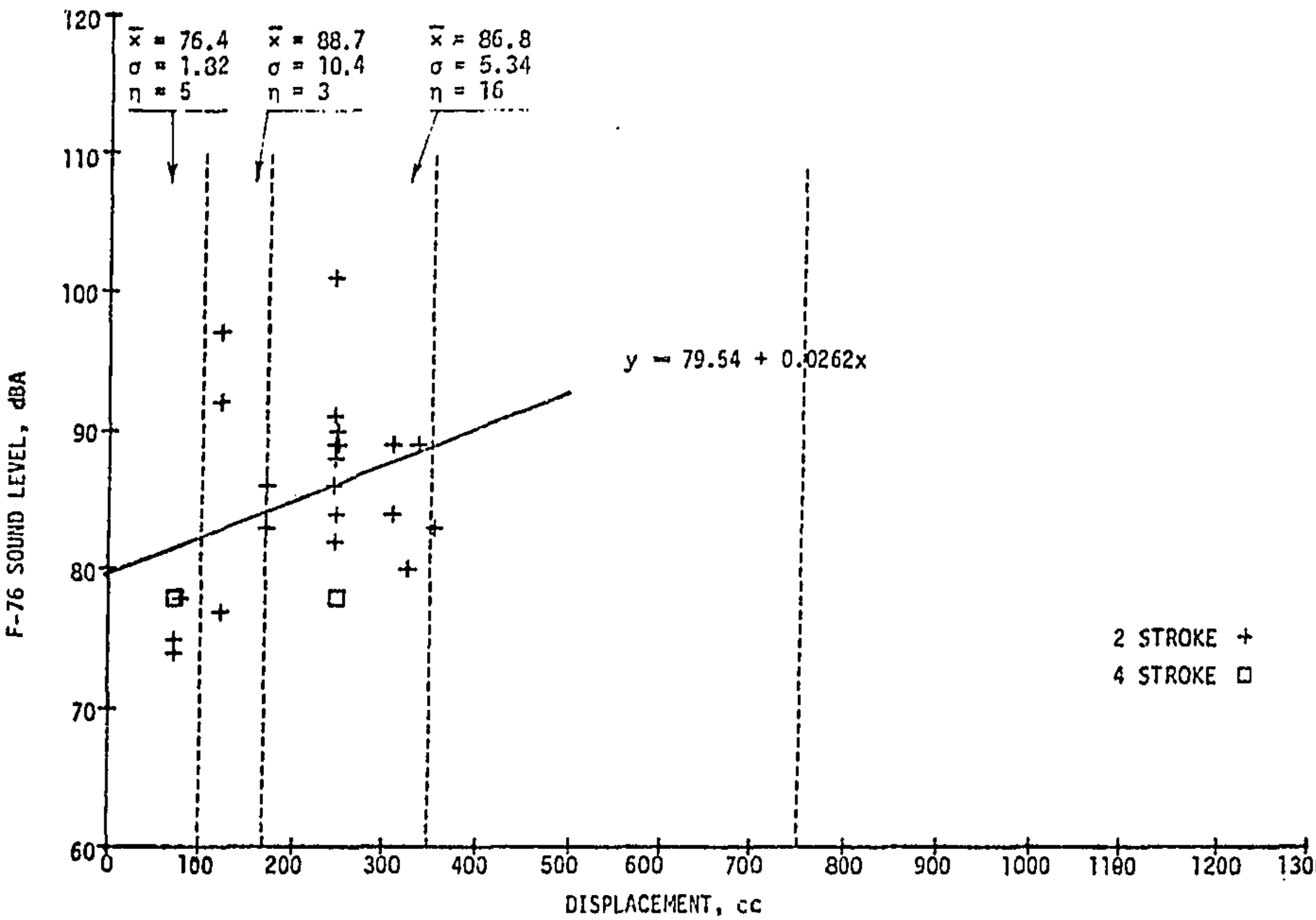


FIGURE 4-4 F-76 SOUND LEVELS, OFF-ROAD (ONLY) '75 - '76 YR. OF MFG. MOTORCYCLES

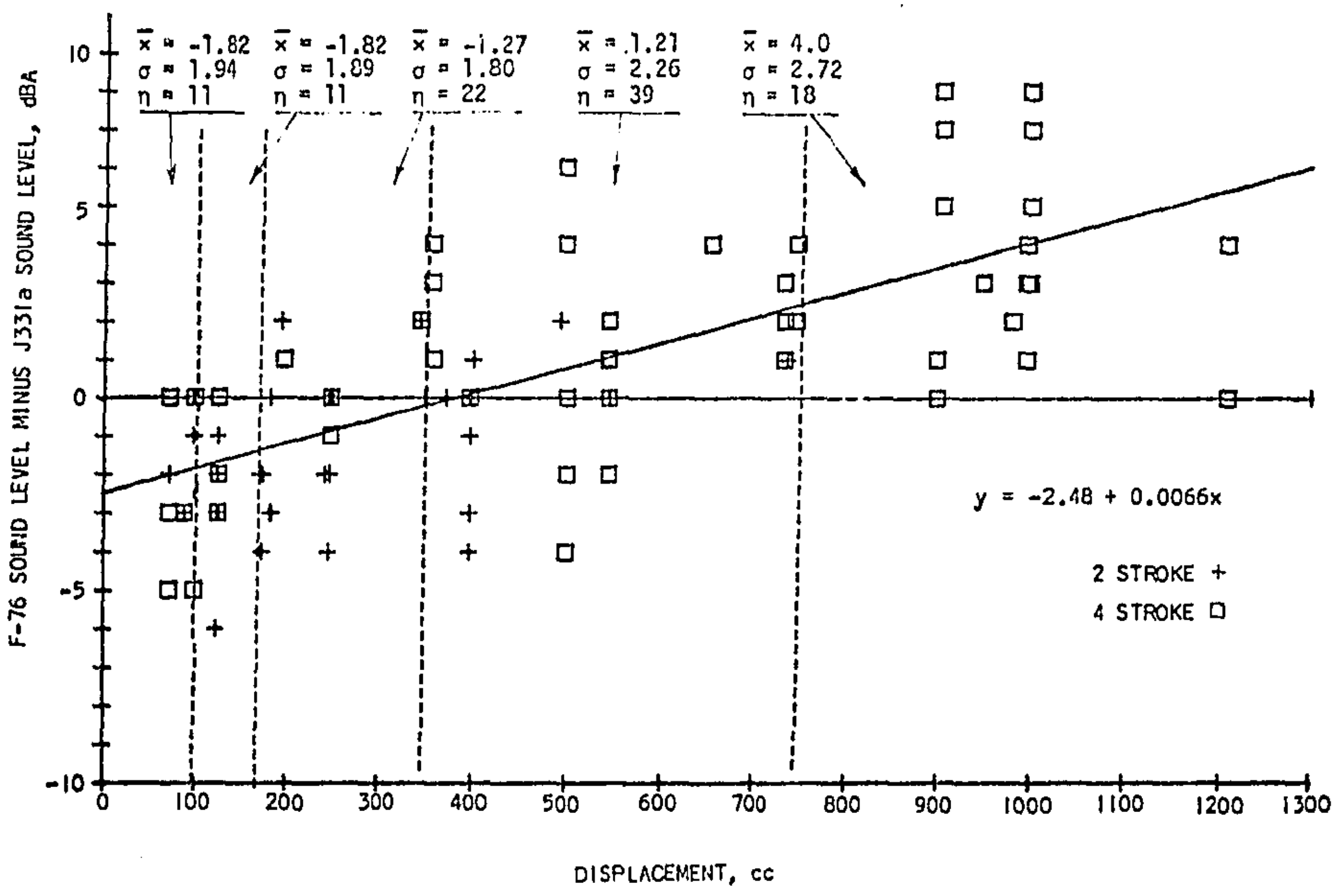


FIGURE 4-5 COMPARISON OF F-76 AND J331a SOUND LEVELS, STREET AND COMBINATION STREET/OFF-ROAD '75 - '76 YR OF MFG MOTORCYCLES

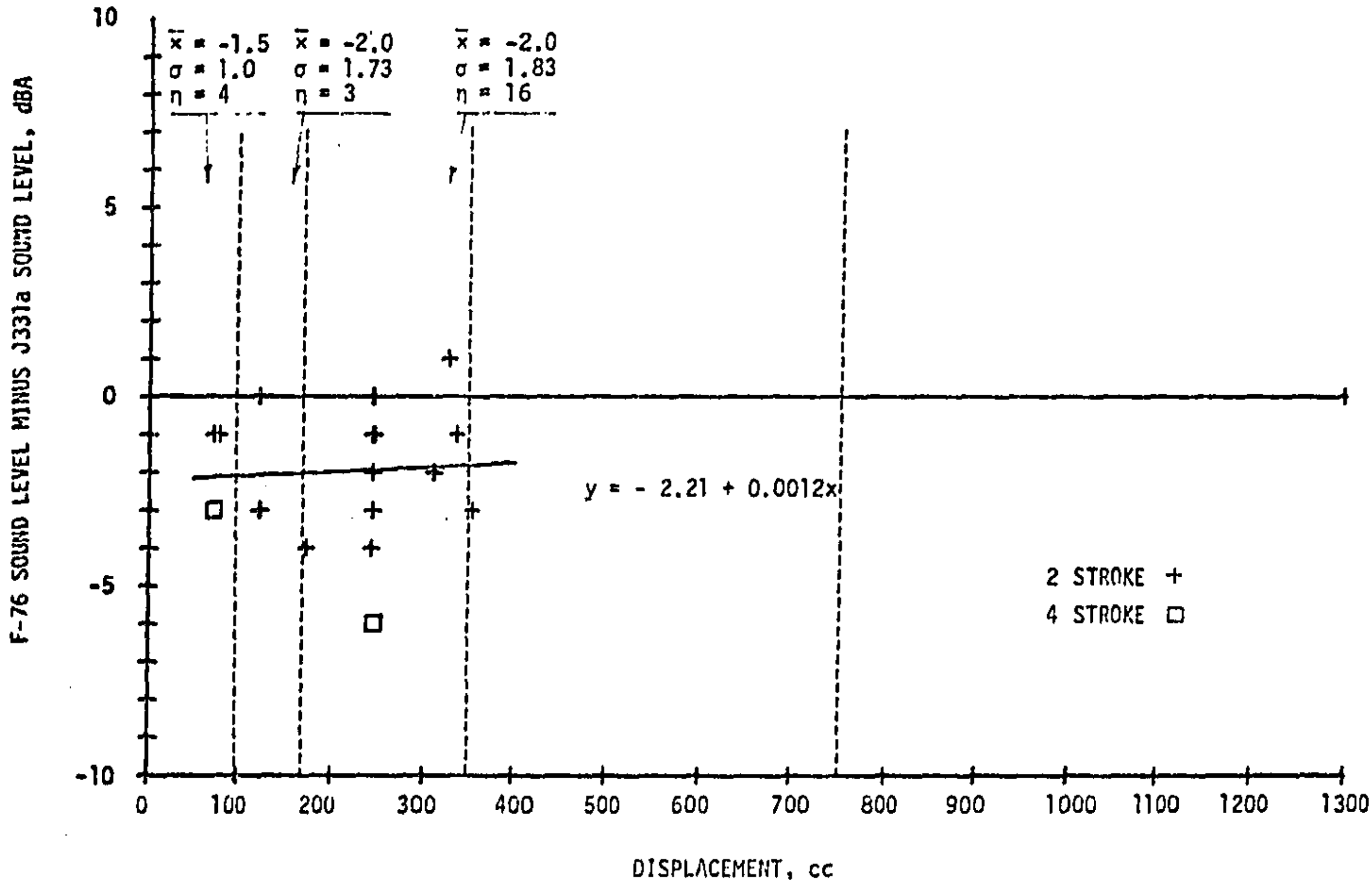


FIGURE 4-6 COMPARISON OF F-76 AND J331a SOUND LEVELS, '75 - '76 YR OF MFG OFF-ROAD (ONLY) MOTORCYCLES

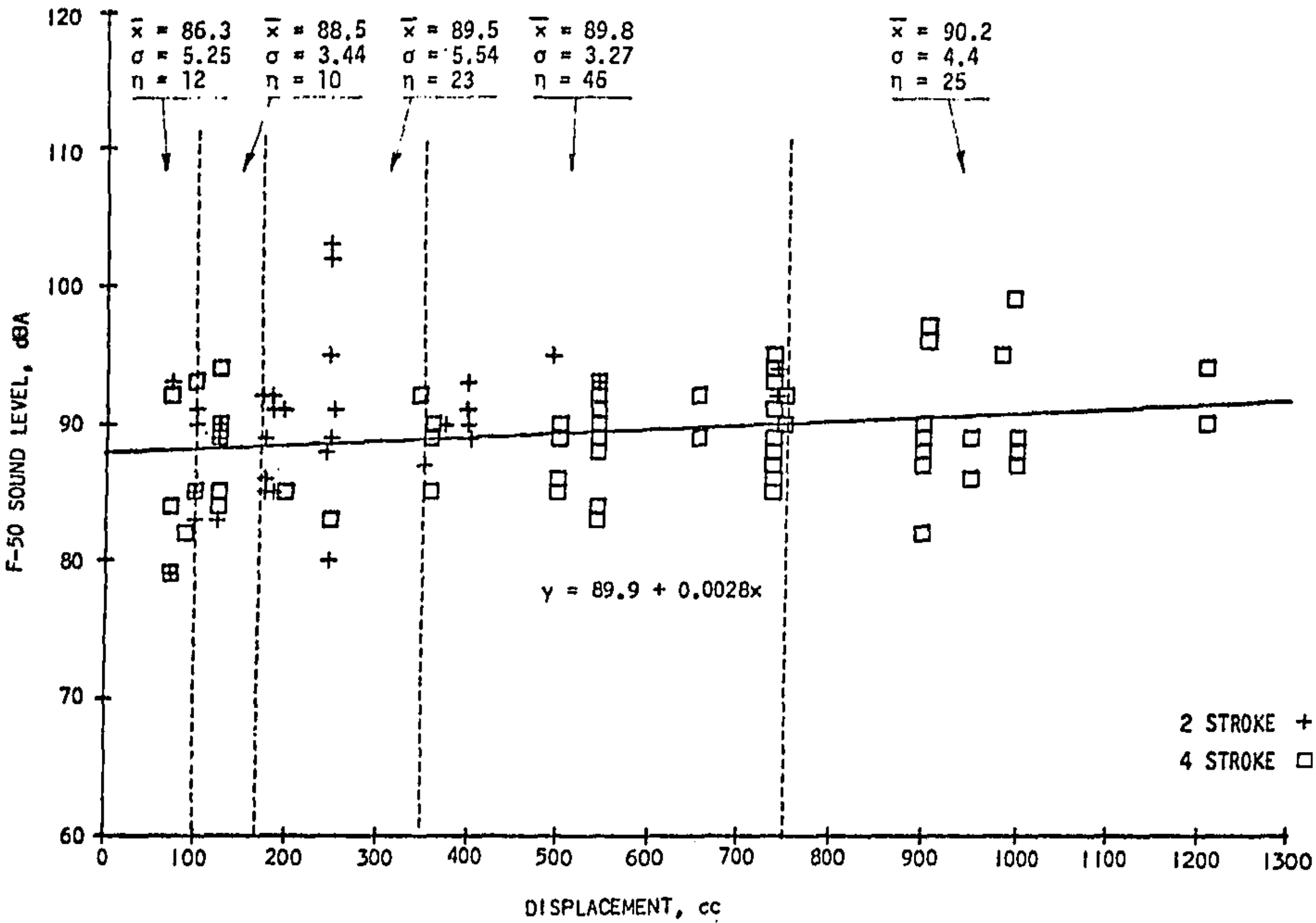


FIGURE 4-7 F-50 SOUND LEVELS, STREET AND COMBINATION STREET/OFF-ROAD '75 - '76 YR OF MFG MOTORCYCLES

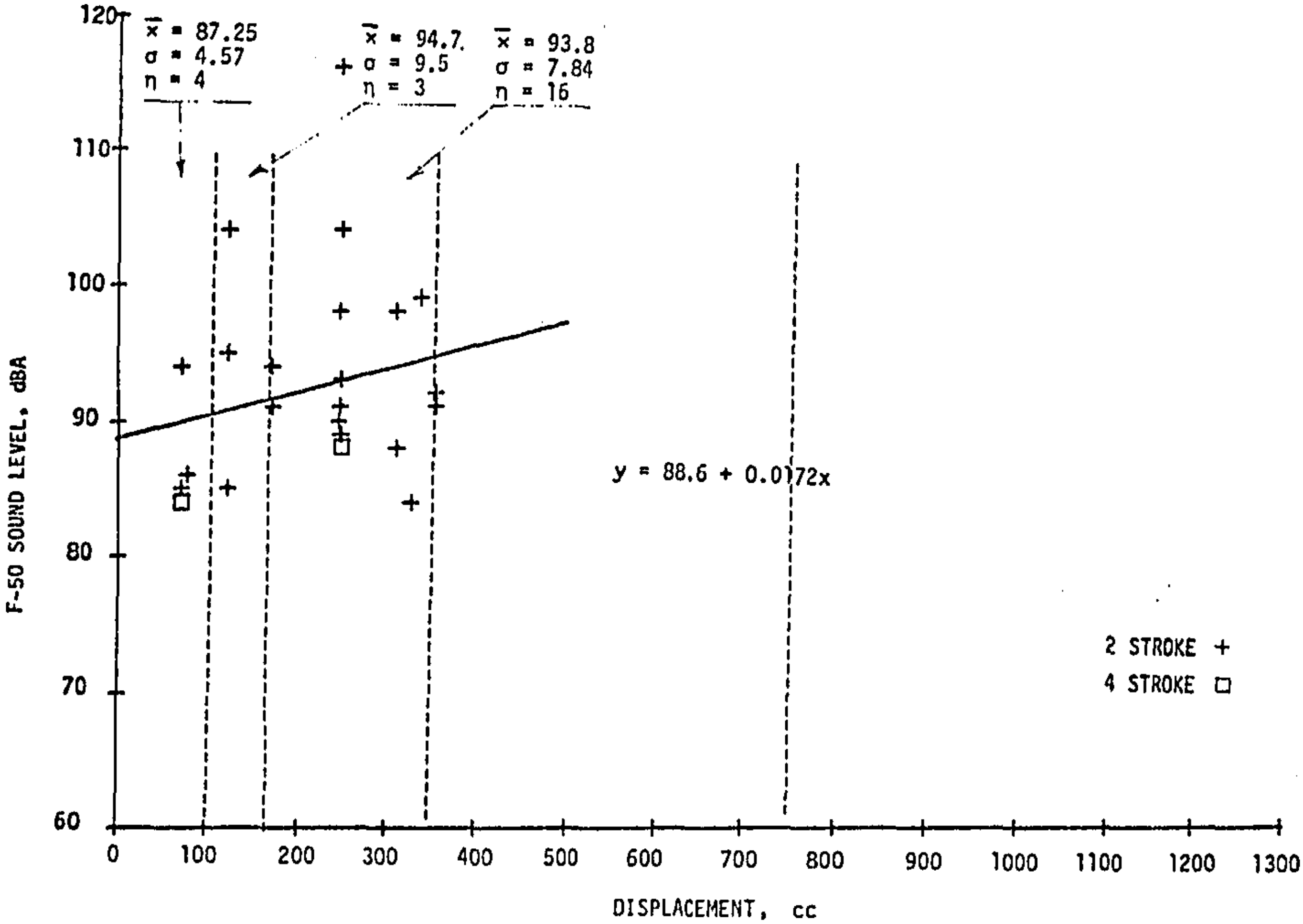


FIGURE 4-8 F-50 SOUND LEVELS, OFF-ROAD (ONLY) '75 - '76 YR. OF MFG. MOTORCYCLES

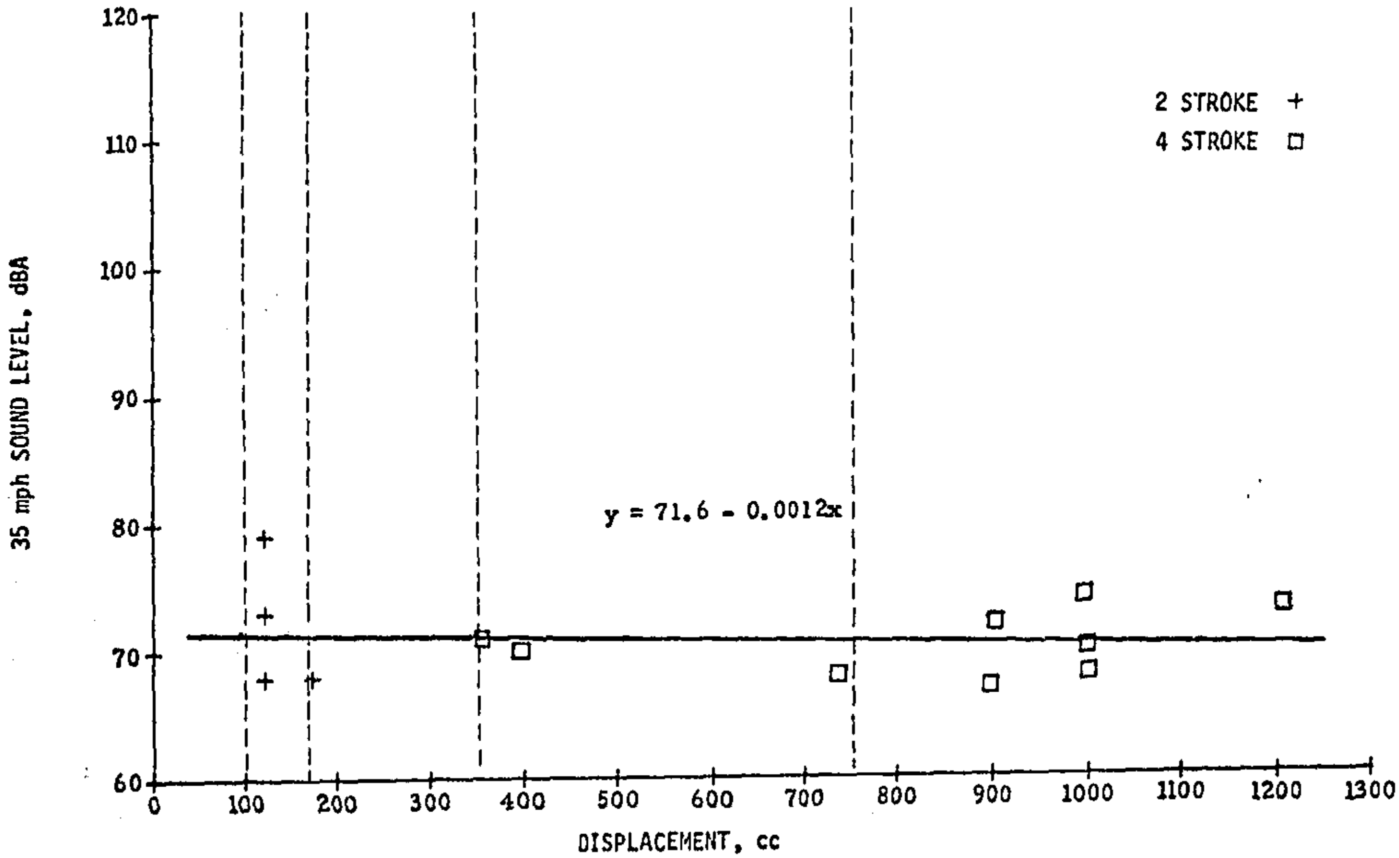


FIGURE 4-9 35 mph SOUND LEVELS, STREET AND COMBINATION STREET/OFF-ROAD '75-'76 YR. OF MFG. MOTORCYCLES

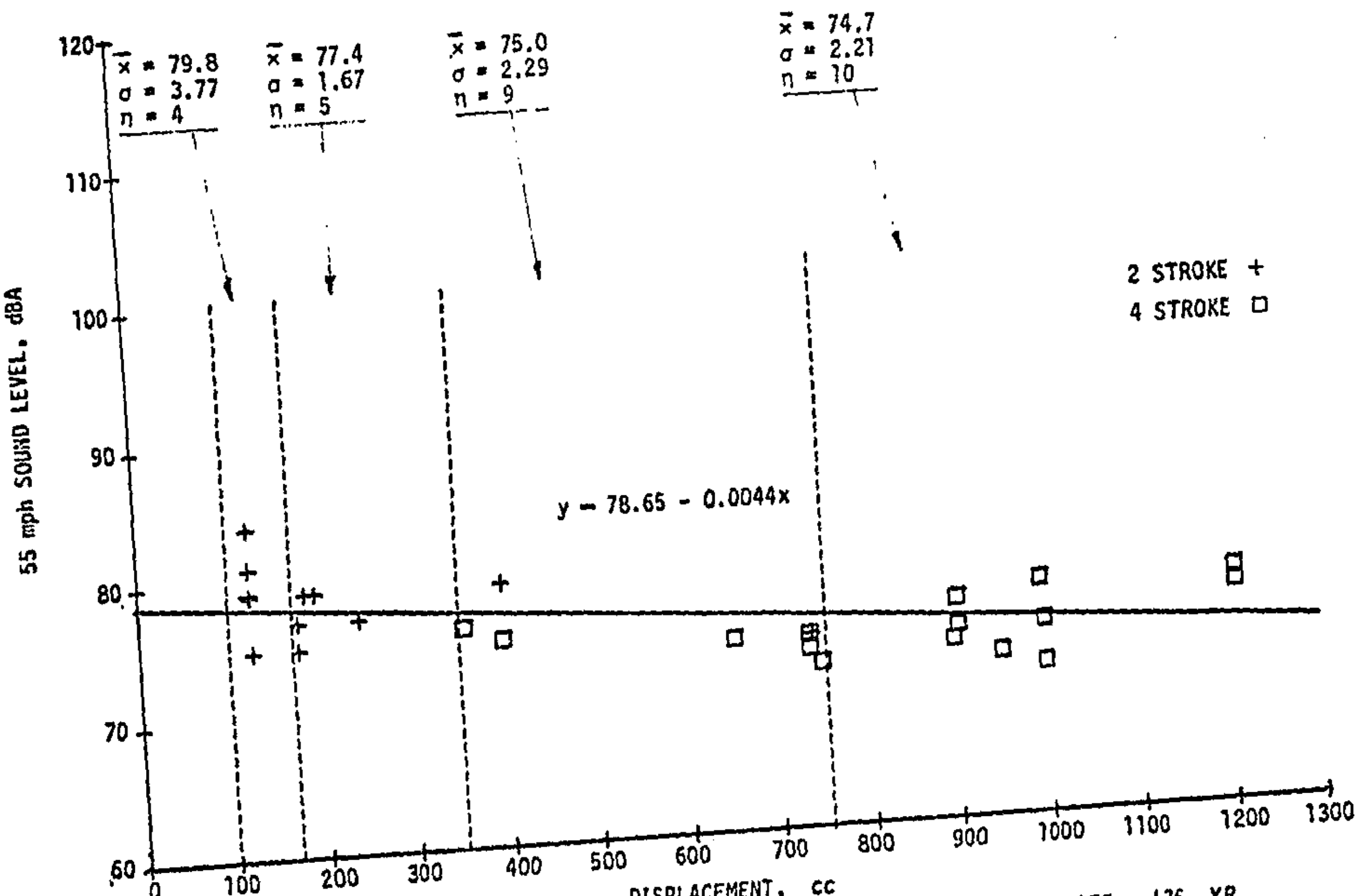


FIGURE 4-10 55 mph SOUND LEVELS, STREET AND COMBINATION STREET / OFF-ROAD '75 - '76 YR. OF MFG. MOTORCYCLES

(d) Sound levels (J-331a, F-76, F-77, F-50), by displacement and use categories; in-service motorcycles, year of manufacture '69-'76, modified exhaust system: Table C-7.

(e) Change in sound levels (J-331a, F-76, F-50), referred to original equipment manufacture (OEM), associated with installation of aftermarket exhaust systems and user modifications: Table C-10.

Detailed information on test procedures, test sites, vehicle identification, and aftermarket product identification, is provided in Appendices A, B and C.

4.2 Test Site, Rider, and Vehicle Variables

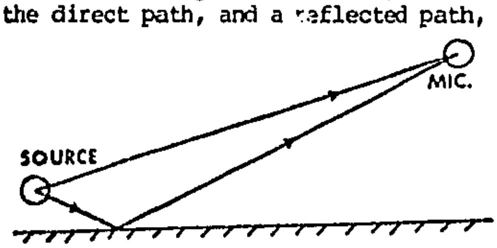
Test Sites

Noise data obtained in the course of this study were obtained at eleven different test sites:

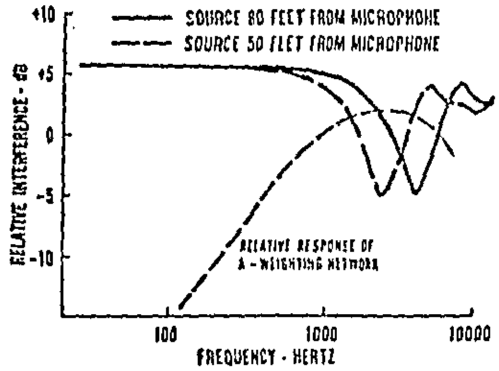
LETTER CODE	LOCATION
A	Argosy Ave., Huntington Beach, California
B	Orange County Fair Grounds, California
C	Daytona Beach, Florida
D	Los Alamitos Naval Air Station, California
E	Pomona, California
F	Houston, Texas
G	St. Petersburg, Florida
H	Albany, Georgia
I	Chapel Hill, North Carolina
J	Suffolk, Virginia
K	Ft. Belvoir, Virginia

Test sites B, D, E, H, and J comply fully with SAE J-331a Recommended Practice in all respects; the other sites depart in varying degrees (but were the best sites available in the respective local areas), particularly in reference to the requirement for concrete or asphalt ground surfacing between the vehicle path and the microphone. Descriptions and photographs of the test sites are contained in Appendix B.

In moving vehicle tests, sound reaches the microphone by two paths; the direct path, and a reflected path, as illustrated below:



Direct and reflected sound paths.



Calculated interference of third-octave band noise for a source height of one foot, microphone height of four feet, and a surface reflection of 0.9. (From Reference 3)

This suggests that noise measurements taken over hard pavement could be either higher or lower than measurements taken over turf or weeds, depending on the spectral content of the source noise. The tabular and graphical data presented in this report include noise measurements taken at all of the test sites. To assess the impact of the non-conforming test sites on the statistical summaries (as shown on the graphical presentations), the statistics of Figure 3-1, J-331a vs. displacement were re-computed with data from the non-conforming sites exluded. Results of this comparison are as follows:

Displacement	Data from test sites A thru K	Data from test sites B, D, E, H, J
50-99 cc	$\bar{x}$ = 78.0*	$\bar{x}$ = 78.4
	σ = 4.44	σ = 3.53
	n = 15	n = 11
100-169 cc	$\bar{x}$ = 81.5	$\bar{x}$ = 80.9
	σ = 2.95	σ = 2.27
	n = 10	n = 7
170-349 cc	$\bar{x}$ = 83.1	$\bar{x}$ = 83.6
	σ = 4.49	σ = 4.78
	n = 23	n = 19
350-749 cc	$\bar{x}$ = 80.6	$\bar{x}$ = 81.6
	σ = 2.99	σ = 2.22
	n = 45	n = 25
750 cc and over	$\bar{x}$ = 81.4	$\bar{x}$ = 82.3
	σ = 3.96	σ = 4.17
	n = 28	n = 15

* is the mean sound level, dB(A)
is the standard deviation, dB(A)
is the number of vehicles in the sample

The foregoing indicates that while site discrepancies could be very important in determining compliance of a particular vehicle with a noise standard, the effect of site discrepancies as encountered in test sites A, C, F, G, I, and K do not materially affect the statistical summaries of the motorcycle noise data base. Additional data on site variables are presented in Appendix C, Table C-15.

Rider Variables

At test site C (Daytona Beach) each motorcycle was operated by the owner of the vehicle; rider weight specifications of the J-331a procedure were not observed. The Daytona tests (run concurrently with the Daytona Beach 200 Nationals) were conducted primarily to obtain a sample showing the range of vehicle types, and the types of user modifications, representative of vehicles currently on the road.

At all of the other sites, the rider was within the 165-175 lb. specification. A different rider, properly trained and instructed, was used at each site, but all bikes at a given site were tested by the same rider, except for site B, where three riders were employed.

Vehicle Variables

Production variability data provided by the vehicle manufacturers show that a three-sigma variation of 1.5 dB(A) is common. Samples taken over a six-month period by one manufacturer have shown a total variation range of up to 4 dB(A). The reason for the latter, which may be a seasonal variation, has not been explained. This suggests that a 2 dB(A) allowance between design and not-to-exceed levels is an absolute minimum, without considering the need for a further allowance in the enforcement situation.

Combined Variables Effect

Factors known or suspected to affect measured sound levels include:

(a) Weather variables affecting sound propagation:

- sunny vs overcast sky
- wind velocity/gradient/direction
- temperature and temperature gradients
- barometric pressure
- humidity

(b) Weather variables affecting engine sound power generation:

- barometric pressure
- temperature
- water vapor pressure
- dry barometric pressure
- dry air density

(c) Manufacturing/assembly/adjustment tolerances affecting engine sound power generation:

- dimensional variations
- spark timing
- fuel/air mixture
- compression variations

(d) Operations variables:

- engine temperature
- entering RPM or speed (J-331a)
- rapidity of throttle opening (J-331a)
- entering start point (J-331a)
- choice of gear selection (J-331a)
- closing RPM (J-331a and F-76)
- closing point (F-76)

(e) Site variables (site assumed to be in compliance with SAE J331a Recommended Practice):

- surface texture (affecting tire noise)
- porosity (affecting absorption coefficient)

(f) Instrumentation variables:

- acoustical calibrator accuracy
- sound level meter ANSI Type (1 or 2)
- sound level meter crest factor
- speedometer accuracy (J-331a)
- tachometer steady-state accuracy (J-331a)
- tachometer dynamic lag (J-331a and F-76)

Much work has already been done in assessing the effect of many of these variables[1,2]; however, many undefined areas still exist. Although the evaluation of the effects of these variables was outside the scope of the EPA study, quantitative data on the effect of tachometer accuracy, RPM control, and gear selection were obtained in the course of test procedure development.

In addition, in the process of acquiring the noise data base, substantial information was collected on the effects of combined variables. Sound level data comparisons between/among vehicles were made in four groupings:

(a) Different vehicles of the same model tested at different sites;

(b) Different vehicles of the same model tested at the same site;

(c) The same vehicle tested at different sites; and

(d) The same vehicle tested at the same site.

The sound level variations (summarized in paragraph 4.3, detailed in Appendix C, Table C-14) are smaller than might be expected, considering the extensive range of variability factors. Vehicles of the same model but known to be configured differently (e.g., to meet different standards in different States) have not been included in the comparisons.

4.3 Data Base Statistical Summaries

Sound levels, year of manufacture '75-'76 motorcycles:

		J-331a		F-76	
Displacement		Street*	Off-Road	Street*	Off-Road
50-99 cc	$\bar{x}$ =	78.0	78.8	77.0	76.4
	σ =	4.64	3.35	4.22	1.82
	n =	15	5	11	5
100-169 cc	$\bar{x}$ =	81.5	91.8	79.5	88.7
	σ =	2.95	10.11	2.64	10.4
	n =	10	4	10	3
170-349 cc	$\bar{x}$ =	83.1	88.8	81.95	86.8
	σ =	4.49	4.96	4.94	5.34
	n =	23	16	40	16
350-749 cc	$\bar{x}$ =	80.6	92.3	81.9	
	σ =	2.99	3.79	2.63	
	n =	45	3	40	
750 cc and Over	$\bar{x}$ =	81.4		85.5	
	σ =	3.96		3.47	
	n =	28		18	

*Includes combination street/off-road motorcycles

Transfer function, F-76 to J-331a sound levels (least squares linear regression line):

$y = -2.48 + 0.0066x$ for street* motorcycles

$y = -2.21 + 0.0012x$ for off-road motorcycles

y = F-76 level - J-331a level

x = displacement, cc

The F-76 method yields statistical levels 4.1 dB higher than the J-331a method at a displacement of 1000 cc, reducing to 1.9 dB(A) lower at 100 cc for the street machines, with a similar trend in the off-road vehicles.

Constant speed 55 mph sound levels as a function of displacement (least squares linear regression line), yr. of mfg. '75-'76 motorcycles:

$y = 78.65 - 0.0044x$

y = sound level, dB(A) at 50 ft.

x = displacement, cc

It is of interest to note that this is a downward sloping line with displacement, with motorcycles in the 900-1200 cc range being statistically 3.9 dB quieter than motorcycles in the 100-250 cc range, in the 55 mph operating mode.

Variability in sound level data (from Table C-14); combined effect of site, rider and vehicle variables:

J-331a	F-76	F-50
$\bar{x} = 0.91$	$\bar{x} = 1.17$	$\bar{x} = 1.21$
$\sigma = 1.29$	$\sigma = 1.58$	$\sigma = 1.83$
$n = 87$	$n = 69$	$n = 85$

*Includes combination street/off-road motorcycles

Comparison of motorcycles with modified exhaust systems vs. stock configurations; data from test site C (Daytona Beach) only:

J-331a Sound Levels, dB(A)

Motorcycles in stock configuration	Motorcycles with obviously modified exhaust systems
$\bar{x}$ = 84.4	$\bar{x}$ = 93.6
σ = 7.2	σ = 5.2
n = 49	n = 27

The tests at Daytona Beach were timed to coincide with the Daytona Beach 200 National motorcycle events, to permit sampling from a wide range of motorcycle types on a random basis. Vehicles were obtained by open invitation to riders visiting the race and show events; all vehicles offered were tested, and are reflected in the above statistics.

4.4 Aftermarket Exhaust Systems

The EPA study included making contacts with leading motorcycle organizations such as the Motorcycle Industry Council, the Motorcycle Trades Association, the National Motorcycle Dealers Association and many local organizations, to invite a large segment of the aftermarket manufacturers and distributors of replacement exhaust systems to participate in the EPA study. Major meetings and product display shows at Las Vegas and Daytona Beach were attended to explain the objectives of the study, answer questions, obtain basic information about the aftermarket industry, and to solicit active participation by aftermarket manufacturers in a comprehensive test and evaluation program of aftermarket exhaust systems. These meetings were attended by manufacturer representatives from all parts of the United States, thereby giving broad exposure to the program.

Subsequently, formal contacts were made with selected aftermarket manufacturers in the California area, at which time the individual factories were toured, detailed discussions were held with officials in each company, and each company was asked to cooperate in providing replacement exhaust systems to be tested on a family of selected motorcycles.

Companies listed below were contacted either by phone, at a display booth in the aftermarket shows, or visited at their manufacturing facilities:

Action-4*
Alphabets West*
Bassani*
Bates Industries
Butte Industries
Custom Chrome
Cyclone
Dean Maro's Pipelyne
Discojet
Doug. Thorley Headers
Hooker Headers*
Jardine Headers*
J&R Expansion Chambers*
Kook's Custom Headers
MCM Manufacturing*
R.C. Engineering*
S&S Manufacturing*
Santee Industries*
Skyway*
Torque Engineering*
Triple-A Accessories*
Winning Performance Products

Aftermarket Exhaust System Testing Program

An important part of the EPA motorcycle noise study involved sound testing of aftermarket exhaust systems. With the full cooperation and participation of aftermarket exhaust system manufacturers, a comprehensive noise test program was conducted on approximately 107 aftermarket exhaust systems and/or variations. These units were tested on 16 different motorcycles representing the five major motorcycle manufacturers. The testing involved conducting the SAE J-331a and F-76 acceleration tests, and the F-50 stationary test on each of the motorcycles equipped with stock (OEM) exhaust systems, followed by testing with the applicable aftermarket exhaust systems. In addition to testing with the applicable aftermarket and stock exhaust systems, variations were tested such as removing inserts, baffles, fiberglass, and in some cases removing the mufflers altogether, all of which represent forms of modified motorcycles found in circulation.

The participating aftermarket exhaust system manufacturers included Santee, Alphabets, Jardine, Hooker, Bassani, S&S, MCM, Yoshimura, Torque Engineering, Winning Performance Products, J&R, Dick's Cycle West, RJS, Kerker, Trabaca

*Toured facility

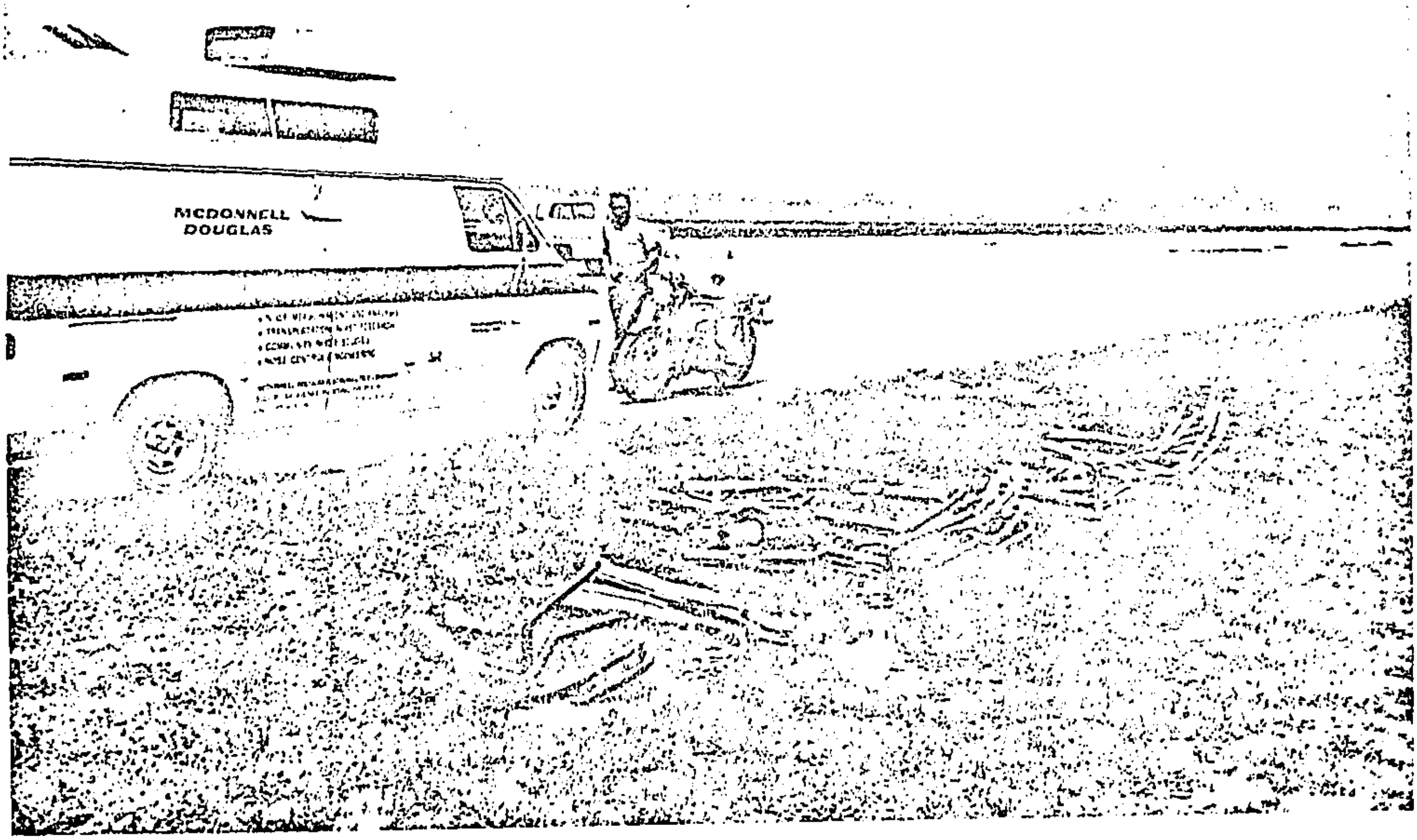
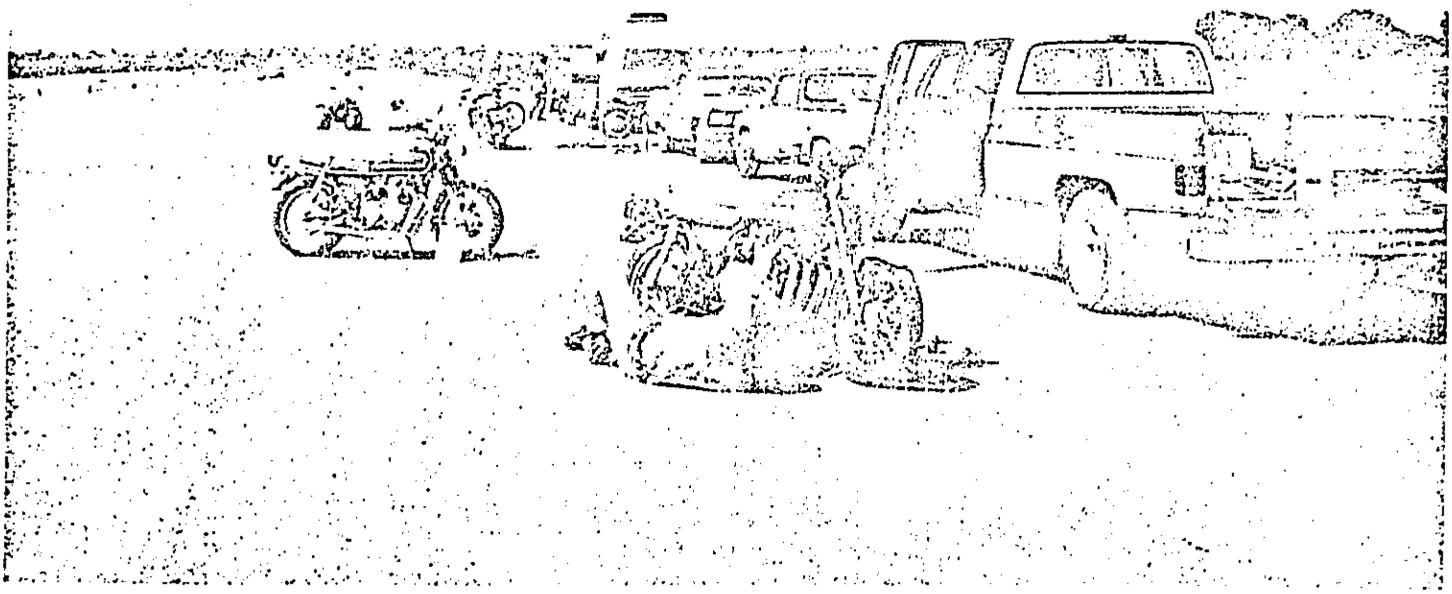


FIGURE 4-11 AFTERMARKET EXHAUST SYSTEMS TO BE TESTED



AFTERMARKET EXHAUST SYSTEM BEING INSTALLED FOR TEST and R. C. Engineering. Figure 4-11 shows some of the exhaust systems laid out at the test site prior to installation and test. Figure 4-12 shows actual installations in progress.

Information on test procedures employed, the test site, and vehicle and aftermarket product identification is provided in the Appendices.

Aftermarket Product Study Results

Detailed sound level data on aftermarket and modified exhaust systems are contained in Appendix C, and organized as follows:

(a) Listing of motorcycles used in the aftermarket product study; Table C-8.

(b) Listing of aftermarket exhaust systems/components tested, correlated with test vehicle employed; Table C-9.

(c) Sound level data for each configuration designed for the motorcycle on which tested (aftermarket manufacturer disguised); Table C-10.

A summarization of the test results follows.

Aftermarket Exhaust Systems as Configured by the Manufacturer

Sound Level	Number of Configurations
Same as OEM	6
Quieter than OEM	9
1 dB higher than OEM	7
2 dB higher than OEM	6
3 dB higher than OEM	4
4-16 dB higher than OEM	50
Total configurations tested	82

Summary: 32 within 3 dB(A) of the OEM
50 4-16 dB(A) higher than the OEM

The above tabulation excludes configurations designated by the manufacturers as "competition" or "racer." Sound levels of configurations so designated were as follows:

dB(A) re OEM
+14
+15
+ 9
+10

Data on mufflers with competition or racer cores are included to illustrate the increase in sound level that could be expected if a muffler that has been specifically designed for competition usage is put on a street bike or a combination street/off-road bike. Owners of street and combination street/off-road motorcycles are known to modify their machines with a competition-type exhaust system to obtain increased performance.

User Modifications

(a) Effect of removing the interchangeable baffles or inserts from aftermarket mufflers:

dB(A) re OEM
+15
+21
+22
+29
+21
+15
+21

(b) Effect of removing the glass blanket from the removable insert (insert replaced):

dB(A) re OEM
+ 4

(c) Effect of removing the OEM muffler:

dB(A) re Stock Config.
+22
+19
+16
+20
+19
+21

The sound levels resulting from removal of the muffler are indicative of what could be expected if stock (OEM) or good quality aftermarket exhaust systems are drastically modified. Removing inserts from aftermarket mufflers (which is a very simple operation on some makes) has an effect similar to removal of the entire muffler, without changing the outward appearance of the motorcycle.

Performance vs. Noise

To illustrate the effect on performance and the effect on sound levels of aftermarket exhaust systems available for some of the more popular motorcycles, a comparison is shown in Table 4-1 of exhaust systems for the Honda CB750. Both performance and sound level data were acquired on a variety of systems, including the original equipment. The maximum horsepower and peak torque performance data on this particular motorcycle were obtained on a dynamometer, whereas the sound measurements were obtained using the J-331a vehicle acceleration type test procedure. It is apparent from the data that the aftermarket exhaust systems designed to increase performance over the original equipment also significantly increase the sound level. Conversely, the quieter aftermarket exhaust systems that approach the sound levels produced by the OEM system, have a somewhat adverse effect on vehicle horsepower although the peak torque is somewhat enhanced. It has been pointed out by some manufacturers that the effect of peak torque occurring at a lower RPM than the OEM unit gives the feel of greater "pulling" power, therefore leading to the conclusion that a particular exhaust system has improved the motorcycle performance.

Another important point illustrated in Table 4-1 is the availability of different inserts or cores with the same baseline muffler. Several manufacturers offer exhaust systems with a variety of removable cores or adjustable vanes that can be added or decreased in number to obtain the desired end-result in performance and sound level. This type of product is offered for motorcyclists who have combination street/off-road bikes which are used for competitive events or off-road activities in which increased performance is important. The adjustable-vane type mufflers have been designed to accommodate a range of motorcycles. Manufacturers state that they purposely provide mufflers with two inserts: one for use in an off-road situation, which will increase performance significantly, but as a by-product will also increase the noise level, and a second insert which is to be used by the motorcyclist when he is to ride that motorcycle on the street. With a simple change, the motorcyclist can remove the noisier high performance insert and replace it with the street-legal type insert which will comply with existing sound limits.

TABLE 4-1 COMPARISON OF AFTERMARKET EXHAUST SYSTEMS FOR HONDA CB750

SOUND LEVEL AND PERFORMANCE

EXHAUST SYSTEM	SOUND LEVEL (dBA) (J331A)	MAX. H.P.	Peak Torque
HONDA 750 (OEM)	81 dBA	57.67 @ 8500 RPM	36.25 @ 8000 RPM
BASSANI (RACING) 4:1	91		
BASSANI SMALL 4:1	81	55.28 @ 8000	36.12 @ 7000
RJS QUIET CORE	82		
RJS STOCK CORE	87		
DICK'S CYCLE WEST	82	56.89 @ 8500	37.00 @ 6500
TRABAÇA 2:1	89	47.52 @ 7500	35.25 @ 6500
J&R WITH STREET CORE	84	56.0 @ 8000	37.06 @ 6500
J&R WITH COMPETITION CORE	91	60.3 @ 8500	39.25 @ 6500
HOOKER 4:1	89	57.92 @ 8500	38.62 @ 6500
TORQUE ENGINEERING	83	56.75 @ 8000	37.93 @ 6500
JARDINE	82	53.6 @ 8000	37.00 @ 6500
R.C. ENGINEERING	87	55.6 @ 8500	35.75 @ 7500
ALPHABETS	83.5	56.6 @ 8500	38.43 @ 6500
WINNING	88	59.38 @ 8500	37.68 @ 7500

SOURCE: Street Bike - July 1976,
"Honda 750 Header Shoot-Out," Jeff Peck

4.5 Sound Levels at the Operator and Passenger's Ear Position

In order to assess potential benefits in hearing risk to motorcycle operators from reducing motorcycle noise emissions, EPA conducted a study of motorcycle sound levels at the operator and passenger ear positions. The details of the study program are described in Appendix E. Measurements were made on three large motorcycle models (Honda 750, BMW, Harley-Davidson) in various operating modes. Measurements were made with the motorcycle stationary, on a dynometer and under moving conditions. In addition, measurements were made with bare head, head covered with a cap to reduce wind effects, and inside a helmet. An attempt was made to distinguish wind turbulence and motorcycle (only) contributions.

The information presented in the Appendix shows that wind-induced noise (turbulence caused by wind flowing by the ear) is an extremely complex phenomenon. It depends not only on wind speed but vehicle and operator geometry and head attitude. In addition, it appears that operator-induced turbulence increases passenger exposure. The influence of helmets on operator exposure is another extremely complex phenomenon, again depending on geometery and attitude. Both enhancement and attenuation of sound levels compared to bare head levels were noted in different frequency bands and for different head attitudes. It appears that helmet-induced turbulence may increase operator sound exposure for some helmet geometries.

At this time, motorcycle (alone) sound level (absent wind and helmet effects) appears to be the best measure for assessing motorcycle operator noise impact. Both dynamometer and moving runs indicated that the operator sound levels under F-76a acceleration conditions were about 100 dB(A) for the motorcycles tested (J-331a valves (50 feet)—Honda: 81 dB(A), BMW: 81 dB(A), Harley-Davidson: 84 dB(A)). Wind noise was below 90 dB(A) for all speeds up to 45 mph except for the trailing ear when a motorcyclist without a helmet inclined his head 45 degrees away from the line of travel. It can be concluded that under rapid acceleration conditions, for the motorcycles tested, motorcycle (alone) contributions would outweigh wind noise for a helmeted operator.

The extent to which operator ear sound levels would decline as fifty-foot sound levels declined in response to wayside regulations cannot be confidently predicted. However, since attention must be given to intake and mechanical noise (both nearer the operator's ear than the exhaust noise source), some reduction is to be expected.

REFERENCES

1. Hillquist, R. K. and Bettis, R. A., Measurement of Automotive Pass-by Noise, paper presented at the SAE Automotive Engineering Congress, Detroit, Michigan, January 10-14, 1972.

2. Hemdal, John F., et al., A Study of Repeatability at Motor Vehicle Noise Measurement Sites, Environmental Research Institute of Michigan, 1974.

SECTION 5

PUBLIC HEALTH AND WELFARE ANALYSIS

Section 5

PUBLIC HEALTH AND WELFARE ANALYSIS

The benefits to the public health and welfare which are expected to occur as a result of establishing noise emission limits on motorcycles are presented in this section. No significant adverse environmental impacts are foreseen.

Because of inherent differences in individual responses to noise, the wide range of traffic situations and environments, and the complexity of the associated noise fields, it is not possible to examine all traffic situations precisely. Hence, in this predictive analysis, certain stated assumptions have been made to approximate typical or average situations. The approach taken to determine the benefits associated with the noise regulation is, therefore, statistical in that an effort is made to determine the relative numbers of people that may be affected for each regulatory option. It was necessary to make various assumptions in this analysis; therefore, some uncertainties with respect to individual cases and absolute numbers will remain.

People are exposed to motorcycle noise in a variety of situations. Some examples are:

(1) Inside a home or office.

(2) Around the home (outside).

(3) In recreational areas.

(4) As a motorcycle operator or passenger.

(5) As a pedestrian or in transit in other vehicles.

Reducing noise emitted by motorcycles may produce the following benefits:

(1) Reduction in average traffic noise and associated cumulative long term impact upon the exposed population.

(2) Reduction in activity interruption from individual (single-event) acceleration noise, and associated impact on the exposed population.

(3) Reduction in sound levels at operator or passenger positions which may result in reduced hearing risk.

The phrase "health and welfare" in this analysis and in the context of the Noise Control Act is a broad term which includes personal comfort and well-being, and absence of mental anguish, disturbances and annoyance as well as the absence of clinical symptoms such as hearing decrement or demonstrable physiological injury.

Dose respose relationships for noise induced hearing loss have been fairly well documented. The non-auditory effects of exposure to noise are less well understood. A number of stress reactions have been observed to occur which result from a generalized syndrome caused by the "flight or fight" reaction. Other physiological effects, such as cardiovascular disease, increased susceptability to viral infection, birth defects, and even cancer are suspected to have some relation to the synergistic effects of noise exposure.

Annoyance due to noise is generally a manifestation of stress. This stress reaction occurs when exposure to noise is experienced as an unwanted intrusion on various activities, such as during sleep, speech communication, or various types of relaxation. Such annoyance often occurs after exposure to noise of very short duration.

Predictions of motorcycle noise emissions under various regulatory levels (referred to as study levels) are presented in Section 5.2 in terms of the sound levels which are associated with motorcycle operating modes. These sound levels are weighted according to traffic populations or mixes before averaging to determine overall traffic sound levels in urban areas. Predicted reductions in average urban traffic sound levels from current conditions are presented in Section 5.3 for various regulatory options for new motorcycles, both with and without noise emission regulations for other types of vehicles. Projections of the population impacted as well as the relative reductions in impact from current conditions are determined from these reductions in average traffic sound levels.

The use of average traffic sound levels to describe motorcycle noise impact is of value in only a limited sense, since such an analysis does not adequately describe the individual disturbances produced by single motorcycle passbys in various situations. Annoyance frequently depends on the activity and location of the individual exposed to such n[illegible]. Thus, an average sound level does not account for the disruptive and annoying peak noise intrusions produced by a single motorcycle acceleration. Therefore, in residential urban, suburban, and rural areas, in those cases where motorcycle accelerations are not likely to be masked by other traffic noise, effects of current representative motorcycle acceleration sound levels and future regulated sound levels are evaluated as single events in Sections 5.4 and 5.5. Speech and sleep interferences are presented as indicators of activity interference and the associated adverse impact of motorcycle noise.

In Section 5.6, the benefits to be derived from lowering motorcycle sound levels in off-road environments are estimated in terms of reductions in the area currently impacted by motorcycle noise. Reductions in potential hearing damage (risk to motorcycle operators and passengers) are discussed in Section 5.7.

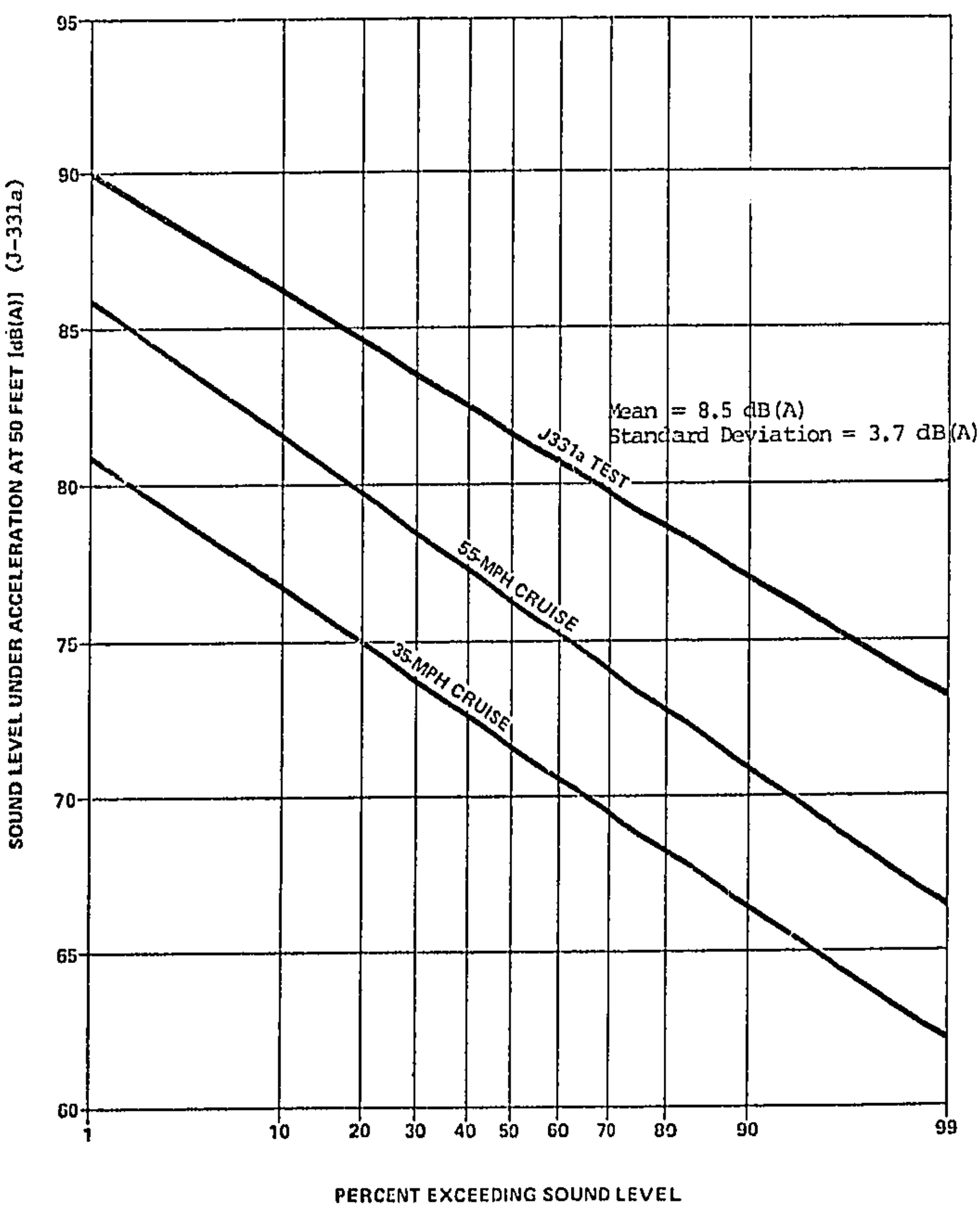
The analyses below present both absolute numbers of people impacted and impact events and relative reductions in impact from current conditions. While absolute values of present or future impact may not be known precisely, the relative reductions in impact--of primary interest here--are known with much greater accuracy. For example, while it may not be possible to completely characterize the extensiveness and severity of the noise impact of current motorcycle operations, relative reductions can be accurately calculated and used for comparing various regulatory alternatives. In addition, the relative changes found to occur in the measures used in this analysis may help indicate what equivalent changes would occur in impact measures which are not used in this analysis but whose absolute values may reflect more accurately the effects of motorcycle noise on people.

5.1 Current Street Motorcycle Sound Levels

A statistical representation of stock motorcycle sound levels, based on the data in Appendix C, is presented in Figure 5-1. These data are acceleration sound levels as measured by the SAE J-331a test procedure. This procedure is representative of very rapid acceleration from 30 m.p.h. (full-throttle, high engine speed). Acceleration sound levels as measured by J-331a can be adjusted to account for more commonly encountered acceleration modes (near full-throttle, moderately high engine speed). As discussed in Section 3, sound levels as measured by the proposed regulation test procedure are assumed to be statistically equivalent to J-331a levels. Cruise sound levels are based on steady-state operation at various constant speeds. The data in Figure 1 were developed from noise measurements of 200 unmodified motorcycles which were selected to be representative, by year of manufacture and type, of the national population of motorcycles in-service licensed for street use in 1975. Additional noise measurements, discussed in Appendix C, of 160 newly manufactured (1975-1976) street and dual-purpose motorcycles yielded sound levels which did not differ significantly from the distribution shown in Figure 5-1. Hence, Figure 5-1 is considered to be applicable to motorcycles currently on the road as well as to present day newly manufactured motorcycles.

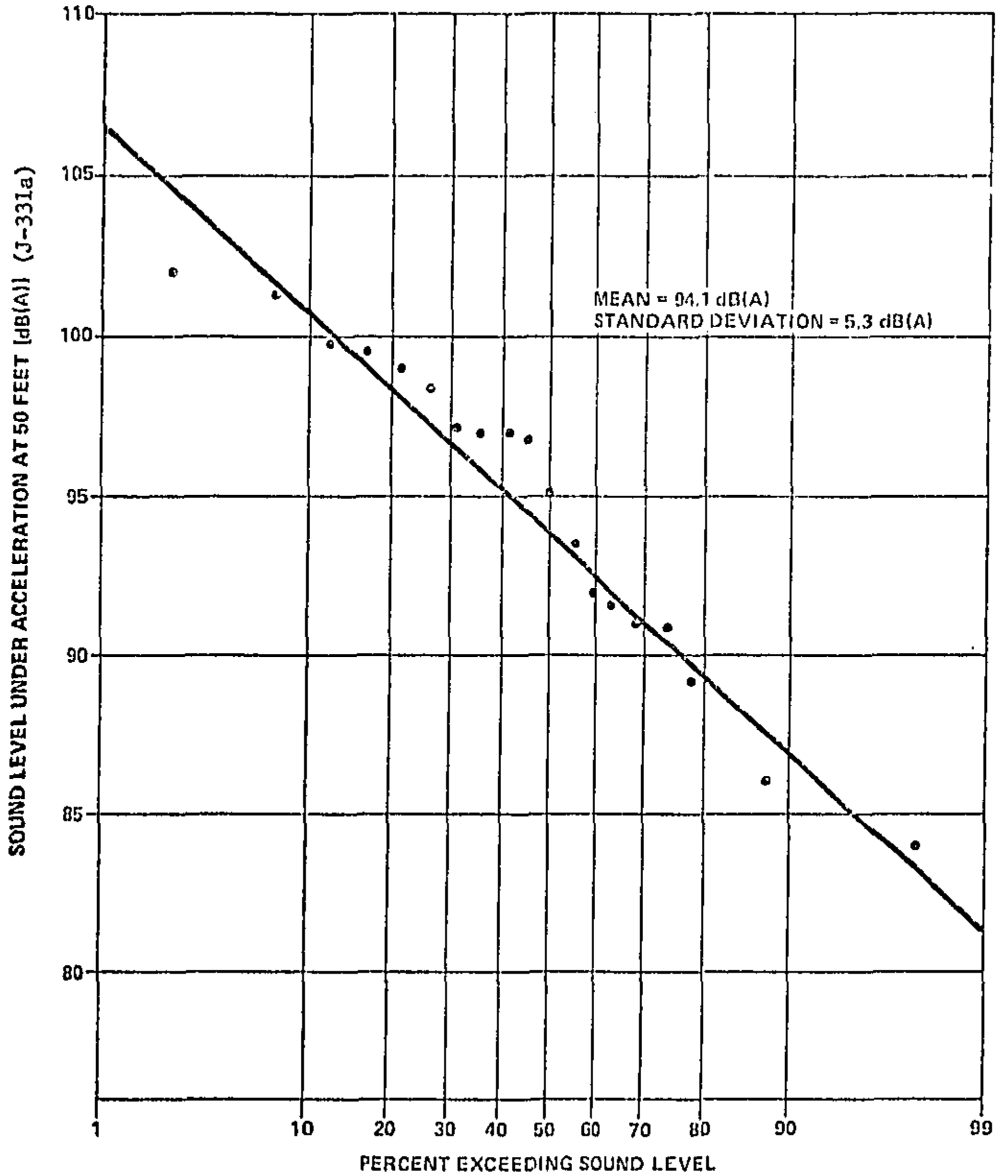
According to a national survey (Ref. 6), at least 12 percent of street motorcycles, 12 percent of dual-purpose motorcycles (treated in this analysis as street motorcycles), and 26 percent of off-road motorcycles have modified exhaust systems. (In Los Angeles and San Francisco, these percentages were higher, approximately 15, 13, and 47 percent

Figure 5-1. Percent of Unmodified Street Motorcycles which Exceed Any Given Sound Level



Source: Appendix C

Figure 5-2. Sound Levels of Exhaust-Modified Motorcycles



Source: Appendix C

for street, dual-purpose, and off-road, respectively.) In general, modification of a motorcycle exhaust system significantly increases the motorcycle's sound level. Although other types of modifications such as intake modification may also affect the sound level of a motorcycle, exhaust system modifications are typically the most noticeable form of motorcycle noise tampering.

In this analysis, statistics are developed using several different assumptions on the incidence of modified motorcycles. The current incidence, unchanged by Federal regulation (12%), and two lower incidences (7% and 3%) are modelled for street motorcycles to reflect the expected reduction of exhaust modifications. No modifications (0%) is analyzed for comparison purposes and to focus on the unmodified motorcycle population. Eliminating motorcycle modifications entirely, however, is not considered to be feasible with even the most vigorous commitment to noise enforcement by Federal, state and local governments. Reduction of modified motorcycles to about half the current incidence (7% of the population) is considered the biggest reduction achievable through a Federal regulation alone. Reduction to about one-quarter of the current incidence (3%) is considered to be the biggest reduction achievable from a combination of Federal regulation and vigorous state and local enforcement programs. Similar reductions (24%, 16%, 8%, 0%) are also modelled for off-road motorcycles.

The sound levels of 21 known exhaust-modified (non-competition) motorcycles are plotted in Figure 5-2. The best fit of a normal distribution to the data is indicated by the straight line. In comparison with the J-331a test results for unmodified motorcycles shown in Figure 5-1, it can be seen that the mean sound level for exhaust-modified motorcycles is 12.6 dB(A) greater than that for unmodified motorcycles. The distribution of sound levels also shows a greater dispersion, with a standard deviation of 5.3 dB(A) as compared to 3.7 dB(A) for the unmodified motorcycles. These results are confirmed by previous measurements of both unmodified and exhaust-modified motorcycles. Additionally, test data indicate that the 25-35 mph steady speed sound levels of exhaust-modified motorcycles are 15.6 dB(A) higher than those of unmodified motorcycles (mean values of 88.9 dB(A) versus 73.3 dB(A)). It is apparent that modified motorcycles are typically much louder than unmodified motorcycles under both steady speed and acceleration conditions.

Since increasing a sound level by 12 decibels increases the distance at which the sound can be heard by a factor of 4, and the area by a factor of as much as 16 (assuming spherical spreading propagation losses), it is apparent that motorcycles with modified exhaust systems contribute to the overall noise impact from motorcycles in much larger proportion than their actual numbers would indicate.

Based on data presented in Figure 5-1, it is assumed in this analysis that 55-mph and 35-mph cruise sound levels for motorcycles are, respectively, 5 and 10 dB(A) lower than current J-331a sound levels, and have the same standard deviations.

The median sound levels and standard deviations which have been assumed for current and near-future populations of in-use motorcycles are presented in Table 5-1. Representative acceleration sound levels, as used in the following analysis, are assumed to be 3 dB(A) less than the measured J-331a test level (see Appendix G).

For a population of instantaneous sound levels observed at equally spaced time intervals that has a normal (Gaussian) distribution, the energy-average of the sound levels over time is given by

$$L_{eq}^{*} = L_{50} + 0.115\,{}^{2} \qquad (1)$$

where L_{50} is the median noise level and   is the standard deviation.[1] In the traffic analysis below, it is assumed that the distribution of roadside sound levels for each type of vehicle is approximated by a normal (Gaussian) distribution and that there is a steady stream of closely spaced vehicle passbys. This assumption permits calculation of the energy-average of the sound levels from median sound levels in a manner similar to the computation of L_{eq} in Equation 1. That is:

$$L_{a} = L_{50} + 0.115\,{}^{2} \qquad (2)$$

where L_a is the energy-average of the sound levels, L_{50} is the median level, and   is the standard deviation of the sound levels. As Equation 2 demonstrates, the energy-averaged sound level depends on both the median level and the variability of these levels. The energy-averaged sound levels which will be used in the following analysis are also indicated in Table 5-1.

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*L_{eq} is the equivalent A-weighted sound level in decibels. This is discussed in more detail below.

[1]Johnson, D. R. A note on the relationship between noise exposure and noise probability distribution, NPL AERO Report Ai40 (May, 1969).

Table 5-1: Median Sound Levels of Motorcycles In Use (dB(A))

(Currently and in the Near Future, if Unregulated)

	35 mph Cruise	Full-Throttle Acceleration (J331a)	Representative Acceleration (J331a - 3 db)	Standard Deviation	Energy-Averaged Representative Acceleration
Unmodified Motorcycles Designed for Street Use	71.5	81.5	78.5	3.7	80.0
Exhaust-Modified Motorcycles	84.0	94.0	91.0	5.3	94.2

5.2 Effect of Noise Regulations on Motorcycle Sound Levels

Various regulatory options considered for street motorcycles are presented in Table 5-2. Since an infinite variety of regulatory options are possible it is necessary to focus on a manageable few for analysis purposes. These options have been analyzed both for health and welfare benefits and for cost and economic impact (see below). The options have been chosen close enough together to permit accurate interpolation. The Agency is not bound to select any of the specific options analyzed here nor should any significance be given to the particular options chosen for analysis.

To analyze the effect of a motorcycle noise emission regulation, some assumptions must be made as to the changes which would occur in the sound levels presented in Figures 5-1 and 5-2, due to a particular regulatory standard. It is expected that in order to comply with a Federal noise regulation manufacturers will produce motorcycles with average sound levels about 2.0 dB(A) lower than the regulatory limit to account for production and testing variabilities (see Chapter 6). This production level may be assumed to be the mean of what is actually a distribution of sound levels for the redesigned motorcycles.

Assuming that manufacturers will not quiet motorcycles which already meet noise standards, and incorporating a production level of 2 dB(A) below the regulatory limit, the distribution of future production motorcycle sound levels are estimated in Figure 5-3 according to various regulatory options.

As the distribution of new motorcycle acceleration sound levels is changed with the implementation of noise emission regulations, the population-average acceleration sound level will be reduced over time as more and more old, unregulated motorcycles are replaced by new regulated ones. For example, suppose a regulation were promulgated which provided that no new motorcycle for street-use could exceed 80 dB(A), according to the J-331a test procedure. The motorcycles above this sound level, which comprise the "loudest" 66 percent of the unmodified street-use motorcycles shown in Figure 5-3, would eventually disappear as quieter motorcycles replaced older models. Eventually a new distribution would be formed in which no unmodified street-use motorcycle would exceed the 80 dB(A) standard as measured by the J-331a test.

Acceleration sound levels do not correlate well with cruise sound levels at 55 and 35 mph. A motorcycle which may be quieter than average according to an acceleration test may be louder than average under cruise conditions. This is due to the fact that mechanical noise, chain noise, etc., can contribute significantly to a cruise sound level, since the exhaust noise is generally lower than during acceleration.

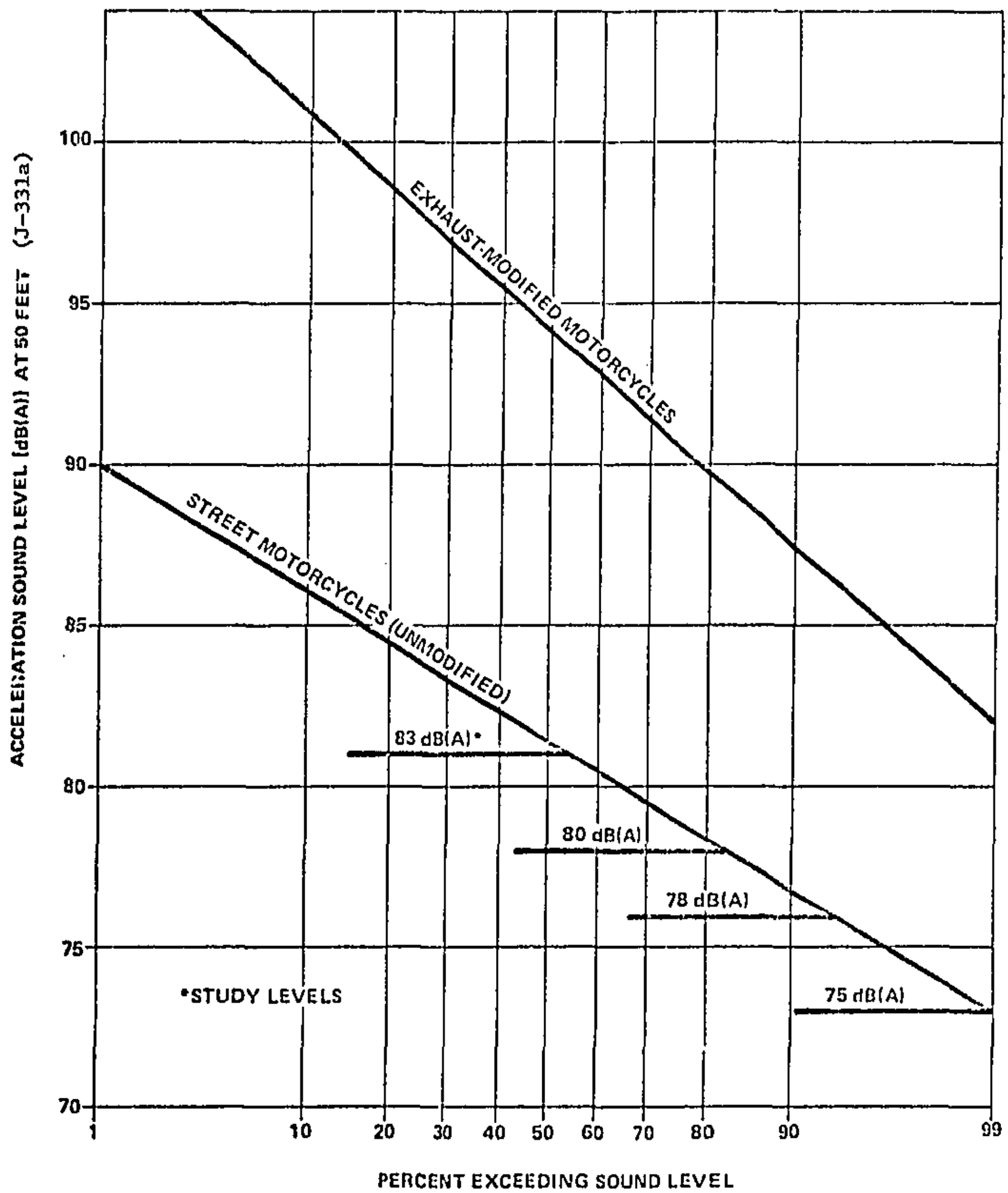
Table 5-2: Regulatory Options Analyzed for Street Motorcycles

Option	Effective Date*			
	1979	1981	1984	1988
1	83	-	-	-
2	83	80	-	-
3	83	80	78	-
4	83	80	78	75

Not-to-exceed Sound Levels (dB(A)) as measured by F-76a procedure. Production levels are assumed to be 2 dB(A) lower than these regulatory levels, as discussed in the text.

*Accelerated lead times, with effective dates of 1979, 1980, 1982, and 1985, and more extended lead times, with effective dates of 1979, 1982, 1986, 1991 have also been analyzed for the 4 regulatory options listed above.

Figure 5-3. Statistical Distributions of Acceleration Sound Levels of Street Motorcycles



NOTE: ASSUMES VARIOUS REGULATORY STUDY LEVEL LIMITS
PRODUCTION LEVEL IS 2 dB(A) BELOW REGULATORY LIMIT

Since quieting a motorcycle to meet a sound level standard based on an acceleration test may not result in a proportional decrease in cruise sound levels, for the purposes of this analysis cruise sound levels will be assumed to remain unchanged by noise emission regulations, with the exception that cruise sound levels cannot exceed the acceleration sound level. This assumption, which understates the benefits of any sound reduction due to regulation, does not materially affect the analysis since acceleration is the principal operational mode of interest.

5.3 Description of Traffic Noise Impact

In order to identify the circumstances in which street motorcycles cause significant noise impact, it is necessary to relate motorcycle sound level distributions to the sound level distributions for other traffic vehicles.

Based on the data contained in Appendix C and Reference 29, Figures 5-4 and 5-5 illustrate the present statistical distributions of sound levels of the various traffic vehicles, in both acceleration and cruise situations, respectively. These figures illustrate that noise from unmodified motorcycles does not stand out in traffic dominated by trucks with current sound levels (but does stand out in automobile-dominated traffic), whereas exhaust-modified motorcycles are noisier than all other vehicles under all operating conditions.

By 1982 heavy and medium trucks will be required to meet a regulatory limit of 80 dB(A), as measured by the J336b test procedure. Figures 5-6 and 5-7 show the truck sound level distributions for this time period, based on the same sort of assumptions used in constructing Figure 5-4 for regulated motorcycles. The J336b distribution is flat at a level of 3 dB(A)* below the regulatory limit, and unchanged for the population of trucks below this level. The cruise distributions are unchanged except they cannot exceed the acceleration sound levels.

When the sound level distributions for the present population of motorcycles are included in Figures 5-6 and 5-7, it can be seen that not only will modified motorcycles continue to be the noisiest vehicles under all conditions, but that a significant fraction of unmodified motorcycles will be louder than trucks under the conditions of interest. Selected study sound levels of various vehicles are shown in Figures 5-6 and 5-7 and it can be seen that a study regulatory level of 80 dB(A) or lower is required to "submerge" motorcycle noise into overall traffic noise.

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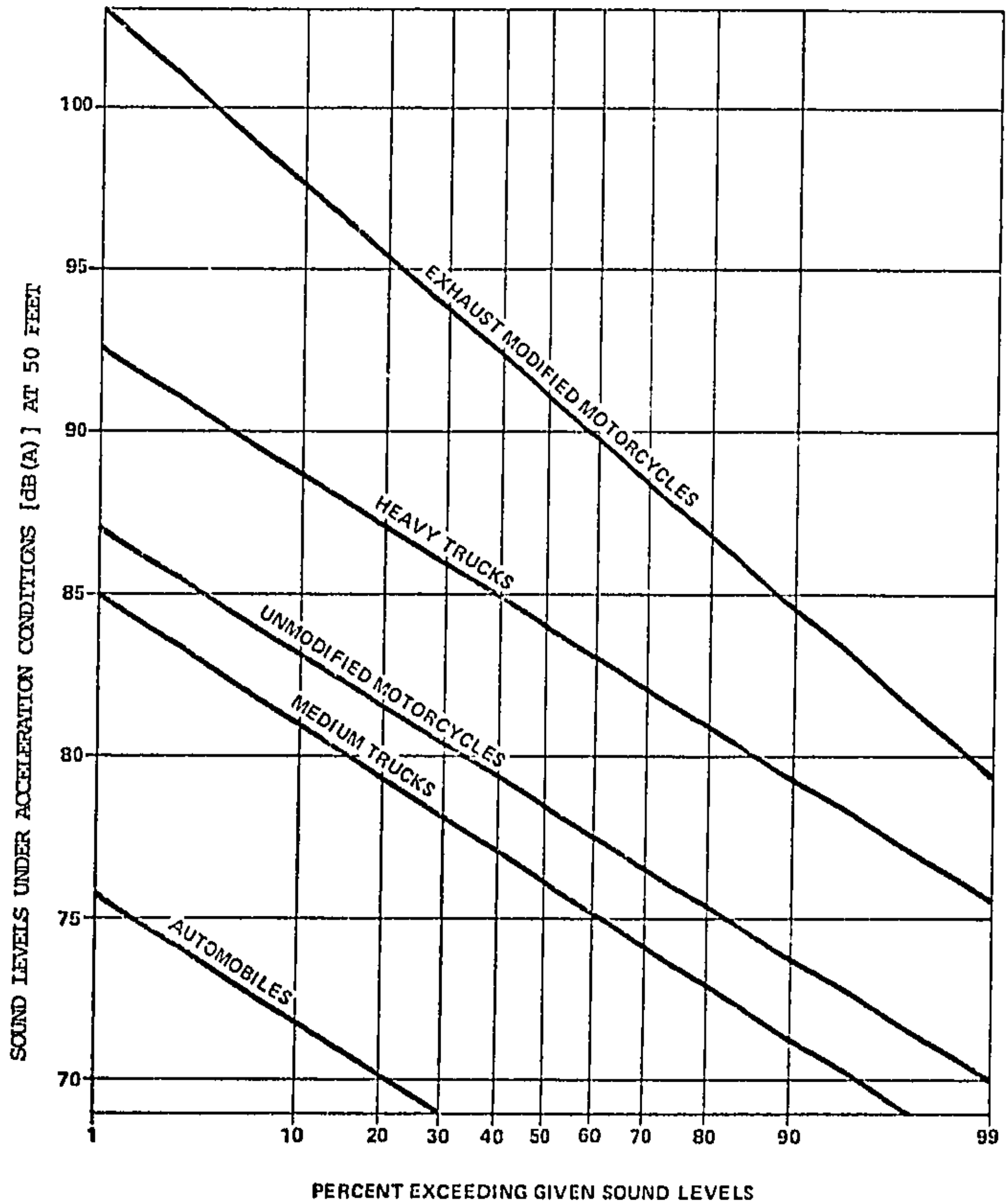
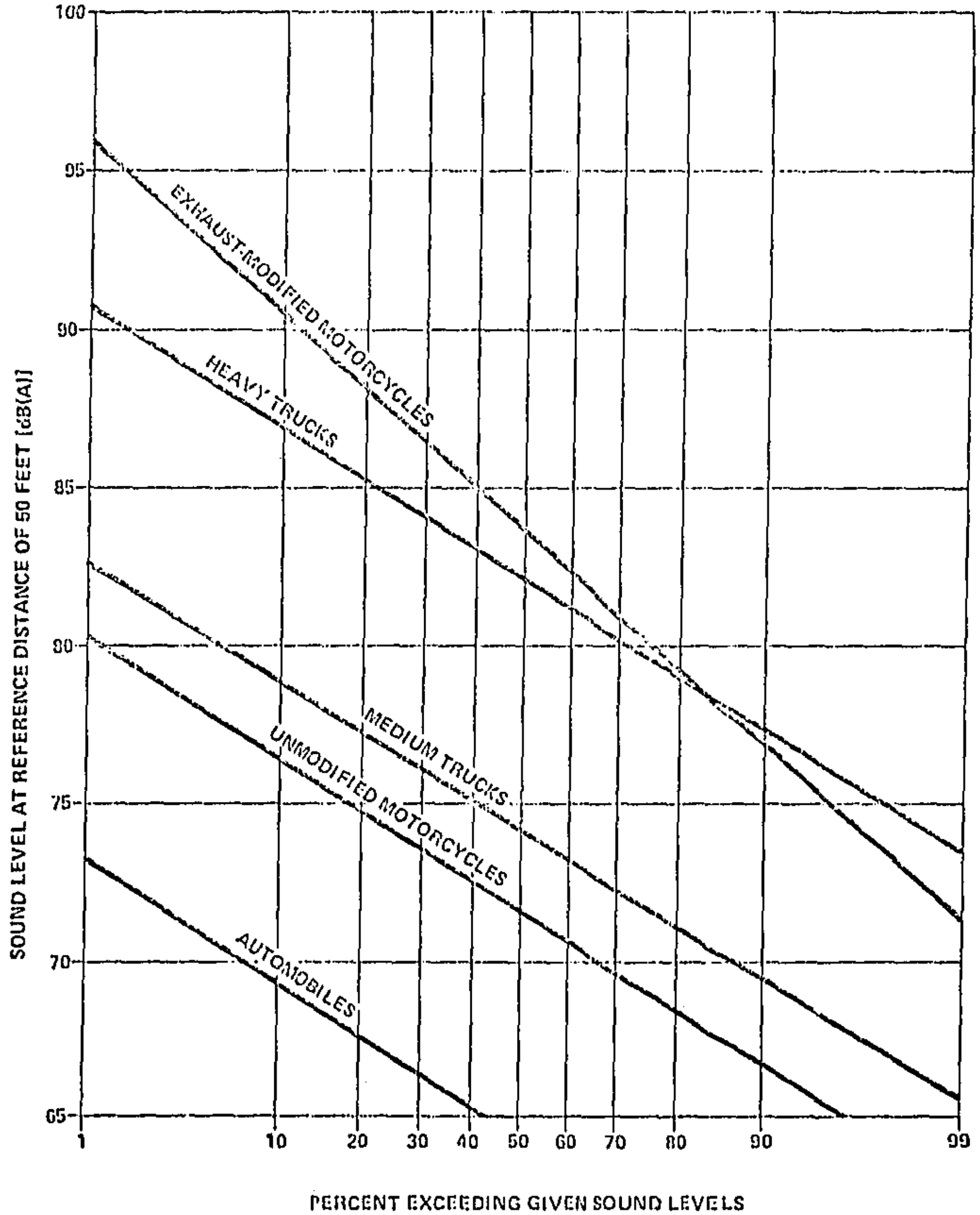
*Allows for production level 2 dB(A) below regulatory level, and typical acceleration level 1 dB(A) below maximum acceleration test level.

Figure 5-4. Distributions of Current Vehicular Sound Levels Under Acceleration Conditions



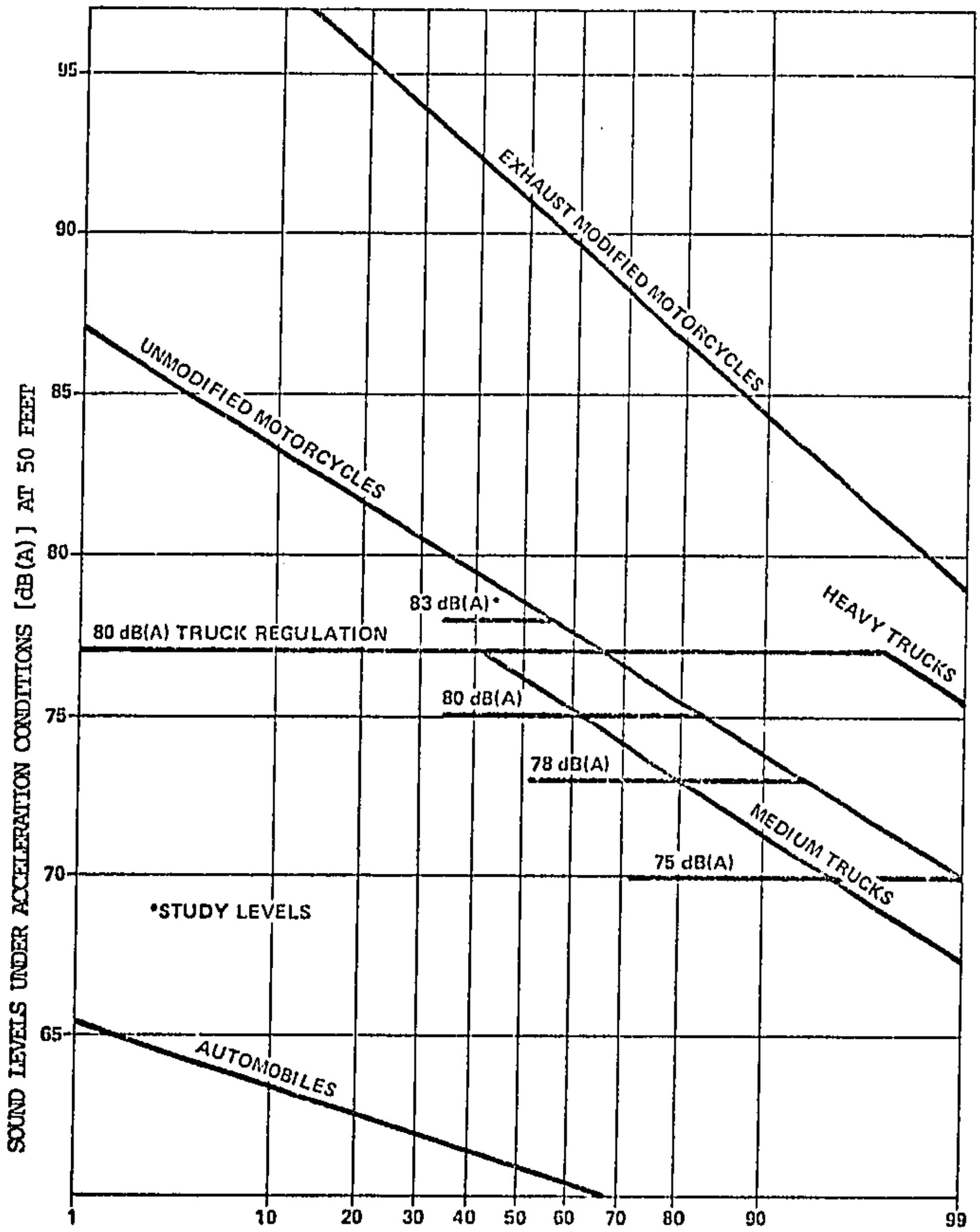
Source: See Text

Figure 5-5. Distributions of Current Vehicular Sound Levels at 27-35 mph Steady Speeds



(Source: See Text)

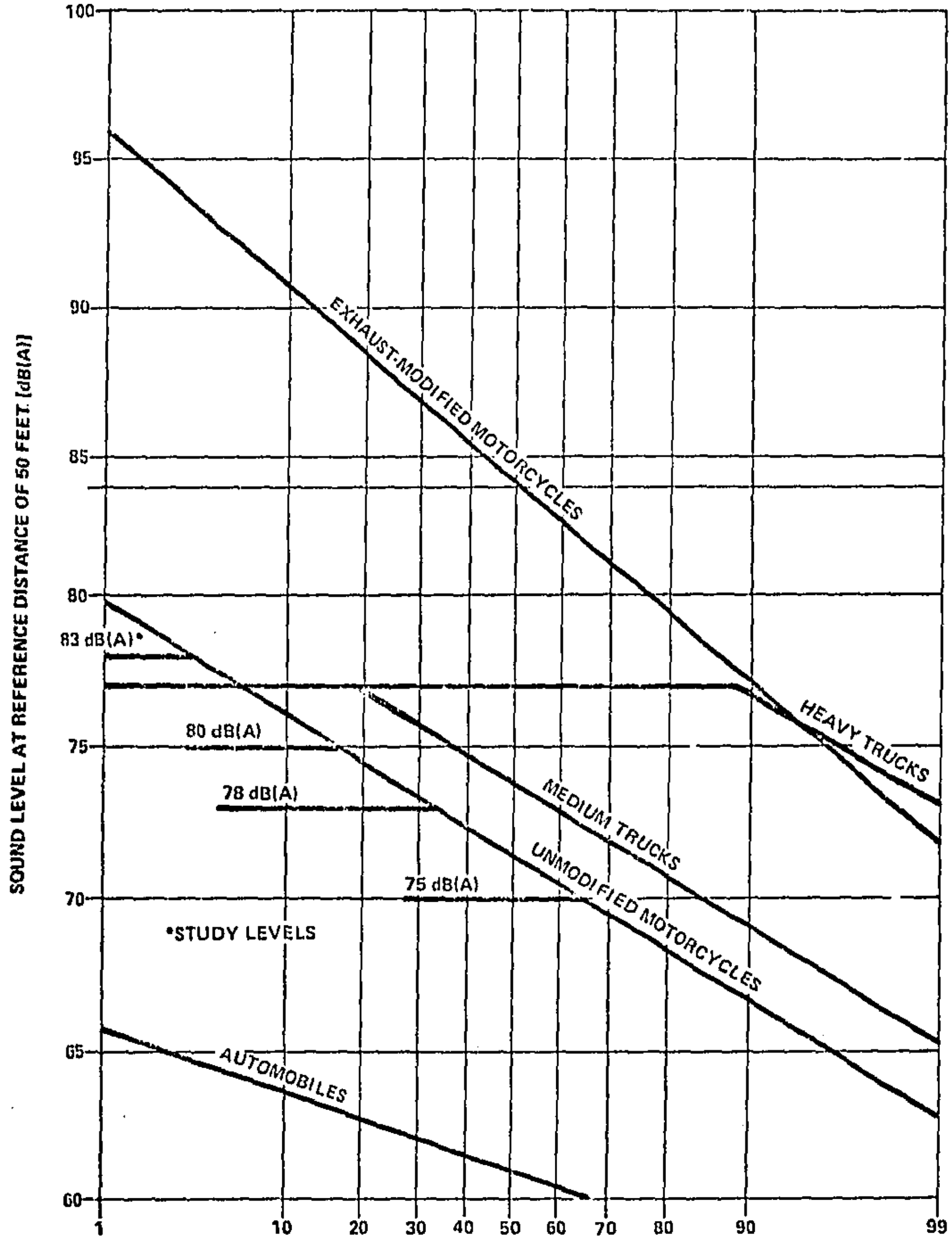
Figure 5-6. Estimated Future Sound Level Distributions for Transportation Vehicles Under Acceleration Conditions



NOTE: ASSUMES VARIOUS REGULATORY STUDY LEVELS

Source: See Text

Figure 5-7. Estimated Future Sound Level Distributions for Traffic Vehicles Under 35 mph Cruise Conditions



NOTE: ASSUMES VARIOUS REGULATORY STUDY LEVELS

Source: See Text

5.3.1 Method for Calculating Traffic Noise Impact

Data for current and projected future street motorcycle sound levels are summarized in Table 5-3. The operation-averaged sound levels were obtained by weighing the acceleration and cruise sound levels according to the time spent in each operational mode (assumed to be, when constrained by traffic, 20% and 80% respectively). Using the same assumption, the operation-averaged sound levels were obtained for other traffic vehicles, and are shown in Table 5-4.

These operation-averaged sound levels are combined in the next step to form the energy-average traffic sound level. This level is computed by weighting the operation-averaged level produced by each type of vehicle according to its relative frequency in a typical traffic mix (indicated in Table 5-4).

Projections of reductions in average traffic sound levels due to noise emission regulations are presented for urban street traffic where the average vehicle speed is assumed to be 30 mph. Additional benefits may accrue on highways where the average vehicle speed is assumed to be 55 mph. Note, however, that the benefits derived from the regulatory schedules for new motorcycles considered here will be less for highway traffic than for urban street traffic for several reasons:

- The number of people exposed to highway traffic noise is less than the number of people exposed to urban street traffic noise (Ref. 29).

- The reductions in traffic noise emissions resulting from new motorcycle regualtion will be less in freeway traffic than in urban street traffic.

- Only a small proportion of motorcycle miles occur on freeways and highways (Refs. 6 and 9).

As predicted in Figure 5-8, the number of people exposed to highway traffic noise is much smaller than the number of people exposed to urban street traffic noise. According to References 6 and 9, only a very small fraction of motorcycle miles occur on highways. For these reasons, only urban street traffic situations are included in this analysis.

To perform the final step in determining the impact of motorcycles in traffic, a noise measure must be utilized which condenses the information contained in a given noise environment into a simple indicator of the quantity and quality of noise, and which is a good descriptor of the overall long-term effects of noise on the public health and welfare. EPA has chosen the equivalent A-weighted sound level in decibels, L_{eq}, as its general measure for environmental noise (Ref. 13). L_{eq} is defined as:

Table 5-3: Sound Levels for Street Motorcycles (dB(A))

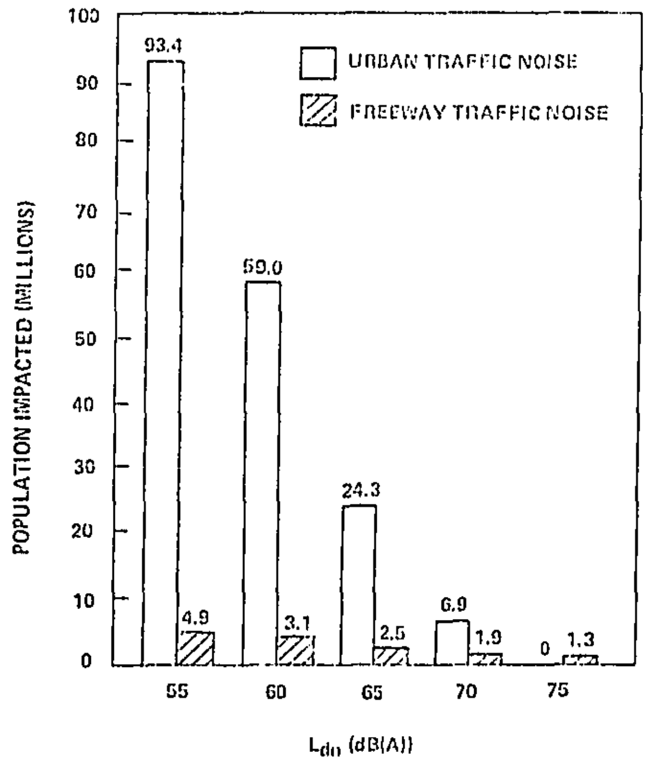
	Acceleration			35-mph Cruise			Operation-Averaged Equivalent Level
	Statistical Median Value	Standard Deviation	Energy-Average Level	Statistical Median Value	Standard Deviation	Energy-Average Level	
Exhaust-modified Motorcycles	91	5.3	94.23	84	5.3	87.23	89.79
Unmodified Motorcycles Current	78.5	3.7	80.07	71.5	3.7	73.07	75.63
83 dB(A) Study Level*	--	--	77.06	--	--	73.07	74.21
80 dB(A) Study Level	--	--	74.84	--	--	72.82	73.31
78 dB(A) Study Level	--	--	72.92	--	--	72.44	72.54
75 dB(A) Study Level	--	--	70	--	--	70	70

*Regulatory Level - Production Level is assumed to be 2 dB(A) lower.

Table 5-4: Operation-Averaged Sound Levels for Non-Motorcycle Vehicles (dB(A)

Type of Vehicle	Urban Street dB(A)			Percent of Traffic Volume (Refs. 11, 27)
	L_{50}	σ	L_a	
Heavy Trucks (Ref. 29)				
(a) Unregulated	85.0	3.7	86.6	1.3
(b) 80 dB(A) Regulatory Level	74.6	2.0	75.1	
(c) 75 dB(A) Regulatory Level	70.8	2.0	71.3	
Medium Trucks (Ref. 29) (including buses)				
(a) Unregulated	77.0	3.7	78.6	5.9
(b) 80 dB(A) Regulatory Level	74.6	2.0	75.1	
(c) 75 dB(A) Regulatory Level	70.8	2.0	71.3	
Automobiles (Ref. 29)				
(a) Unregulated	65.0	3.7	66.6	91.1
(b) Assumed Regulation	61.0	2.0	61.5	
Motorcycles:	See Table 5-4			1.7

Figure 5-8. Estimated Number of People in Residential Areas Currently Subjected to Traffic Noise Above L_{dn} = 55 dB(A)



(Source: Reference 29)

$$L_{eq} = 10 \log_{10} \left[\frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} \frac{P^2(t)}{P_0^2} .dt \right] \qquad (3)$$

where $t_2 - t_1$ is the interval of time over which the levels are evaluated, P(t) is the time-varying magnitude of the sound pressure, and P_0 is a reference pressure standardized at 20 micropascals. When expressed in terms of A-weighted sound level L_A, the equivalent A-weighted sound level, L_{eq}, is defined as:

$$L_{eq} = 10 \log_{10} \left[\frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} 10^{L_A(t)/10} .dt \right] \qquad (4)$$

In describing the impact of noise on people, a measure termed the day-night average sound level (L_{dn}) is used. This is a 24-hour measure with a weighting applied to nighttime sound levels to account for the increased sensitivity of people to intruding noise associated with the decrease in background noise levels at night. Specifically, L_{dn} is defined as the equivalent noise level during a 24-hour period, with a 10 dB weighing applied to the equivalent level during the nighttime hours of 10 p.m. to 7 a.m. This may be expressed by the following equation:

$$L_{dn} = 10 \log_{10} \frac{1}{24} \left[15 \cdot 10^{L_d/10} + 9 \cdot 10^{(L_n+10)/10} \right] \qquad (5)$$

where L_d is the "daytime" equivalent level obtained between 7 a.m. and 10 p.m., and L_n is the "nighttime" equivalent level obtained between 10 p.m. and 7 a.m.

In order to assess the impact of traffic noise, a relation between the changes in traffic noise and the responses of the people exposed to the noise is needed. Responses may vary depending upon previous exposure, age, socio-economic status, political cohesiveness, and other social variables. In general, however, for residential locations, the average response of groups of people is related to cumulative noise exposure as expressed in a measure such as L_{dn} (Ref. 12). For example, the different effects of noise such as hearing damage, speech, other activity interference, and annoyance were related to L_{eq} or L_{dn} in the EPA Levels Document (Ref. 12). For the purposes of this analysis, criteria based on L_{dn} as presented in the EPA Levels Document are used. Furthermore, it is assumed that if the outdoor level meets $L_{dn} \leq 55$ dB, (identified in the EPA Levels Document as the level requisite to protect the public health and welfare with an adequate margin of safety), no adverse impact in terms of general annoyance and community response exists.

The community reaction and annoyance data contained in Appendix D of the EPA Levels Document (Ref. 12) show that the expected reaction to an identifiable source of intruding noise changes from "none" to "vigorous" when the day-night noise level increases from 5 dB below the level existing without the presence of the intruding noise to 19.5 dB above the level before intrusion (Ref. 12). Thus, 20 dB (L_{dn} = 55 to 75 dB) is a reasonable value to associate with a change from 0 to 100 percent impact. Such a change in level would increase the percentage of the population which is highly annoyed to 40 percent of the total exposed population (Ref. 12). Furthermore, the data in the Levels Document suggest that within these upper and lower bounds the relationship between impact and level varies linearly, that is, a 5 dB excess (L_{eq} = 60 dB) constitutes a 25 percent impact, and a 10 dB excess (L_{eq} = 65 dB) constitutes a 50 percent impact.

For convenience of calculation, percentages of impact may be expressed as fractional impact (FI). The fractional impact method explicitly accounts for both the extent and severity of impact. An FI of 1.0 represents an impact of 100 percent, in accordance with the following formula:

$$FI = \begin{cases} 0.05\ (L-55) & \text{for } L > 55 \\ 0 & \text{for } L \leq 55 \end{cases} \qquad (6)$$

where L is the observed or measured L_{dn} for the environmental noise. Note that FI can exceed unity for exposures greater than L_{dn} = 75.

The impact of traffic noise may be described in terms of both extensiveness (i.e., the number of people impacted) and intensiveness (i.e., severity of impact). The fractional impact method explicitly accounts for both the extent and severity of impact.

The magnitude of the impact associated with a given level of traffic noise (L_{dn}^{i}) may be assessed by multiplying the number of people exposed to that level of traffic noise by the fractional impact associated with this level as follows:

$$ENI^{i} = (FI_i)\ P_i \qquad (7)$$

where ENI^i, the equivalent noise impact, is the magnitude of the impact on the population exposed to traffic noise L_{dn}^i, and is numerically equal to the number of people who would all have a fractional impact equal to unity (100 percent impacted). FI_i is the fractional impact associated with an equivalent traffic noise level of L_{dn}^i and P_i is the population exposed to this level of traffic noise. To illustrate this concept, if there are 1000 people living in an area where the noise level exceeds the criterion level by 5 dB (and thus are considered to be 25 percent impacted, FI = 0.25), the environmental noise impact for this group is the same as for 250 people who are 100 percent impacted (1000 x 25% = 250 x 100%).

When assessing the total impact associated with traffic noise, the observed levels of noise decrease as the distance between the source and receiver increase. The magnitude of the total impact may be computed by determining the partial impact at each level and summing the over each of the levels. The total impact is given in terms of the equivalent number of people impacted by the following formula:

$$ENI = \sum_i P_i \cdot FI_i \qquad (8)$$

where FI_i is the fractional impact associated with L_{dn}^i and P_i is the population associated with L_{dn}^i. In this study, the mid-level of each 5 dB sector of levels above L_{dn} = 55 dB is used for L_{dn} in computing ENI.

The change in impact associated with regulations for noise emissions of traffic vehicles may be assessed by comparing the magnitude of the impacts both with and without regulations. One useful measure is the percent reduction in impact, which is calculated from the following expression:

$$\text{Percent Reduction in Impact} = 100 \; \frac{\text{ENI (before)} - \text{ENI (after)}}{\text{ENI (before)}} \qquad (9)$$

The population figures (P_i) in Eq (7) for urban street traffic are based on a survey in which the total population exposed to outdoor noises of L_{dn} above 55 dB was estimated from measurements taken at 100 sites throughout the United States (Ref. 14). The sites were selected far enough from freeway traffic and airports that these sources of noise were not significant contributors to the measured outdoor noise levels. Urban street traffic was a dominant source of noise for each of the survey sites. The results from this study are presented in Table 5-5.

Using the data contained in Table 5-5, an ENI for existing traffic conditions (with trucks not regulated) of 34.6 million is calculated as shown in Table 5-6.

The ENI values associated with reductions in average urban street traffic noise levels are predicted by shifting (reducing) the values of L_{dn} in Table 5-5 by a specified reduction in traffic noise and performing computations similar to those shown in Table 5-6. In following this procedure for estimating ENI, it is assumed that: (1) reductions in urban street traffic sound levels produce equal reductions in the L_{dn} for the outdoor noise, and (2) the population in urban areas will remain constant. The latter assumption is made for convenience only. It does not affect the relative effectiveness of the study regulation schedules. If population increases in urban areas are more or less evenly distributed, only the absolute number of people impacted will be different from the estimates; the relative reductions will remain unchanged. The actual numbers can be approximated by multiplying the ENI estimated for a given year by the fractional population increase expected to occur in that year.

5.3.2 Reduction in Traffic Noise Impact

The reduction in average urban traffic noise expected as a result of motorcycle noise emission regulations is summarized in Table 5-7. Note that if noise emission regulations are applied to other vehicles such as trucks, there will already be an initial reduction in traffic noise,the extent of which is dependent on the stringency of the regulation, the date of its implementation, and the turnover rate for the vehicle population involved. Therefore, two different baseline cases are examined: an 80 dB regulatory limit for new trucks only; and regulatory limits for all vehicles, including a 75 dB regulatory limit for new trucks.

These computations were performed using both normal and accelerated regulatory lead times (shown in Table 5-2). The difference in ENI for the two cases was insignificant, however, since the lead time differences are relatively small and the motorcycle population replacement rate is relatively high.

Since motorcycles comprise only 1.7% of the typical urban traffic stream, reductions in motorcycle sound levels will not result in large reductions in overall traffic sound levels (indicated in Table 5-7). It is apparent from Figure 5-9 that even with a 10 dB reduction in motorcycle sound levels, the impact of current traffic noise (assuming trucks are regulated) is reduced by less than 5 additional percentage points. Reducing the percentage of exhaust modified motorcycles results in a greater improvement, over 15 additional percentage points. Due to anticipated reductions in sound levels of other vehicles, the impact of future traffic noise is projected to be reduced by almost 60%.

The effect of motorcycle noise emission standards in this future quieted environment are shown in Figure 5-10. Unregulated motorcycles will be louder than any other traffic vehicle in this environment. Assuming that modified motorcycles are reduced to 3%, a 78 dB(A) regulatory level

Table 5-5

Distribution of Urban Population at or Greater Than a Specified L_{dn}

L_{dn}	Cumulative Number of People (Millions)	L_{dn}	Cumulative Number of People (Millions)
34	134.09	59	66.738
35	133.94	60	58.997
36	133.76	61	51.234
37	133.46	62	43.668
38	132.99	63	36.542
39	132.34	64	30.061
40	131.46	65	24.320
41	130.37	66	19.352
42	129.04	67	15.200
43	127.53	68	11.791
44	125.87	69	9.046
45	124.09	70	6.853
46	122.19	71	5.155
47	120.15	72	3.826
48	117.98	73	2.776
49	115.64	74	1.963
50	113.01	75	1.347
51	110.12	76	0.889
52	106.80	77	0.559
53	102.98	78	.332
54	98.544	79	.187
55	93.427	80	.093
56	87.665	81	.039
57	81.237	82	.012
58	74.222	83	.002
		84	.0

Source: Ref. 14

Table 5-6

Calculation of Equivalent Number of People Impacted By Urban Street Traffic Noise

L_{dn}^{i}	Population Exposed to L_{dn}^{i} or Higher P_c^i (millions)	Population Exposed to Levels Between L_{dn}^{i} and L_{dn}^{i+1} $P_i = P_c^{i+1} - P_c^i$	Fractional Impact to Mid-Level FI_i	Equivalent Number of People Impacted $FI_i P_i$
55	93.4	34.4	0.125	4.3
60	59.0	34.7	0.375	13.0
65	24.3	17.5	0.625	10.9
70	6.9	5.5	0.875	4.9
75	1.3	1.2	1.125	1.4
80	0.1	0.1	1.375	0.1
			Total ENI =	34.6 M

Source: Ref. 29

Table 5-7: Reduction of Urban Traffic Sound Level (dB(A) at 50 ft.)

Current Baseline Level, All Vehicles Unregulated: 72.26 dB(A)

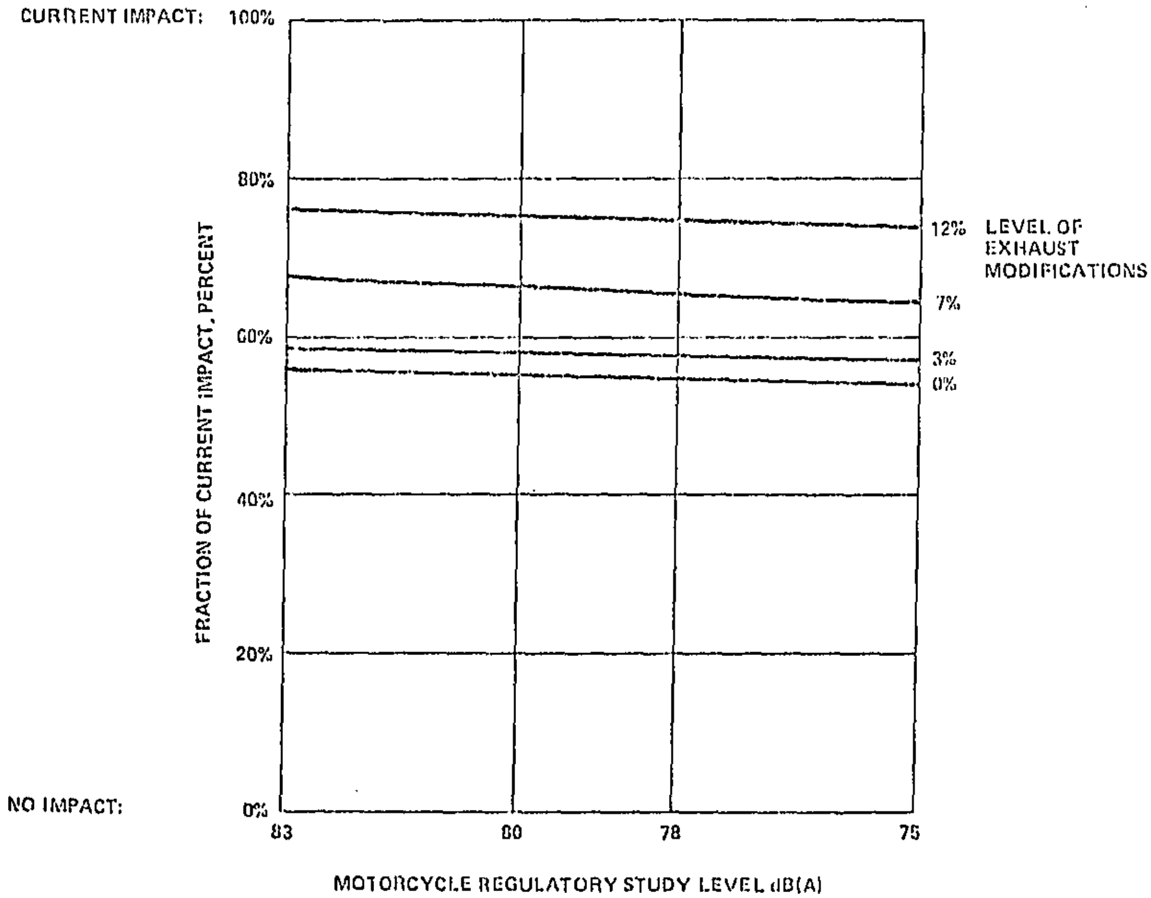
With Trucks Regulated to 80 dB(A)

Motorcycle Regulatory Study Levels--dB(A)	Fraction Modified Motorcycles			
	12%	7%	3%	0%
Current	2.74	3.15	3.47	3.74
83	2.82	3.23	3.56	3.84
80	2.85	3.27	3.61	3.90
78	2.88	3.31	3.65	3.94
75	2.94	3.57	3.73	4.02

With Regulation of All Other Vehicles, Including Trucks at 75 dB(A)

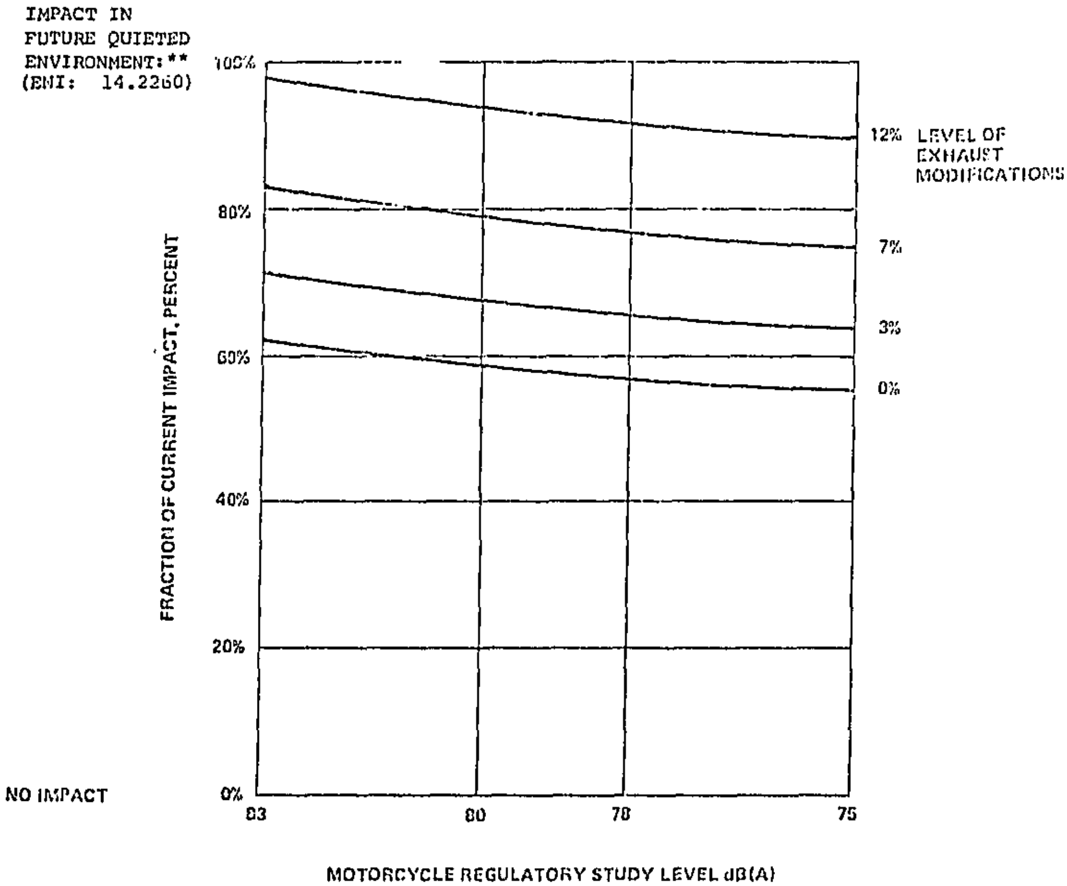
Motorcycle Regulatory Study Level--dB(A)	Fraction Modified Motorcycles			
	12%	7%	3%	0%
Current	5.53	6.78	7.03	7.67
83	5.67	6.99	7.25	7.94
80	5.74	7.10	7.36	8.07
78	5.79	7.17	7.44	8.17
75	5.91	7.37	7.64	8.41

Figure 5-9. Relative Impact of Urban Traffic Noise*
(Current ENI: 34.5800)



*ASSUMES 80 dB(A) TRUCK REGULATORY LEVEL (RESPONSIBLE FOR THE REDUCTION FROM 100% IMPACT--CURRENT IMPACT--TO 76% IMPACT AT 83 dB(A) REGULATORY STUDY LEVEL)

Figure 5-10. Relative Impact of Urban Traffic Noise in Future Quieted Environment* (Current ENI: 34.5809)



*ASSUMES ALL VEHICLES REGULATED (TRUCKS AT 75dB(A) REGULATORY LEVELS)
**NO FURTHER REDUCTION IN MOTORCYCLE NOISE EXCEPT REPLACEMENT

for motorcycles will reduce the impact of future traffic by approximately one-third. Table 5-8 shows the actual number of people exposed to various levels of traffic noise. Although the percentage changes shown in Figure 5-9 are in some instances small, the actual numbers of people exposed may be substantial. For example, with trucks regulated at the 80 dB(A) level, 76.05 million people will be exposed to traffic sound levels of L_{dn} 55 or greater. Reducing motorcycle noise from current levels to a regulatory level of 78 dB(A) would reduce the number of people exposed to these levels by almost one million. If modified motorcycles are limited to 3% of the motorcycle population, traffic sound levels of L_{dn} 55 or greater would impact approximately five million fewer people (76.05 people currently exposed reduced to 70.70 people). The effect of a motorcycle noise regulation in a future traffic environment (with all other vehicles quieted) is, as seen in the second part of Table 5-8, even more dramatic.

5.4 Motorcycles as an Individual Noise Source

To this point, the analysis of motorcycle noise impact has focused on the contribution of motorcycles to day-night average traffic sound levels. The impact contributions which are calculated in this way are somewhat generalized and do not necessarily represent specific impact situations. For example, they do not reflect the fact that a great deal of hourly acoustical energy contributed by motorcycles in a given area may be generated in only a short period of noise during a few accelerations. Yet these short, intrusive events may be the most annoying noise-related situations faced over the entire day by a large number of residents conversing or relaxing in and around their homes. In some situations motorcycle noise will be a constituent of traffic noise, and the conclusions reached by using L_{dn} will be essentially correct. In other instances, however, the motorcycle will be operating in the presence of only one or two other vehicles, and can be considered as a single source.

On some occasions motorcycle noise will be partially masked out by other noise in the environment, and the conclusions reached using L_{dn} will be essentially correct. At other times or situations one can expect that other noise sources will not mask the noise of a passing motorcycle, and thus the motorcycle will cause a finite impact. The actual impact from motorcycles is certainly due to a combination of various levels of motorcycle noise and other environmental noise.

It is difficult to derive a direct measure of the annoyance attributable to the intrusiveness of motorcycle noise. Although numerous surveys indicate that motorcycle noise is a major source of annoyance, there are few scientific studies which have directly related motorcycle sound levels to degrees of annoyance.

Table 5-8: Cumulation Urban Population (millions) vs. Traffic Sound Level (dB(A) at 50 feet)*

With Trucks Regulated to 80 dB(A)

Motorcycle Regulatory Level	Fraction Modified	Day-Night Average Sound Level (L_{DN}) 55	60	65	70	75	80	ENI
Current	12%	76.05	38.39	12.68	3.05	.39	.01	23.14
	3%	70.70	33.50	10.50	2.39	.34	.00	20.52
83	12%	75.48	37.82	12.40	2.97	.37	.00	22.83
	3%	70.03	32.91	10.25	2.32	.25	.00	20.19
80	12%	75.27	37.61	12.30	2.93	.36	.00	22.71
	3%	69.66	32.59	10.12	2.28	.24	.00	20.02
78	12%	75.06	37.40	12.20	2.90	.36	.00	22.60
	3%	69.36	32.33	10.01	2.09	.24	.00	19.84
75	12%	74.64	36.97	12.00	2.84	.35	.00	22.37
	3%	68.76	31.81	9.79	2.18	.23	.00	19.60

With All Vehicles Regulated, Including Trucks at 75 dB(A)

Motorcycle Regualtory Level	Fraction Modified	Day-Night Average Sound Level (L_{DN}) 55	60	65	70	75	80	ENI
Current	12%	54.88	22.34	5.95	1.10	.06	.00	14.22
	3%	43.45	15.10	3.79	.55	.01	.00	10.29
83	12%	53.56	20.99	5.71	1.04	.06	.00	13.65
	3%	42.10	14.45	3.60	.51	.01	.00	9.91
80	12%	53.25	20.64	5.60	1.00	.05	.00	13.31
	3%	41.10	13.97	3.45	.48	.01	.00	9.62
78	12%	52.78	20.33	5.48	.97	.05	.00	13.31
	3%	40.53	13.84	3.36	.50	.01	.00	9.48
75	12%	52.01	19.85	5.33	.94	.04	.00	13.04
	3%	39.11	13.02	3.15	.41	.01	.00	9.04

*For current baseline case, with no regulations, see Table 5-5.

When queried in attitudinal surveys, respondents generally rate motorcycle noise as a major, if not the major, source of annoyance from noise. For example, the response to noise survey questionnaires mailed to a random sample of individuals showed that the respondents rated motorcycles as the major noise "problem" while automobiles and trucks were ranked second and third as noise problems with rankings of 67 percent and 62 percent respectively, relative to motorcycle noise at 100 percent (Ref. 1). In another survey, respondents were asked to rate 25 noise sources on a scale from "not bothering at all" to "extremely bothering". Motorcycles were rated as "not bothering at all" by the smallest percentage of people (32.2 percent) and were rated as "extremely bothering" by the highest percentage of people (12.6 percent). A total of 44.8 percent rated motorcycle noise as either "moderately", "highly", or "extremely" bothering in their neighborhoods (Ref. 2).

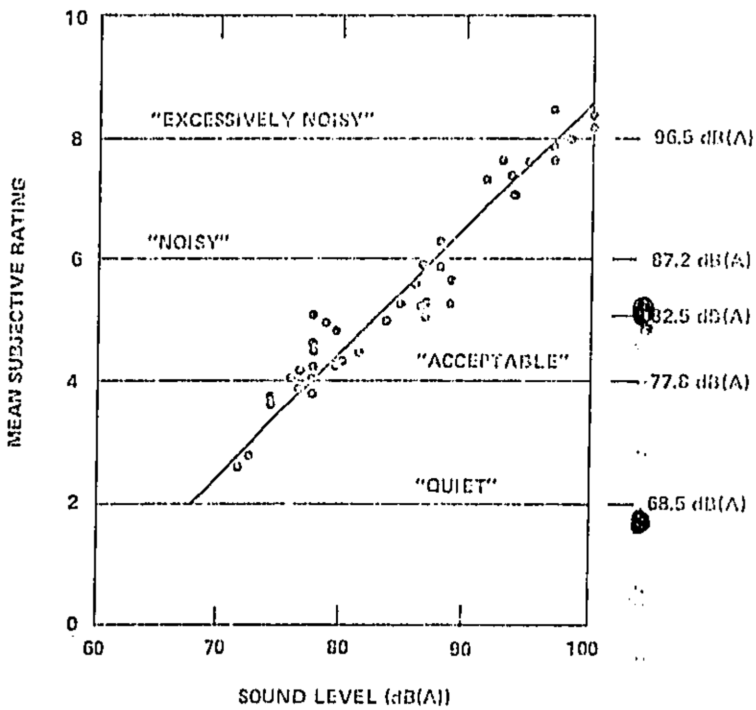
In the same study, people rated traffic noise situations in terms of both intensity and frequency of annoyance. People annoyed by motorcycle noise rated the intensity midway between "definitely annoying" and "strongly annoying". The only vehicle type receiving a higher annoyance intensity rating was buses. In terms of frequency, motorcycles were reported as the source of annoyance 23 percent of the time, second only to automobiles with a 36 percent frequency of annoyance. People are annoyed, it seems, by motorcycle noise greatly out of proportion to actual numbers of motorcycles as compared to other types of traffic vehicles.

The most applicable investigation undertaken is one in which a sample of 57 persons rated vehicular noise at an open-air test track as the vehicles were driven by at a distance of 7.5 meters at the closest point (Ref. 20). Listeners were exposed to both constant speed cruises and accelerations. Figure 5-11 shows the results of the subjective noise rating of motorcycles as a function of A-weighted noise level as heard by the listener. There was little difference in the ratings of 2-stroke and 4-stroke motorcycles. Ratings ranged from "quiet" at 68.5 dB(A) to "excessively noisy" at 96.5 dB(A). These results seem to compare fairly well with those shown in Figure 5-11 for single noise events in which ratings vary from "quiet" at 73 dB(A) to "noisy (strongly)" at 92 dB(A) (Ref. 33).

5.5 Reduction of Single-Event Noise Impact

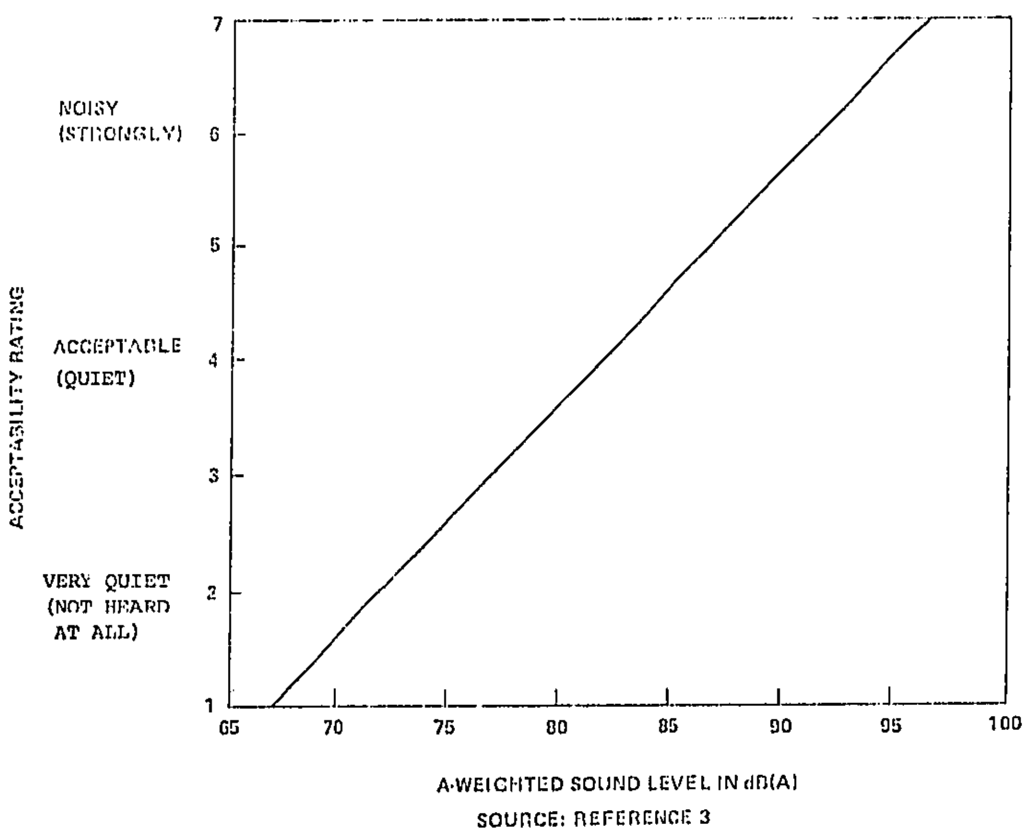
In this section, annoyance caused by motorcycle acceleration noise is analyzed as a single event phenomenon (not part of a continuous traffic stream) in rural, suburban, and residential urban areas. Impacts in high density urban areas have been calculated but are not the focus of this analysis, since motorcycle noise does not frequently occur as a single-event impact in these situations. The previous traffic impact analysis specifically accounts for health and welfare benefits in these high-density urban areas. Potential impacts in high-density urban areas (assuming no traffic masking) are included on page 5-51.

Figure 5-11. Subjective Noise Rating of Motorcycle Sound Levels



SOURCE: REFERENCE 20

Figure 5-12. Individual Judgements of Acceptability of Single Noise Events



Annoyance is a difficult reaction to measure. It may pass rapidly and the actual cause may remain unnoticed, or it may add to other stimuli, causing stress and leading to physiological problems (Ref. 13, 32). As measured from people's responses to questionnaires on this subject (discussed in Section 5.4), however, there is no doubt that considerable annoyance currently exists due to motorcycle noise.

It is clear that a loud vehicle acceleration may interrupt certain activities such as conversation or sleeping. These interruptions may again lead to annoyance, but can in themselves also represent a degradation of health and welfare. For instance, in a recent study of annoyance caused by different levels of simulated aircraft noise for people seated indoors watching television, annoyance was seen to be partially a result of speech interference (Ref. 30). Not only is a television program or another person speaking more difficult to hear during the time in which a noisy vehicle is passing by, but it has been observed that the distraction from a conversation in which a person is engaged may also cause annoyance. A speaker may behaviorally attempt to cope with the noise intrusion either by increasing his or her vocal effort, or in severe cases, by ceasing to speak altogether until the intrusion subsides. Such behavioral reactions may be quite indicative of general annoyance and disturbance with the intrusive noise event. Similarly, the reaction to a noise intrusion during sleep may in many cases be a change in sleep stage (from "deeper" to "lighter" stage). If the intrusive noise is of sufficient duration or intensity, awakening may result. In either case, repeated disturbance of people's activities may be expected to adversely affect their well-being (Ref. 13).

For these reasons it seems appropriate that the analysis examine the effects of noise on both speech communication and sleep in some detail, in order to determine the direct effect motorcycle noise may have on these activities, as well as to aid in an estimation of the total annoyance attributable to motorcycle noise. These single-event noise intrusions become particularly important in light of anticipated regulations and efforts to reduce noise from other motor vehicles and other urban noise sources. Without a reduction in motorcycle noise, the motorcycle may very well stand out as one of the most intrusive noise sources in the community.

5.5.1 Speech Interference

The interference of speech (i.e., conversation) due to other noise intrusion can occur when people are both indoors and outdoors. For purposes of this analysis, it will be assumed that virtually all conversation takes place during the daytime hours; thus, only "daytime" (7 a.m. to 10 p.m.) motorcycle operations will be considered to contribute to speech disruption, whereas only "nighttime" operations will be considered to contribute to the disruption of sleep. Data are not avaliable on the number of motorcycle miles occurring at night. In this analysis it is assumed that the vast majority of motorcycle mileage, 95% of the total, occurs during non-sleeping hours. This assumption is a "best guess" and may over-estimate the magnitude of speech interference and underestimate the absolute magnitude of sleep disturbances. The relative benefits in each case, however, is unaffected by this assumption.

Conversation can be disrupted by externally propagated motorcycle noise both inside and outside the home. These two situations will be examined separately. In the discussions that follow, "inside the home" and "outside the home" should be taken to mean respectively "inside any building" and "outside any building".

It is estimated that motorcycles travel a total of 19.7 million miles daily on street and highway systems (Ref. 8). Since there are only some 3 million miles of roads and highways in the United States, public exposure to motorcycles is seen to be quite commonplace. However, there is little information to indicate how motorcycle mileage is distributed between the various land-use areas (high density urban, rural, etc.).

It is assumed in the following analysis that motorcycle miles are apportioned among the various land-use areas in the same manner that the population is distributed. Based on the population data in Ref. 28, this distribution is shown in Table 5-9. This assumption does not account for people living in suburban and rural areas who commute to urban areas. A major portion of street motorcycle operations, however, consist of recreational riding (Ref. 8). It seems reasonable that this kind of operation would generally occur in suburban and rural areas, and would therefore balance commutation to urban areas.

Since motorcycle acceleration sound levels are considerably higher than cruise sound levels, it is important to determine the relative frequency of acceleration situations. The average number of stops per mile for various types of road systems has been determined (Ref. 9), and appear in Table 5-9 for each generalized type of road system. It is assumed that such values are reasonably representative of the frequency of motorcycle accelerations from complete stops. Although not presented in Table 5-9, the percentages of time spent in various modes of operation conform quite well with data obtained for passenger cars and trucks in other studies (Ref. 9).

Table 5-9. Motorcycle Mileage and Road Statistics

Road Type	Fraction of Total Motorcycle Miles	Stops/Mile*	Acceleration Miles/Day
Rural	26%	0.1	20,000
Suburban	49%	1.5	564,000
Urban Residential	18%	1.77	243,000

*Ref. 9

Based on 7.2 billion street motorcycle miles per year (Ref. 8)

Note: High density urban mileage and highway mileage are not included in this single-event analysis.

For the purposes of this analysis, a representative motorcycle acceleration from a complete stop to 35 miles per hour, unconstrained by traffic, is assumed to occur at an average rate of 0.3 g (5.3 seconds, 135 ft.), somewhat more rapid than for a typical automobile acceleration (Ref. 9). For each acceleration from a stop, one passing acceleration of the same sound level but one-half the distance is added. By multiplying the number of motorcycle miles in each land use area by the number of stops per mile and associated distances, "acceleration" miles are determined. These are also tabulated in Table 5-6.

To determine impact on speech and the reduction in speech interference which would be achieved at different levels of motorcycle quieting, the following method was utilized:

Step 1. Representative energy-averaged acceleration sound levels at 50 feet are computed for both modified and stock motorcycles. These data were presented in Table 5-1.

Step 2. The distances from a typical motorcycle acceleration at which these levels are decreased in steps of 5 dB are calculated (Figure 5-13). These distances are taken to begin from the center of the roadway.

Step 3. The number of people living in 5 dB bands from the 50-foot acceleration level is calculated by multiplying the population density of the land uses in which the motorcycles operate by the width of the 5 dB bands (calculated in Step 2) and then by the number of motorcycle acceleration miles within the given land uses. Depending on land use, the first 50 to 90 feet (as indicated in Table 5-11) on each side of the center line are assumed to be part of the roadway and adjoining sidewalk, and thus assumed to contain no people.

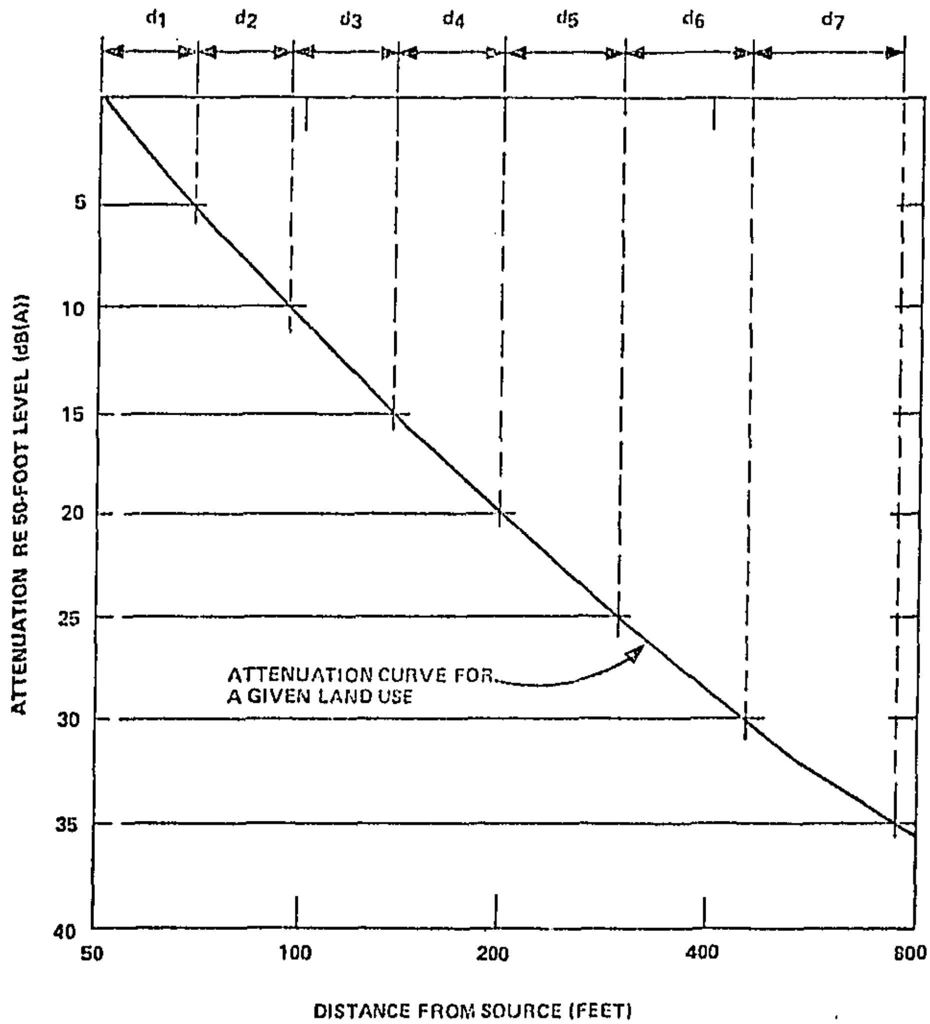
Step 4. Speech impact is calculated for each of the 5 dB(A) bands. The impact, expressed as a fraction, is derived from a curve relating speech interference to equivalent sound level (Figure 5-17).

Step 5. The relative total impact is computed in each band by multiplying the number of people living in each band (from Step 3) by the associated fractional impact (from Step 4.).

This methodology is discussed in more detail, as follows:

Step 1 - Discussed above.

Figure 5-13. Illustrative Example of Calculation of Distances Between Stops of 5 dB(A) Attenuation from the 50 Foot Average Motorcyle Sound Level



Step 2 - For the purpose of analyzing motorcycle acceleration noise in this section, each of the land use areas is assumed to have a simplified mix of high-rise, low-rise, and open-spaced areas which correspond to different propagation laws (Table 5-10). The computation of the distance between each 5 dB(A) attenuation band from the motorcycle involves determining the sound attenuation characteristics typical of each area. In low-rise areas, the sound propogates radially, and attenuation is correspondingly greater. In urban high-rise areas the building density may be so great that the noise rom a point source, such as a motorcycle, located in the middle of an intersection, decays in the lateral direction as if the vehicle were a line source: the acoustical waves have no chance to dissipate in the direction parallel to the motorcycle's line of travel. In addition to these two forms of laterally directed geometric spreading, building, ground, and air absorption also contribute to attenuation. A review of recent literature on urban sound propagation produced the attenuation values for traffic line sources shown in Figure 5-14. Applying the same attenuation values to point source spreading losses yields the curves of Figure 5-15. As a simplification, all low-rise areas are assumed to have point source attenuation characteristics, and all high-rise areas are assumed to have line source characteristics.

The attenuation of noise in rural areas also involves many factors (Figure 5-16). The low density of buildings in rural areas allows us to neglect building reflection and absorption, so the distance computations are straightforward.

Step 3 - Once the 5 dB(A) band distances are known, the band width area within each land use category may be calculated by multiplying the 5 dB(A) distances by the number of day time acceleration miles occuring in each category (95% of the values shown in Table 5-9). The number of people living within each band can then be found by multiplying the bandwidth area by the average population density of the locale (the appropriate population densities are indicated in Table 5-11).

It is estimated that people spend an average of 13 daytime hours inside each day (Ref. 31). That is, they spend approximately 87 percent of the day inside. Taking this fraction of the number of people in each band, the indoor speech impact may be determined. The outdoor speech impact is similarly determined by taking 3 percent of the numbers calculated in step 3 (Ref. 31).. This corresponds to 0.4 hours, estimated to be the time during which people are outdoors each day. It should be noted that the time outdoors does not include pedestrians or people engaged in other forms of transportation during the day. Rather it is intended to include those time periods in which people are relaxing outdoors--either outside a home, business or cultural institution.

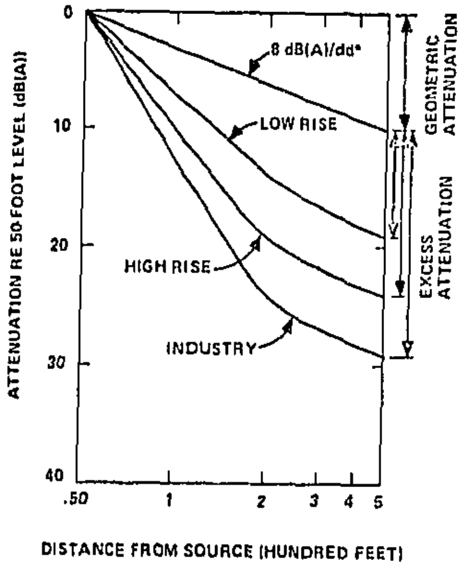
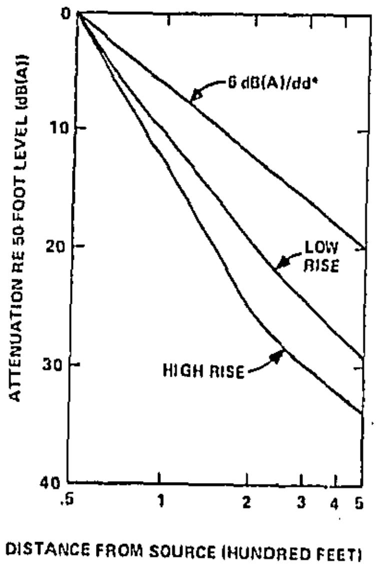


Figure 5-14. Attenuation of Traffic Line Sources, by Urban Land Use[34]



*dd = DOUBLING OF DISTANCE

Figure 5-15. Predicted Attenuation of Point Sources, by Urban Land Use

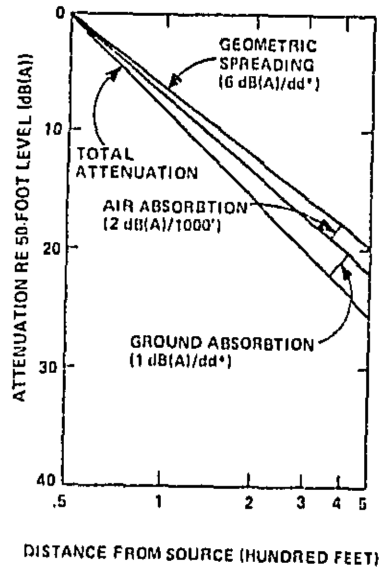


Figure 5-16. Attenuation of Point Source Noise Levels Over Open Terrain[35]

Table 5-10

Assumed Mix of Building Types and Land Uses Impacted

	Percent of Different Types of Building Development Corresponding to Different Propagation Laws*		
Land Use	High-Rise	Low-Rise	Open Space
High Density Urban	100	0	0
Low Density Urban	50	50	0
Suburban	0	100	0
Rural	0	0	100

*See Figures 5-16 through 5-18

Table 5-11: Population Densities for Selected Areas of Motorcycle Operation & Average Setback from Street

Land Use Area	Urban Low Density	Suburban	Rural
Average Population Per Square Mile (Ref. 28)	8,473	2,286	20
Average Setback	50 ft.	65 ft.	90 ft.

Step 4 - The criteria for speech interference (percent sentence intelligibility) by motorcycle acceleration noise is given in Figures 5-17 and 5-18 where the proportion of disturbance is plotted as a function of the equivalent level (L_{eq}) of the intruding noise.

Using the energy-averaged typical acceleration levels given in Table 5-1 : L_{max}, the L_{eq} for the duration of a motorcycle acceleration was calcul. using the following equation (Ref. 17):

$$L_{eq} = L_{max} - 10 \log 2.3 (L_{max} - L_b)/10$$

where L_{max} is the maximum level of a triangular time history and L_b is the background level. Different outdoor ambient sound levels are assumed for each land use area: 60 dB(A) for urban areas, 55 dB(A) for suburban areas, and 45 dB(A) for rural areas (Ref. 12, 24). To determine the resulting L_{eq} level inside the home the following transmission losses were applied to the propagated noise levels, depending on land use:

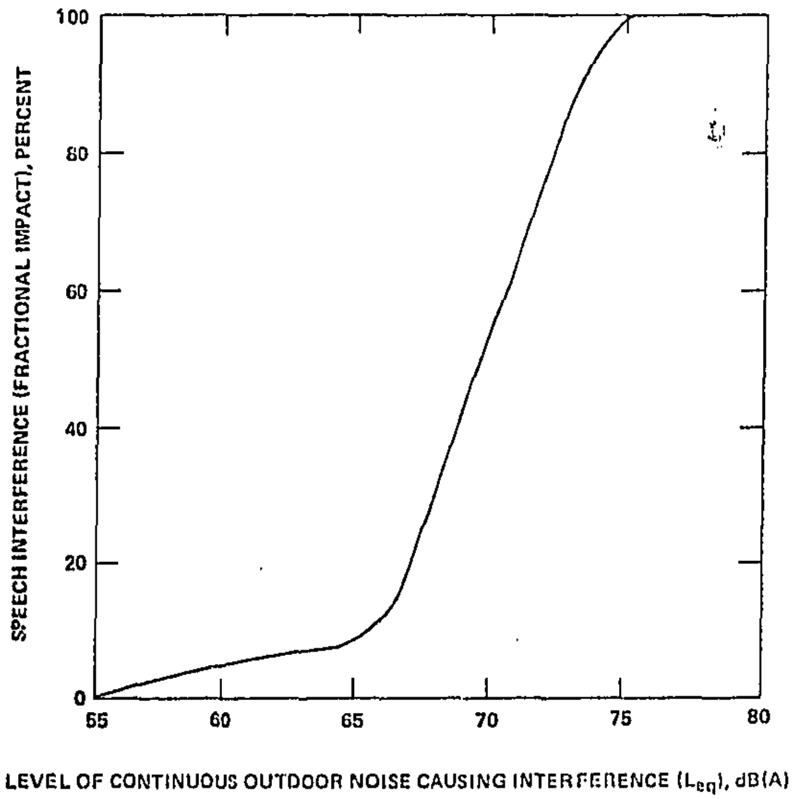
1. An attenuation of 20 dB was used for urban areas to represent an average of the case in which (because of the type of building construction) the windows of half of the homes are open and half are closed (Ref. 29).

2. An attenuation of 15 dB is used for suburban and rural areas to represent an average of the case in which the windows of all homes are open.

Step 5 - The ENI for speech interference is obtained by multiplying the number of people in each band for each land use by the fractional impact criteria (percent speech intelligibility) given in Step 4.

Population distribution as a function of L_{eq}, as calculated in Step 3, is shown in Table 5-12 for each of the study regulatory levels. The relative reduction in outdoor speech interference due to various sound level limits occuring daily, outdoors and indoors, respectively, for motorcycles appears in Figure 5-19. Tables 5-12, 5-13 and 5-14 show the speech interference (ENI) as calculated in Step 5. The relative reduction in indoor speech interferences is approximately the same as that shown in Figure 5-19 for outdoor speech interference.

Figure 5-17. Fractional Impact of Outdoor Speech Interference



NOTE: NORMAL VOICE AT 2 METERS WITH 60 dB(A) IN THE ABSENCE OF INTERFERING NOISE

Source: Reference 12

Figure 5-18. Fractional Impact of Indoor Speech Interference

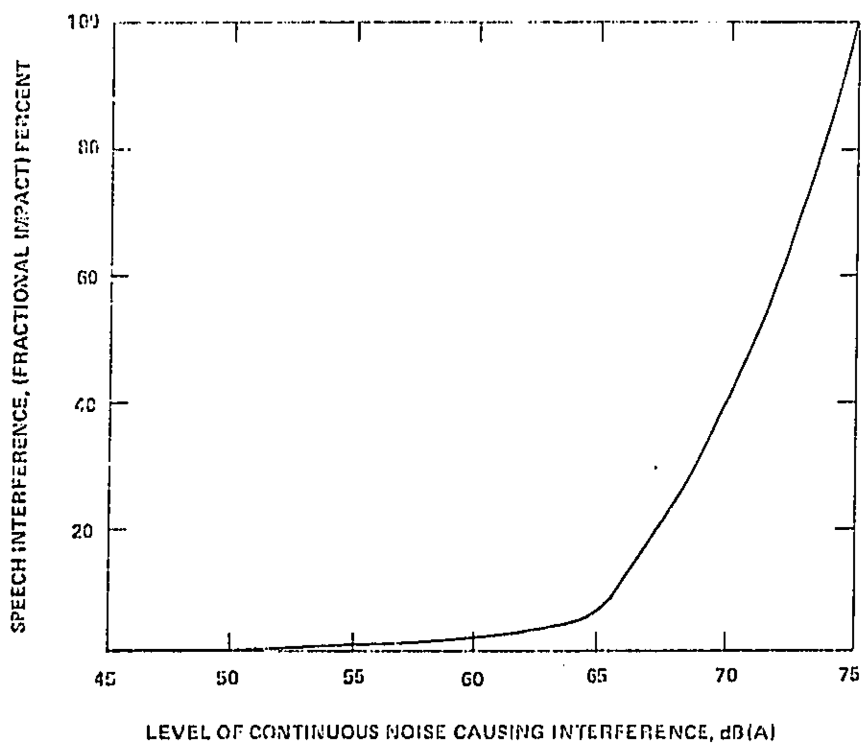
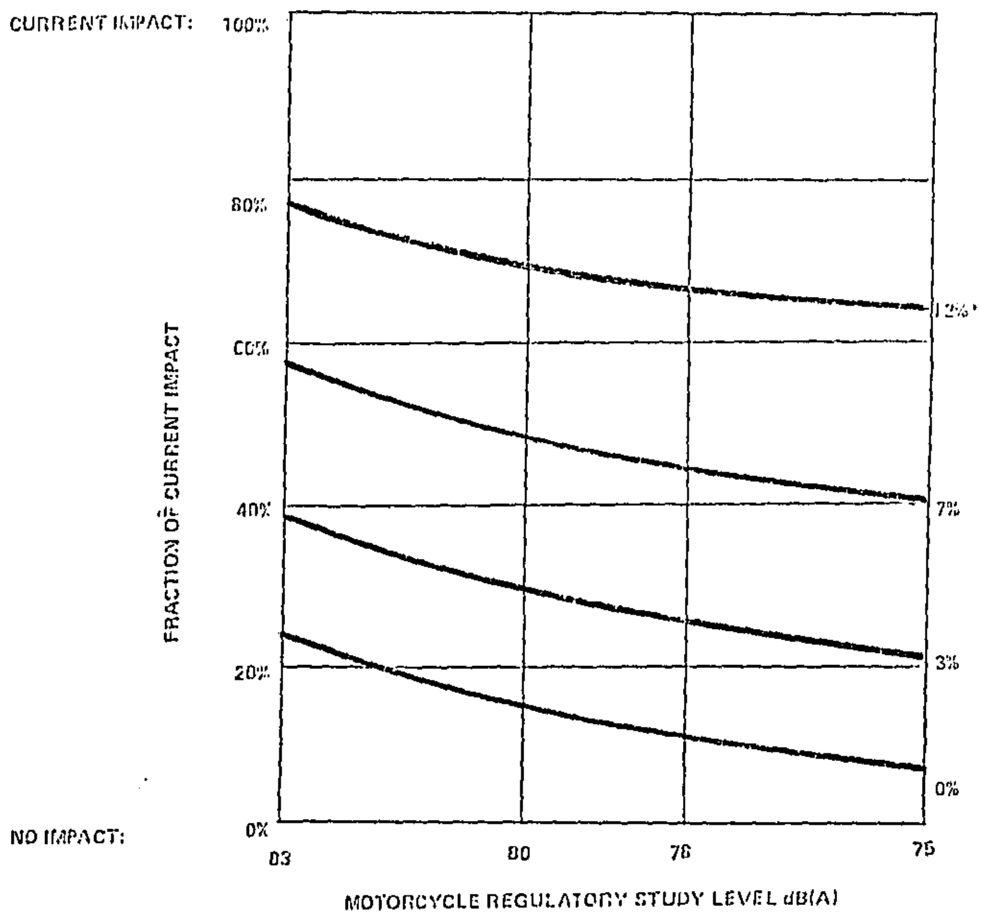


Figure 5-19. Relative Reduction in Outdoor Speech Interferences due to Motorcycle Noise



*FRACTION OF MOTORCYCLES WITH MODIFIED EXHAUST SYSTEMS

Table 5-12. Impact-Events* Distribution as a Function of L_{eq}

	85-80	80-75	75-70	70-65	65-60	60-55
<u>12% Modified</u>						
Regulatory Level						
Current	1,083,000	2,134,000	3,075,000	16,200,000	31,890,000	50,690,000
85	"	"	"	14,570,000	30,430,000	49,030,000
83	"	"	"	13,030,000	29,030,000	47,590,000
80	"	"	"	10,570,000	25,950,000	44,360,000
78	"	"	"	9,950,000	24,320,000	42,810,000
75	"	"	"	8,890,000	19,790,000	40,410,000
<u>3% Modified</u>						
Regulatory Level						
Current	271,000	534,000	769,000	13,950,000	24,360,000	35,320,000
85	"	"	"	12,160,000	22,750,000	33,500,000
83	"	"	"	10,460,000	21,200,000	31,820,000
80	"	"	"	7,740,000	17,810,000	28,350,000
78	"	"	"	7,060,000	16,020,000	26,640,000
75	"	"	"	5,900,000	12,570,000	23,990,000

*Persons can be impacted by more than one event per day.

Table 5-13: Outdoor Speech Interference (ENI) Occurring Daily Due to Motorcycle Acceleration Noise (in Thousands)

	Low Density Urban	Suburban	Rural	Total
12% Modified				
Regulatory Level*				
Current	1242	474	Negligible	1716
85	1059	459	"	1518
83	963	408	"	1317
80	834	394	"	1228
78	807	381	"	1188
75	732	350	"	1082
7% Modified				
Regulatory Level				
Current	996	343	Negligible	1339
85	804	325	"	1129
83	699	272	"	971
80	567	256	"	823
78	537	243	"	780
75	459	209	"	668
3% Modified				
Regulatory Level				
Current	798	236	Negligible	1034
85	597	218	"	815
83	492	163	"	655
80	351	147	"	498
78	321	134	"	455
75	240	98	"	338
0% Modified				
Regulatory Level				
Current	651	156	Negligible	807
85	444	138	"	582
83	333	80	"	413
80	189	65	"	254
78	159	49	"	208
75	75	13	"	88

* dB(A)-J331a

Table 5-14: Indoor Speech Interference (ENI) Occurring Daily Due to Motorcycle Acceleration Noise (in Thousands)

	Low Density Urban	Suburban	Total
12% Modified			
Regulatory Level			
Current	201	254	455
85	183	229	412
83	168	214	382
80	147	192	339
78	138	189	327
75	126	174	300
7% Modified			
Regulatory Level			
Current	156	189	345
85	138	165	303
83	120	147	267
80	99	129	228
78	90	120	210
75	78	105	183
3% Modified			
Regulatory Level			
Current	120	138	258
85	102	111	213
83	84	94	178
80	63	76	139
78	51	67	118
75	39	49	88
0% Modified			
Regulatory Level			
Current	93	98	191
85	75	71	146
83	57	51	108
80	33	33	66
78	24	25	49
75	12	7	19

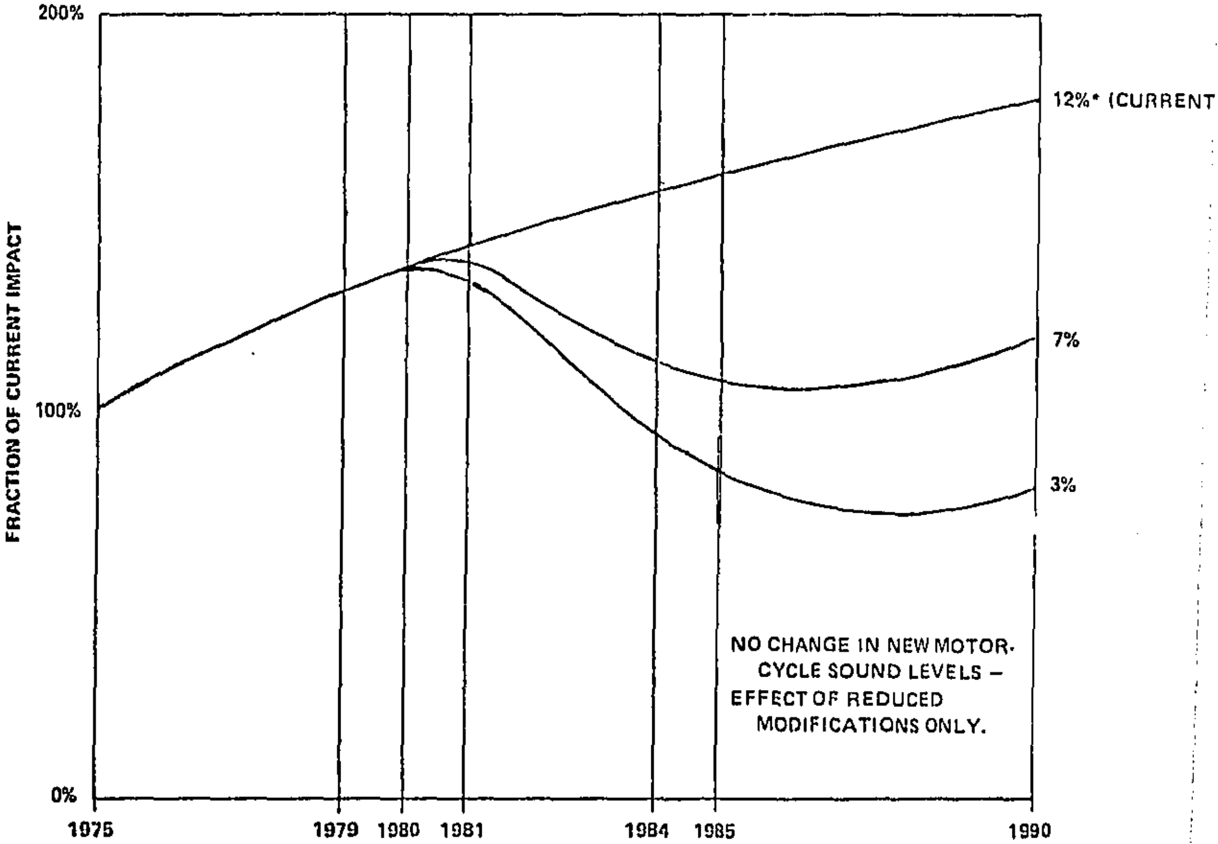
As discussed above, motorcycle impacts in low-density urban, suburban and rural areas has been the focus of the speech interference analysis. In most of these areas motorcycle accelerations stand out as single events above a traffic stream. Excluding high-density urban areas, where many instances of motorcycle noise standing out above traffic undoubtedly occur, was felt to be a reasonable balance for those low-density urban, suburban and rural cases where motorcycle acceleration noise is masked by traffic. However, potential impacts in high-density urban areas, as a separate case, were also assessed. Assuming no traffic masking and a representative background noise level, some 6.4 million potential impact-events could be occuring daily in the U.S. in high-density urban areas due to motorcycles alone. At the 75 dB(A) regulatory level these potential impacts would fall to 4.4 million, a 29.6 percent decline. The relative decline is considerably less than for low-density urban areas and about the same as for the suburban case.

This speech interference analysis represents the change in impact after the motorcycle population has been fully replaced at any given regulatory level (i.e., all motorcycles in the population meet standards). The fully implemented statistics are felt to be the most illustrative for comparison of regulatory alternatives. The benefits, of course, would occur gradually as older motorcycles are replaced by quieter models, with approximately 90% of the ultimate benefits achieved four to five years after the effective date of the final step standard.

These data are also based on the finding that, as a class average, properly used and maintained motorcycles do not degrade significantly over their expected life. Although certain models may degrade somewhat, statistics indicate that other models actually become quieter with use (see Chapter 6). This analysis also assumes that rapidly deteriorating mufflers will be eliminated from the market (to the extent they are not eliminated, they are included in the "percent modified" figures).

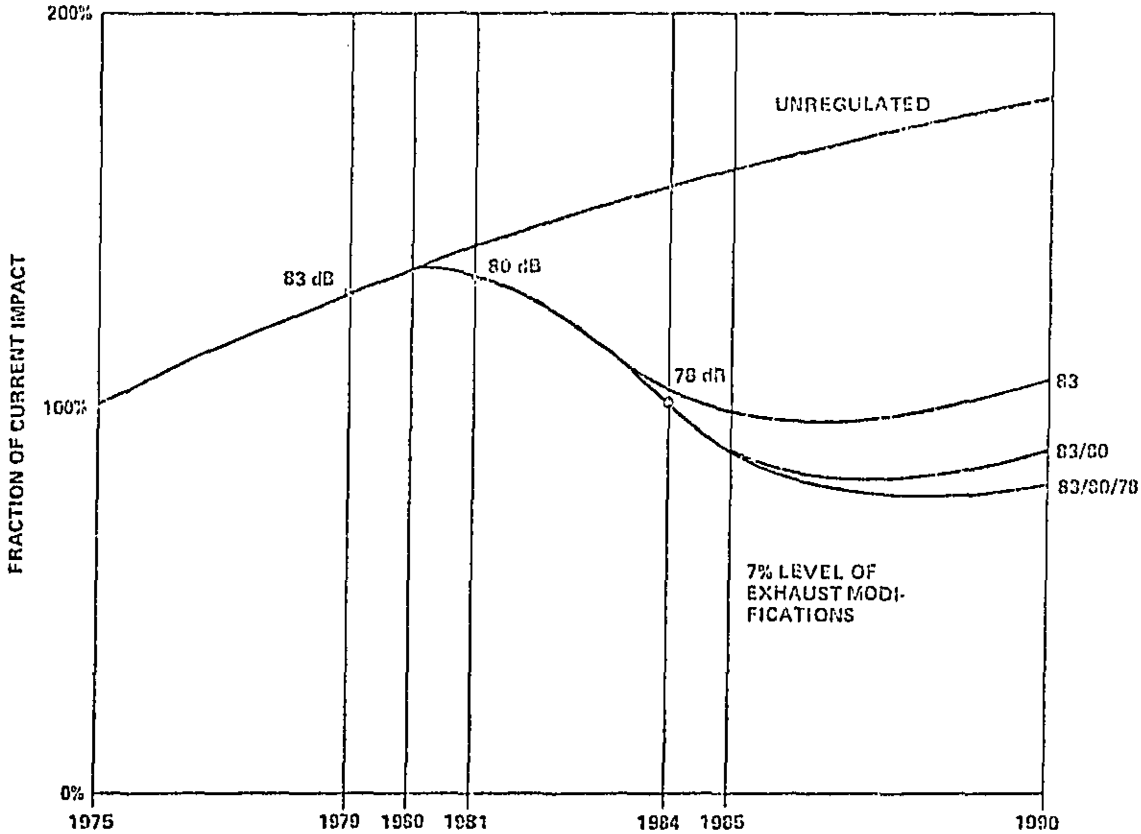
Figures 5-20 and 5-21 show the reduction in outdoor speech interferences over time, projected for the years 1975 to 1990. Figure 5-20 illustrates the effect of reducing only the percentage of modified motorcycles. It should be noted that if the percentage of modified motorcycles remains unchanged, outdoor speech interferences due to motorcycle noise will increase over time, due to projected increases in the total motorcycle population. Figure 5-21 details the reduction in such impacts for various motorcycle regulatory levels. For illustrative purposes, these figures assume that the number of modified motorcycles will be reduced to 7 percent of the street motorcycle population. It should also be noted that the relative benefits over time shown in Figures 20 and 21 for outdoor speech interference will be approximately the same for other noise-induced activity interference effects, i.e., indoor speech interference and sleep disruption.

Figure 5-20. Reduction in Street Motorcycle Impact (Outdoor Speech Interference) Over Time – Effect of Reduced Modifications



*FRACTION OF MOTORCYCLES WITH MODIFIED EXHAUST SYSTEMS.

Figure 5-21. Reduction in Street Motorcycle Impact (Outdoor Speech Interference) Over Time — Three Regulatory Options



5.5.2 Sleep Disturbance

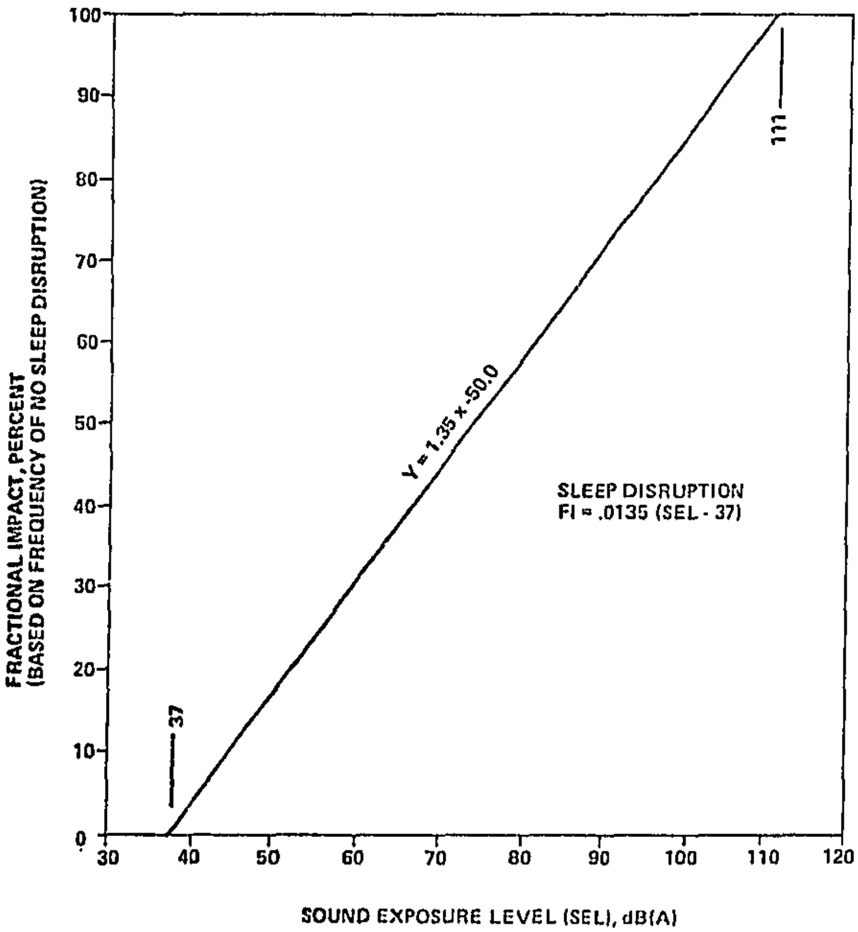
Sleep periods of humans are typically classified into five stages. In stages I and II sleep is light and the sleeper can be easily awakened. Stages III and IV are states of deep sleep in which a person is not as easily awakened by a given noise, but such a stimulus may cause a shift to a lighter stage of sleep. An additional stage of sleep is the rapid eye movement stage (REM), which corresponds to the dream state. When exposed to an intrusive noise, a sleeper may (1) show response by a brief change in brainwave pattern, without shifting sleep stages; (2) shift to a lighter sleep stage; or (3) awaken. The greatest known impact occurs due to awakening, but there are also indications that disruption of the sleep cycle may cause other behavioral changes (irritability, etc.) even though the sleeper may not awaken (Ref. 13).

Recent studies (Ref. 19, 38) have summarized and analyzed sleep disturbance data. These studies show a relationship between frequency of response (awakening or disturbance) and the sound level of a noise stimulus, and determined as well that the duration of the noise stimulus was a critical parameter in predicting response. The studies also showed that the frequency of sleep disruption is predicted by noise exposure better than is arousal or behavioral awakening. Sleep disturbance is defined as any physiological change which occurs as a result of a stimulus. The person undergoing such disturbance may be completely unaware of being affected; however, such disturbance may disrupt the total sleep quality and thus lead to, in certain situations, behavioral or physiological consequences (Ref. 13).

The fractional impact of the disruption of sleep is given in Figure 5-22 where the frequency of no sleep disturbance (as measured by changes in sleep state, including behavioral awakening) is plotted as a function of the Sound Exposure Level (SEL) of the intruding noise. Similarly, the frequency of behavioral awakening as a function of SEL is shown in Figure 5-23. These relationships, adapted from Figures 5-1 and 5-2 of Reference 19, consist of data derived from a review of the recent experimental sleep and noise exposure relationship data.

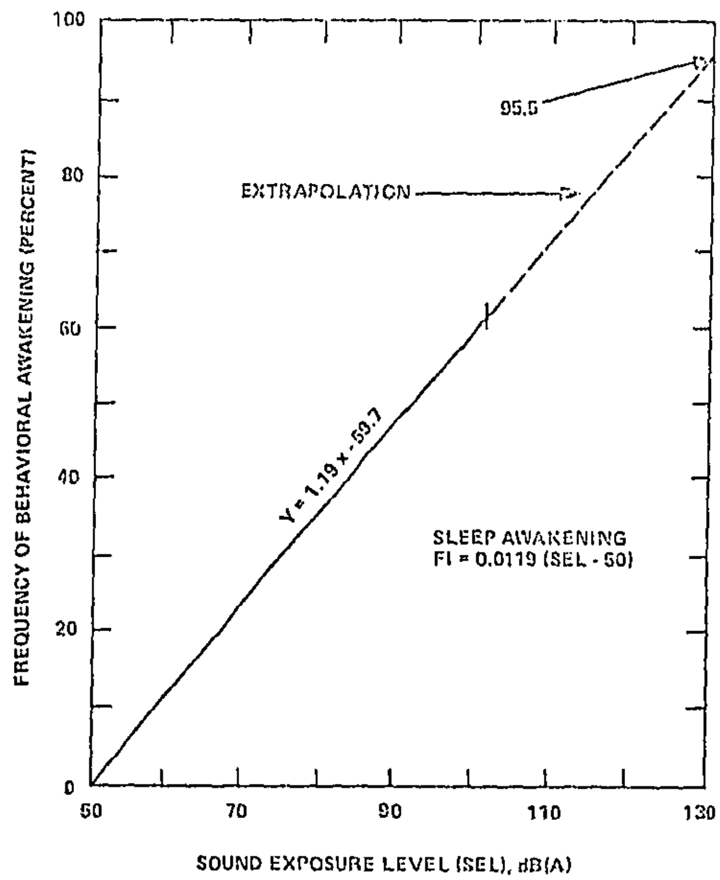
Figures 5-22 and 5-23 indicate the approximate degree of impact (percent disruption or awakening) as a function of sound exposure level. The noise data contained within these references were measured in terms of "effective perceived noise level" with a reference duration of 0.5 second ($EPNL_{0.5\ sec.}$). $EPNL_{0.5\ sec.}$ is converted to Sound Exposure Level (SEL) by using the following approximate relationships:

Figure 5-22. Fractional Impact of Sleep Disruption as a Function of Sound Exposure Level 19 (Regression of Sleep Disruption on SEL)



Source: Reference 19
(Regressions of Sleep Disruption on SEL Revised)

Figure 5-23. Frequency of Arousal or Awakening from Sleep in College or Middle-Aged Men and Women as a Function of Sound Exposure Level (Regressions of Percent Awakened on SEL, Revised)



Source: Reference 19
(Regressions of Percent Awakened on SEL, revised)

$$SEL = EPNL_{0.5\ sec} - 16\ dB$$

The SEL is defined as:

$$SEL = \log_{10} \int_0^t \frac{P(t)^2}{P_o^2}\, dt$$

where:

t is the duration of the noise

P(t) is the A-weighted sound pressure as a function of time

and,

P_o is the reference pressure

For triangular time histories such as vehicular accelerations, an approximation is

$$SEL = L_{max} + 10 \log_{10} t/2$$

where

L_{max} is the maximum A-weighted sound level

and

t is the duration in seconds measured between the "10 dB(A) down" points where the sound level is equal to $L_{max} - 10$.

For the purpose of this analysis, t is equal to the duration of a representative motorcycle acceleration, assumed to be 8 seconds.

Using the representative energy-averaged acceleration levels given in Table 5-1 for L_{max}, the SEL's were found for each motorcycle type. Before the fractional impact was computed, the same reductions in sound levels due to transmission through walls which were used in Section 5.5.1 were taken into account.

As discussed on page 5-36, this analysis uses 5% as the fraction of street motorcycle mileage which occurs during nighttime hours. As discussed above, this may over- or underestimate the actual impact on sleep, but the relative impacts and reductions are unaffected by this assumption. Although some fraction of the population sleeps during the daytime, it is also assumed for purposes of this analysis that sleep only occurs during the nighttime hours.

Propagation loss is computed for each land use category in the same manner as discussed in Section 5.5.1. Again, the distances from the roadway at which the acceleration sound levels fall off in 5 dB(A) steps are computed, and the equivalent number of "impacted people" per mile living within each band is derived using the fractional impact relationship shown in Figures 5-22 and 5-23. These numbers are multiplied by the number of nighttime motorcycle acceleration miles to give the total potential sleep disruption and sleep awakening (ENI) due to motorcycle acceleration noise.

Population distribution according to SEL is shown in Table 5-15. The sleep disruption ENI is given in Table 5-16 for the various study levels, and translated into percent reduction from the current baseline in Figure 5-23. The sleep awakening ENI is indicated in Table 5-17. The associated percent reduction in sleep awakening is approximately the same as that for sleep disturbance, indicated in Figure 5-24.

5.5.3 Other Factors in Reduction of Single-Event Noise Impact

Most commonly used social indicators of the effects of noise and subsequent human response assess the impact of noise primarily in terms of simple A-weighted sound levels or exposure (Refs. 12, 13). The above analysis has used this measure exclusively. The presence of identifiable pure tones, however, and other properties of the sound signal independent of amplitude or frequency distribution are also known to annoy or otherwise impact humans in a manner not adequately predicted by a time-integrated A-weighted measure. For example, pure tone components in aircraft noise are known to be more annoying than broadband noise at the same sound level.

There exist several characteristics of motorcycle noise signals which may result in greater subjective annoyance than would be predicted by simple sound level measures. The irregular impulsiveness of two-stroke engines, for example, and the high frequency tones associated with engine-related mechanical sounds are two characteristics of motorcycle noise that are not properly reflected in currently used sound descriptors. Except for Italian noise standards (see Section 3), EPA knows of no accepted motorcycle noise rating that accounts for these specific temporal and spectral properties of motorcycle noise. The time-integrated A-weighted sound level still remains as the best descriptor currently available for characterizing motorcycle noise.

It should be noted that there is an additional, fundamental problem associated with assessing the objectionable qualities of motorcycle noise. Specifically, some segments of the population are undoubtedly annoyed by motorcycle noise for reasons that have little to do with the sound emitting characteristics of the vehicle. Negative reactions to apparent land destruction, dangerous driving habits and other factors emotionally associated with the motorcycle may be triggered by the mere audible detection of a motorcycle. This does not, of course, negate the fact that people are still annoyed by motorcycle noise even though that response is in some cases an outlet of other, more general reactions to the motorcycle or its operator. Such emotionally associative responses to noise are commonly experienced with other sources of noise as, for example, annoyance with aircraft noise mediated by a fear of aircraft crashes (Ref. 40).

As motorcycle noise emissions are lessened, the number of people who can audibly detect the presence of the motorcycle will be reduced and, accordingly, the general negative reactions discussed above should not occur as often. However, for those individuals within the population segment still exposed to motorcycle noise (even at a reduced level), this "mediated" annoyance may not be significantly reduced. Due to this associative effect a full reduction in motorcycle noise impact may not be fully realized.

5.5.4 Summary

It is to be noted that the preceding analysis of street motorcycle noise impact is meant to be a conservative estimate of the dimensions of this problem. The various assumptions which must necessarily be made in an analysis of this nature have been consistently made with the intent that any error would tend to underestimate, rather than overestimate the amount of impact. It is quite possible that the impact figures which are derived in the analysis do substantially underestimate the actual impact of motorcycle noise on the public health and welfare.

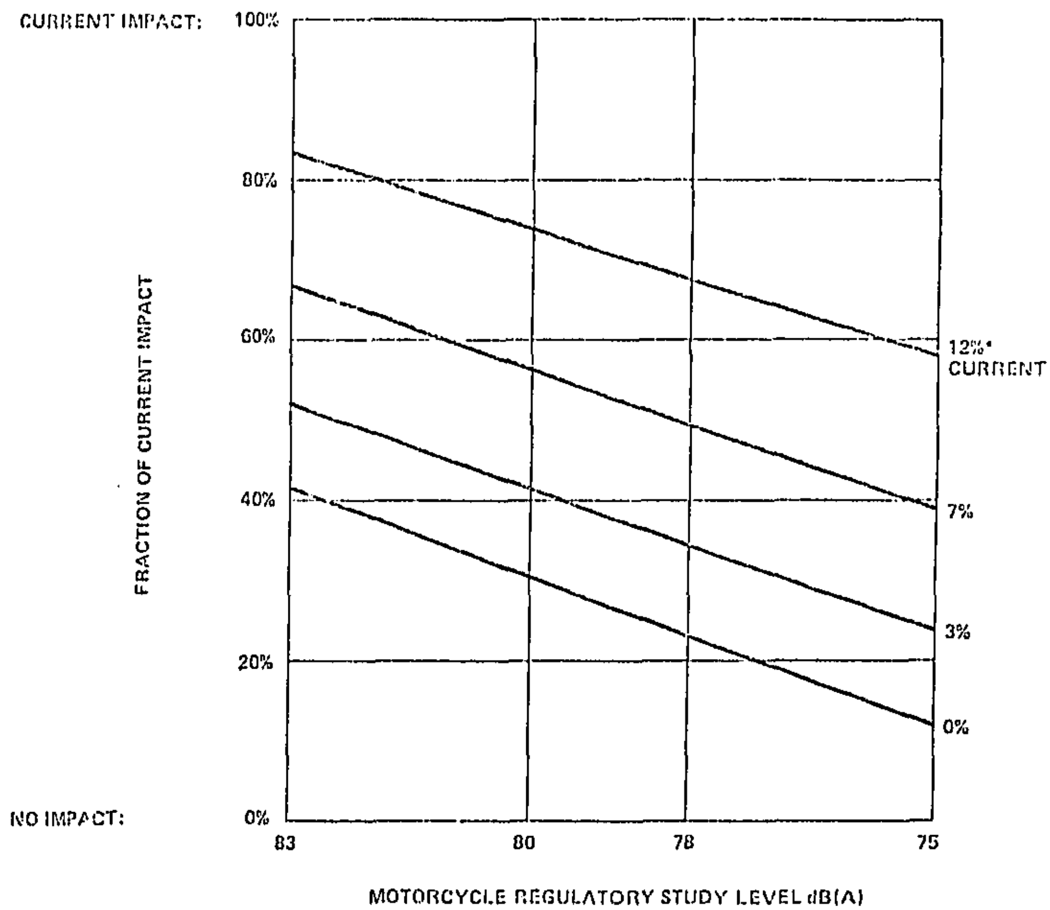
The following are some of the assumptions made in the analysis which could have the effect of understating the magnitude of total impact from street motorcycles:

(a) Percentage of exhaust system modifications. Rather than the 12% figure used some authorities estimate much higher number of modifications. Spot checks in several locales (mostly in Southern California) have seen up to 40% of the motorcycles observed having replacement exhaust systems.

(b) The analysis measures impact occuring only from motorcycle accelerations. Some amount of impact almost certainly occurs during deceleration and cruise conditions.

(c) The proportion of mileage accumlated during the night is assumed to be 5%. This could be significantly understated, in which case the numbers of sleep disturbances would also be understated.

Figure 5-24. Relative Reduction in Sleep Disruption Due to Motorcycle Noise



*FRACTION OF MOTORCYCLES WITH MODIFIED EXHAUST SYSTEMS

Table 5-15: Population Distribution as a Function of SEL

	85-80	80-75	75-70	70-65	65-60	60-55	55-50	50-45	45-40	40-35
<u>12% Modifications</u>										
Regulatory Level										
Current	4680	36,000	47,000	74,000	178,000	343,000	423,000	539,000	601,000	346,000
85	"	"	"	60,000	150,000	311,000	408,000	501,000	519,000	369,000
83	"	"	"	"	125,000	283,000	390,000	483,000	484,000	351,000
80	"	"	"	"	96,000	234,000	373,000	443,000	469,000	346,000
78	"	"	"	"	88,000	210,000	343,000	433,000	457,000	312,000
75	"	"	"	"	"	171,000	264,000	412,000	439,000	307,000
<u>3% Modifications</u>										
Regulatory Level										
Current	1170	9100	11,700	32,000	121,000	235,000	255,000	309,000	330,000	142,000
85	"	"	"	15,000	90,000	200,000	239,000	268,000	239,000	167,000
83	"	"	"	"	63,000	169,000	219,000	247,000	201,000	148,000
80	"	"	"	"	31,000	115,000	201,000	204,000	185,000	142,000
78	"	"	"	"	22,000	89,000	167,000	193,000	171,000	104,000
75	"	"	"	"	"	46,000	80,000	170,000	152,000	98,000

Table 5-16: Sleep Disruption (ENI) Due to Motorcycle Acceleration Noise (in Thousands)

	Low Density Urban	Suburban	Rural	Total
12% Modified				
Regulatory Level*				
Current	1050	788	Negligible	1838
85	957	711	"	1668
83	888	657	"	1545
80	789	561	"	1350
78	744	510	"	1254
75	636	443	"	1079
7% Modified				
Regulatory Level				
Current	840	682	Negligible	586
85	744	599	"	1343
83	669	541	"	1210
80	567	441	"	1008
78	519	388	"	907
75	402	316	"	718
3% Modified				
Regulatory Level				
Current	672	595	Negligible	1267
85	573	510	"	1083
83	495	450	"	945
80	387	345	"	732
78	336	290	"	626
75	216	214	"	430
0% Modified				
Regualtory Level				
Current	549	530	Negligible	1079
85	444	443	"	887
83	366	381	"	747
80	255	274	"	529
78	201	216	"	417
75	78	138	"	216

*dB(A)-J331a

Table 5-17: Sleep Awakening (ENI) Due to Motorcycle Acceleration Noise (in Thousands)

	Low Density Urban	Suburban	Total
12% Modified			
Regulatory Level			
Current	297	272	569
85	261	238	499
83	243	221	464
80	222	189	411
78	198	169	367
75	177	149	326
7% Modified			
Regulatory Level			
Current	240	229	469
85	201	194	395
83	183	176	359
80	159	143	302
78	145	120	265
75	114	98	212
3% Modified			
Regulatory Level			
Current	192	196	388
85	153	158	311
83	135	140	275
80	111	107	218
78	84	82	166
75	63	60	123
0% Modified			
Regulatory Level			
Current	159	172	321
85	117	134	251
83	99	114	213
80	72	78	150
78	48	53	101
75	24	31	55

(d) Distribution of mileage accumulated in the different population density areas is an estimate and could result in understating impact if more usage occurs in suburban areas than is assumed.

(d) The sound propogation patterns used in assessing impact are conservatively biased. For the sake of simplicity persons within a 70 dB noise band are assumed to experience only 70 dB, even though the actual exposure could be 71, 72, 73 or 74 dB.

It is clear from the analysis of street motorcycles that both modified and unmodified motorcycles cause significant noise impact on the population. Although exhaust system modifications do account for a large portion of motorcycle noise impact, unmodified motorcycles are also substantial contributors to the problem. It is apparent that the most effective means of reducing the noise impact of street motorcycles is to control the numbers of exhaust system modifications while at the same time lowering the sound levels of unmodified vehicles.

5.6 Analysis of Noise Impact of Motorcycles Used Off-Road

This analysis addresses the impact of regulations to limit the noise from motorcycles used off-road. Noise from off-road use of motorcycles is considered to be a problem of significant proportions. In a survey of 250 senior Federal and state managers of public lands, forests, lakes, parks and wilderness areas of the United States regarding the adverse effects of off-road recreational vehicles (which included other factors besides noise), trail motorcycles were rated as the "most urgent problem for them to solve" (Ref. 3). Minibikes (considered as motorcycles in this analysis) and snowmobiles (when in season), were listed as second and third priorities, with about one-half the frequency of response.

In a survey which addressed public attitudes toward different noise sources, the largest number of respondents said they were "very much" annoyed by noise from trail motorcycles, even though motorboats, automobiles, and children were heard more "often" by respondents. A total of nearly 30 of the 113 people hearing trail motorcycles said they were "very much" annoyed, and approximately 10 of the remaining persons said they were annoyed "quite a lot" (Ref. 4).

In a U.S. Forest Service study, seven experienced recreation guards at the Oregon Dunes National Recreation Area rated the noisiness of dune buggies as to acceptance by the public (Ref. 21). While moving at 10 mph up a grade, the dune buggies were accelerated full-throttle for a distance of 50 feet. The listeners were placed 50 feet from the midpoint of the acceleration, perpendicular to the dune buggy path. The results of this experiment are shown in Figure 5-25.

It is estimated that approximately one half of all recreational off-road vehicle use in the United States takes place on lands administered by the Bureau of Land Management (BLM). BLM lands comprise some 20% of total U.S. land area, accounting for about 60% of all lands owned by the

Federal government. Over half of ORV use takes place in the following areas: Alaska; western Arizona; southern California; southern Nevada and central Utah.

BLM has the authority to close certain areas to off-road vehicle use, if such use endangers soils, vegetation, archeological sites or other valuable resources. Designation of lands as closed to ORV use involves a public notification and participation process which can take a number of months to complete. The Bureau is currently in the process of evaluating all lands under its control to determine their designation either as closed or open to ORV use.

5.6.1 Distribution of Off-Road Motorcycle Sound Levels

Sound levels of current non-competition off-road motorcycles are to a large extent dependent upon the size of the vehicle. The data in Appendix C and data submitted by manufacturers indicate that small off-road machines of 170 c.c. or less have a median acceleration sound level (J-331a) of about 80 dB(A), while the sound levels of off-road motorcycles over 170 c.c. displacement range from 86 to 95 dB(A). Of the total current population of off-road motorcycles, 73% fall into the smaller displacement category; 27% into the larger. The following average sound levels are assumed for the purposes of this analysis (Sec. 3):

< 170 c.c.	80 dB(A)
> 170 c.c.	89 dB(A)

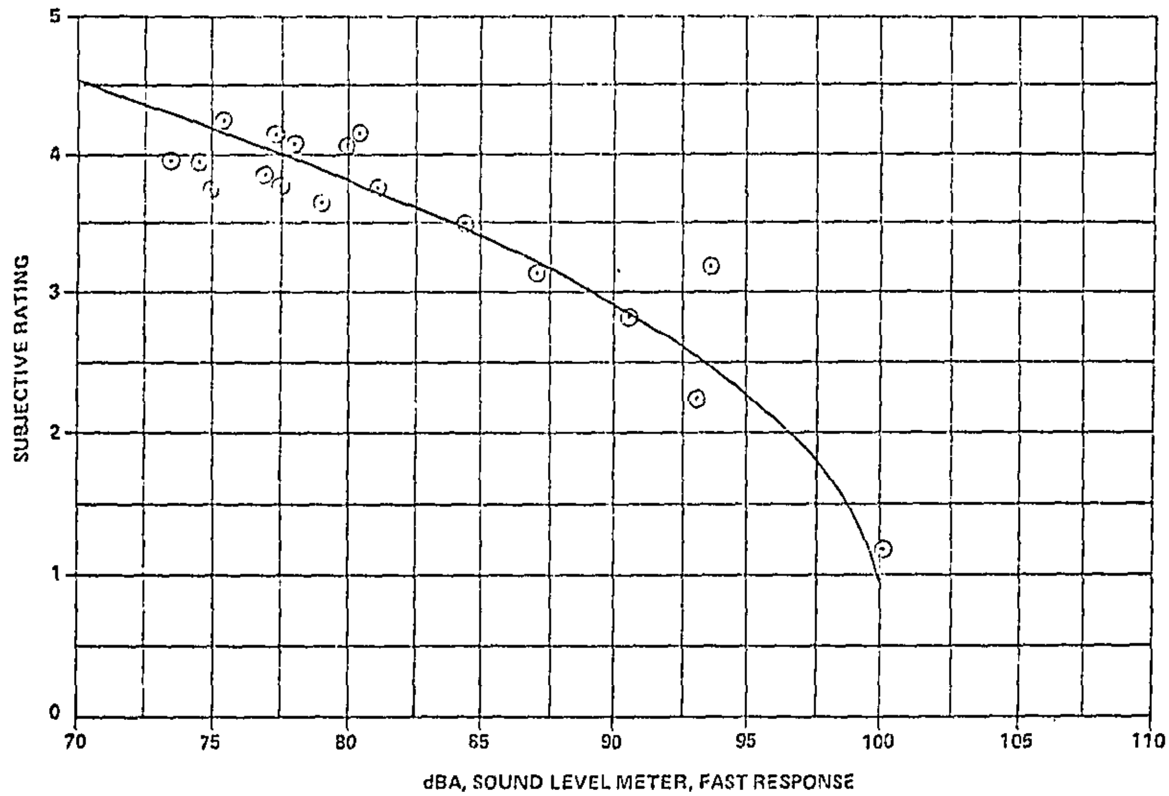
Representative acceleration sound levels are assumed to be 3 dB(A) lower than these levels, the same assumption as made for street motorcycles (Appendix G). The standard deviation for each group is assumed to be the same as that for street motorcycles.

Exhaust-modified off-road motorcycles are assumed to have the same J-331a sound level distribution as exhaust-modified street motorcycles (shown in Figure 5-2), and representative acceleration levels 3 dB less than the J-331a level. The various regulatory options considered for off-road motorcycles are indicated in Table 5-18.

Off-road mileage by motorcycles is approximately 10 million miles daily (Ref. 8). Table 5-19 shows the off-road motorcycle mileage mix estimated by the Motorcycle Industry Council (MIC). According to MIC, 57 percent of all off-road mileage is accumulated by street and dual purpose motorcycles. It can be seen that regulation of motorcycles designed for use on streets will have a significant effect on reducing the impact from off-road motorcycle usage.

The use of motorcycles which are designed for competition use in off-road areas also contributes to noise impace in such areas. Sound levels of competition-type motorcycles generally exceed 90 dB(A), with

Figure 5-25. Subjective Noise Rating of Dune Buggy Noise Levels



1) Very poor; noise completely unacceptable to almost all users.
2) Poor; noise unacceptable to most users.
3) Acceptable to most users, marginal.
4) Good; noise mildly offensive to some users.
5) Excellent; noise not offensive to most dune users.

(Source: Reference 21)

Table 5-18: Regulatory Options Considered for Off-Road Motorcycles

	Single Class Regulatory Options (dB(A))*			
Option	1979	1981	1984	1988
1	86	-	-	-
2	86	83	-	-
3	86	83	80	-
4	86	83	80	78

	Two Class Regulatory Options (dB(A))		
Option	1979	1981	1984
1a	86/83*	86/80	86/78
2a	86/83	83/80	83/78
3a	86/83	83/80	80/78

*Motorcycles over 170 c.c.: 86 dB(A)
Motorcycles under 170 c.c.: 83 dB(A)

Not-to-exceed Sound Levels as measured by F-76a procedure Production levels are assumed to be 2 dB lower than these regulatory levels, as discussed in the text.

*Accelerated lead times, with effective dates of 1979, 1980, 1982 and 1985, and more extended lead times, with effective dates of 1979, 1982, 1986 and 1991 have also been analyzed for the regulatory options listed above.

Table 5-19: Off-Road Motorcycle Mileage Mix (Ref. 8)

	Annual Mileage (Billions)	% of Total
Street-Use Motorcycles		
Unmodified	1.85	50
Modified	.26	7
Total	2.1	57
Off-Road Motorcycles		
Unmodified	1.2	32
Modified	.4	11
Total	1.6	43
Total Off-Road Mileage From All Motorcycles	3.7	100%

many exceeding 100 dB(A). Such levels dramatically increase the detectability distances of these vehicles (discussed below), resulting in relatively large land areas being impacted. Although the numbers of competition motorcycles which are used off-road are not known, most land management officials contacted by EPA reported that such vehicles constitute a very significant part of the off-road vehicle noise problem. Labels and other means of distinguishing competition motorcycles from off-road motorcycles, combined with well planned and enforced land use restrictions are considered to be the most effective means of dealing with the problem of competition motorcycles used in off-road areas.

5.6.2 Detectability Criterion

Off-road motorcycle operations often occur in areas with otherwise low ambient levels, near quiet suburban areas or more remote areas where people are hiking, camping and pursing other activities where man-made sounds are usually undesirable. In such situations, motorcycle noise is preceived by the listener as being alien to the environment and therefore an objectionable intrusion. For these reasons "detectability" is considered to be the best criterion for the impact of off-road motorcycle operations.

In Reference 22, "detectability distances" are calculated by a method described in Reference 23 for various types of vehicles under "typical" forest conditions where the background sound level is assumed to be 40 dB(A). The detectability distances are 1400, 2600 and 3900 feet for motorcycles with reference sound levels at 50 feet of 74, 83 and 93 dB(A), respectively. Detectability distance is defined as the distance at which 50 percent of the listeners with a "40 percent hearing efficiency" would detect a given sound level with a one percent false alarm rate. A 40 percent hearing efficiency means a person not only has good hearing but is a "good listener".

A more typical value of hearing efficiency for persons in remote or rural areas would be 20 percent, which would reduce the above described detectability distances by a factor of about 2 (Ref. 36). Therefore, detectability distances of 700, 1300 and 1950 feet from motorcycles with reference sound levels of 74, 83, and 93 dB(A) at 50 feet, respectively, are assumed to apply in quiet remote areas, with typical forest background levels of 40 dB(A).

In Reference 24 a single test is described where, at a distance of 1000 feet, only a few listeners from a gr[illegible] of seven could hear the maximum acceleration noises from three dual-[illegible]pose motorcycles being operated simultaneously (the sound level at [illegible] feet should have been approximately 85 dB(A)). In the same study [illegible]ectability is presented as a function of distance for typical and q[illegible] forest conditions and for typical trail motorcycle operations. Typic[illegible]y, less than 20 percent of motorcycles used off-road are heard beyond a distance of 1000 feet with usual forest background sound levels. For quiet forest conditions, the detectability distance for a given detection percentage is approximately doubled.

Figure 5-26 illustrates this relationship between detectability distances and 50-foot acceleration sound levels. For simplicity of analysis, it is assumed that all persons within the detectability distances will perceive the motorcycle noise and that none beyond the detectability distance will perceive the motorcycle.

5.6.3 Off-Road Motorcycle Operations

Off-road motorcycle riding typically consists of numerous low-speed, near full-throttle accelerations interspersed with quieter cruise and deceleration operations. Figure 5-27 illustrates two cases of interest: the case of a motorcycle being used on a trail or cross-country, and the case of a motorcycle operating within an ORV (off-road vehicle) area where other ORVs are also likely to be operating at the same time. The circles indicate the distance from each acceleration at which noise exceeds a given criterion level, i.e., the criterion distance.

In the case of a motorcycle being operated on a trail it can be seen that if the criterion distance is large enough so that it is a significant fraction of the straight-line distance between accelerations, the impacted area is approximately the sum of the straight-line distances between accelerations multiplied by double the criterion distance for the low-speed, high acceleration case. Since detectability distances for off-road motorcycle noise are on the order of one-half mile, the criterion distance is typically a significant fraction of the straight-line travel distance. This model of a typical impacted area is assumed to apply for trail and cross-country riding. All persons within the impacted area are impacted at least once with noise above the criterion level.

For the case of motorcycles being operated in an off-road vehicle area, it is assumed that all persons within the boundaries of the area are ORV operators who are not greatly annoyed or otherwise impacted by ORV noise. Therefore, the impacted area would be the area bordering the ORV boundary which is within the criterion distance of the boundary, i.e., its size is the criterion distance multiplied by the approximate perimeter of the ORV area. It can be seen that the relative reduction in area impacted above a criterion level when a motorcycle is quieted a given amount is the same for operations on the trail or relatively large ORV areas.

5.6.4 Estimate of Current Noise Impact

The impact of noise from off-road motorcycle operations is more difficult to quantify in terms of the "people impact" criteria used in the street motorcycle analysis. Based on the information available an impact estimate was developed as described below.

Figure 5-26. Assumed Detectability Distance of Motorcycle Sound Under Typical Forest Conditions

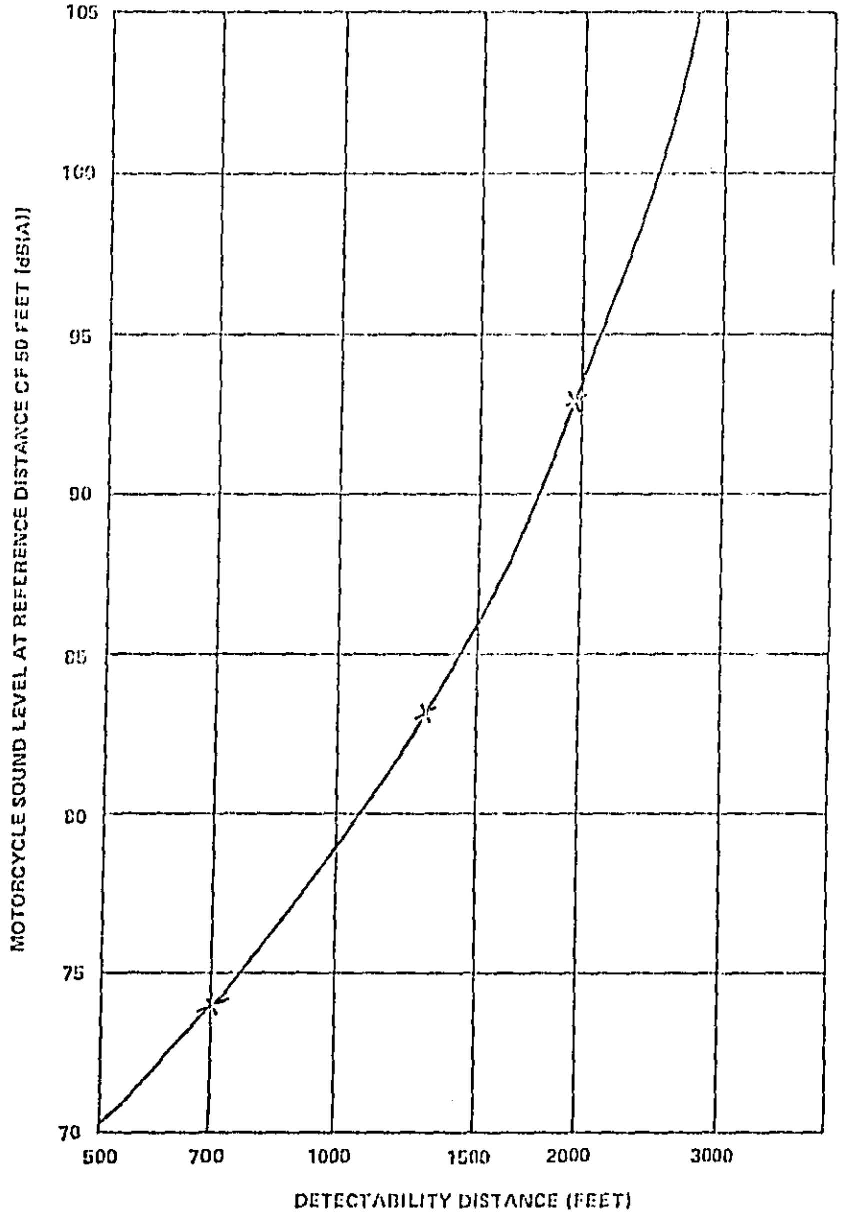
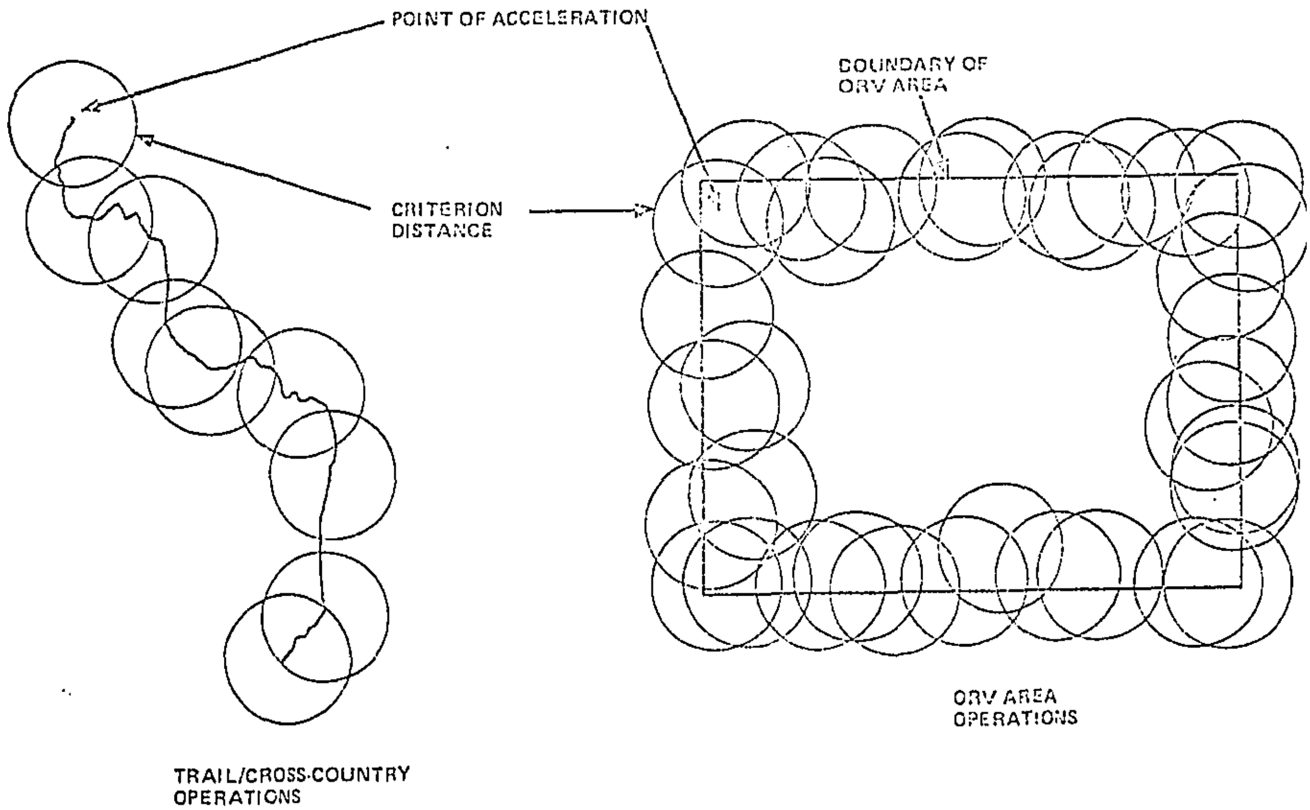


Figure 5-27. Illustration of Off-Road Operations



Off-road mileage by motorcycles is estimated to be 10 million miles daily (Ref. 8). For illustrative purposes it could assumed that, on the average, there are three motorcyclists riding off-road together. Increasing the number of motorcycles operating together does not significantly increase the detectability range (Ref. 16), so the effect is that of reducing the total effective mileage by a factor of 3, to approximately 3.3 million miles daily. Based on the average detectability range of one-quarter mile, the average motorcycle is heard within a path one-half mile wide, so the 3.3 million effective miles form an area of 1.65 million square miles which is exposed daily to noise above detectability levels.

Some of the miles will overlap; i.e., the same or other motorcycles will impact the same area more than once. If we assume again, for illustrative purposes, that this overlap reduces the area by a factor as great as 50, the people within 33,000 square miles of area will hear motorcycles used off-road at least once a day. Operations of off-road motorcycles account for almost 35% of this impacted area, while dual-purpose motorcycles account for approximately 25%. Modified motorcycles account for over 40% of the impacted area.

Assuming a population density of 20 persons per square mile (equivalent to a rural population density) approximately 660,000 persons would be exposed at least once daily to noise from motorcycle operations off-road. If only 5 percent of these total miles are in the vicinity of campgrounds, small towns, and quiet suburban areas where background sound levels are low and the outdoor population density may be on the order of 1,000 people per square mile, nearly 1.7 million additional people could be impacted above the detectability criterion.

In the case of such populated areas which are exposed to off-road motorcycle noise an analysis similar to that used to assess street motorcycle noise impact can be performed. Using the 5% figure for off-road motorcycle mileage occurring in these areas it can be calculated that approximately 2.1 million speech interferences could occur daily from this type of off-road motorcycle usage. Impact reductions which may result from Federal noise regulation and in-use enforcement can be similarly calculated. Without regulations for off-road motorcycles, a street motorcycle standard of 78 dB(A) (which includes dual purpose motorcycles), and a reduction in exhaust system modifications to 3% of the street motorcycle population accomplishes a 15% reduction in this speech interference impact. With noise emission standards of 83 dB(A) and 78 dB(A) for large and small off-road motorcycles respectively, off-road and exhaust modifications limited to 8% speech interference impact will be reduced by approximately 80%.

5.6.5 Relative Reduction in Noise Impact

The above numbers on the current impact of off-road motorcycles are illustrative only since statistics on areas of operation and population impact are unavailable. More reliable statistics can be developed on the relative reduction of the current impact to be expected from various regulatory alternatives.

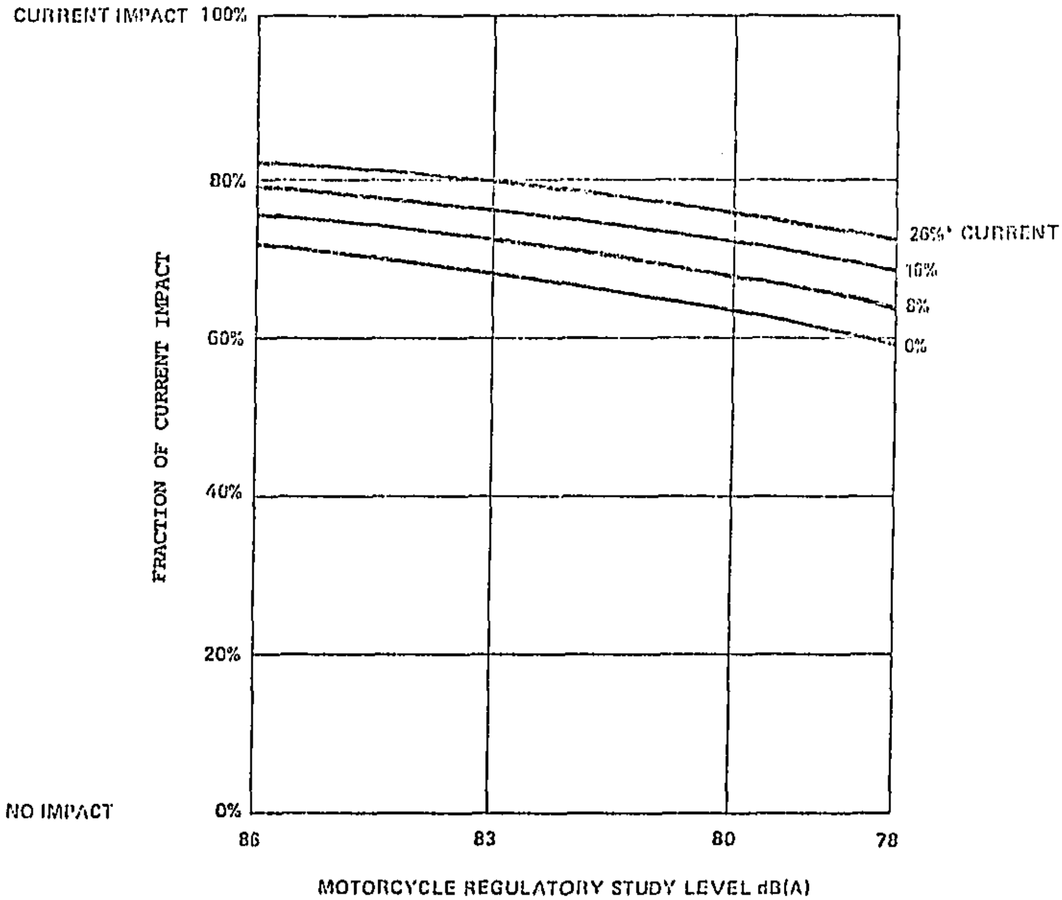
Using detectability distance as the noise impact criteria, the relative reduction in land area impacted by off-road motorcycle noise above the criterion level can be calculated in the same manner as was done for the street motorcycle analysis.

Detectability distance as a function of motorcycle reference (50 feet) sound level is plotted in Figure 5-26. The average detectability distance can be calculated by selecting the detectability distance from Figure 5-26 for each possible motorcycle reference sound level; multiplying each detectability distance by the fraction of motorcycles with that reference sound level; and summing the results for unmodified street-use motorcycles, unmodified off-road motorcycles, and modified motorcycles. The resulting summations can be weighted by the fractions of motorcycles of each type, and the results summed to obtain the overall average detectability distance. This can be repeated for various study levels and assumed percentages of exhaust-modified motorcycles to obtain different equivalent detectability distances. The relative decrease in equivalent detectability distance represents the relative decrease in impact.

Figure 5-28 is based on the estimated mileage mix shown in Table 5-19. This figure assumes that all street and dual-purpose motorcycles are limited to a regulatory study level of 80 dB(A), reducing the average detectability distance to 83% of its current value. Also illustrated are the additional relative reductions in detectability distance due to quieting off-road unmodified motorcycles and limiting off-road modified motorcycles. As shown, an 80 dB(A) regulatory level for off-road motorcycles (exhaust modifications reduced to 16%) would accomplish a 28% reduction in the amount of land area impacted by off-road motorcycle noise when combined with the 80 dB(A) standard for street and dual purpose motorcycles. Similarly, a 78 dB(A) regulatory level for off-road motorcycles, with 8% modifications, would yield a 36% reduction in noise impacted land area.

Based on the estimate of over 2 million people currently impacted one or more times daily by noise from off-road use of motorcycles, limiting street and dual-purpose motorcycles to 80 dB(A) would eliminate the impact on approximately 345,000 people. Quieting unmodified off-road motorcycles would eliminate the impact on an additional 70,000 to 300,000 people for study level limits of from 85 to 78 dB(A). If the number of modified off-road motorcycles is reduced to 8%, impact would be eliminated for an additional 185,000 people.

Figure 5-28. Relative Reduction in Area Impact of Off-Road Motorcycles (Assuming Street and Dual-Purpose Motorcycles are Regulated to 80 dB(A) with 3% Modifications)



*FRACTION OF EXHAUST-MODIFIED OFF-ROAD MOTORCYCLES

Figure 5-29 shows the relative reduction in impact from quieting off-road motorcycles alone, without considering dual-purpose motorcycles which will be subject to standards for street motorcycles.

Additional reductions in detectability distances would be achieved with a two-class regulation, assuming a 78 dBA regulatory level for small off-road motorcycles (less than 170c.c.). Figure 5-30 illustrates the effect of establishing separate sound level standards for small and large off-road motorcycles.

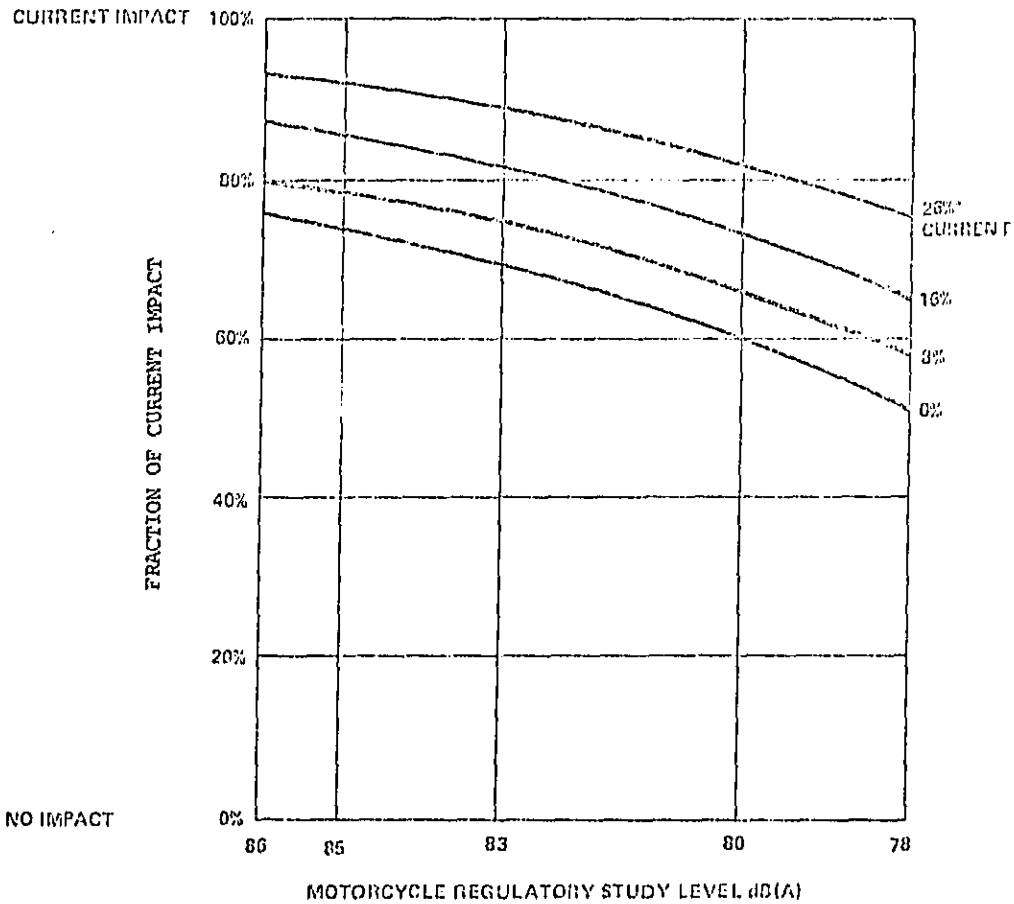
5.7 Operator and Passenger Noise Impact

The information in Appendix E indicates that sound levels at the motorcycle operator's and passenger's ear during rapid acceleration are approximately 100 dB(A), discounting wind and helmet effects. Although this data was collected for only three large displacement motorcycles and does not represent a valid statistical sample, it is not expected that operator ear levels would differ dramatically among motorcycles having similar wayside acceleration sound levels (81-84 dB(A) at 50 ft.). (Recently-gathered information is included in Appendix H).

The impact of motorcyc[l] operator noise exposure is calculated below in two ways. First, the ly equivalent exposure (Leq (24)) is assessed for three types of rcycles: Playbike--smaller motorcycle used for pure recreation; Comm motorcycle--medium sized motorcycle used for urban and suburban tr rtation; Touring motorcycle--large motorcycle used for long distan touring. In each case assumptions are made about the numbers of hours of operation representative of heavy but not intensive use and the fraction of time spent in the acceleration mode. Cruise operational levels are sufficiently below acceleration levels to be considered negligible for Leq calculations. In each of the three situations, the yearly Leq for motorcycle (alone) exposure is within 5 or 6 dB of the L_{eq} (24) 70 dB no-effect level listed in the Levels Document (Ref. 12) as requisite to protect the public health and welfare with an adequate margin of safety.

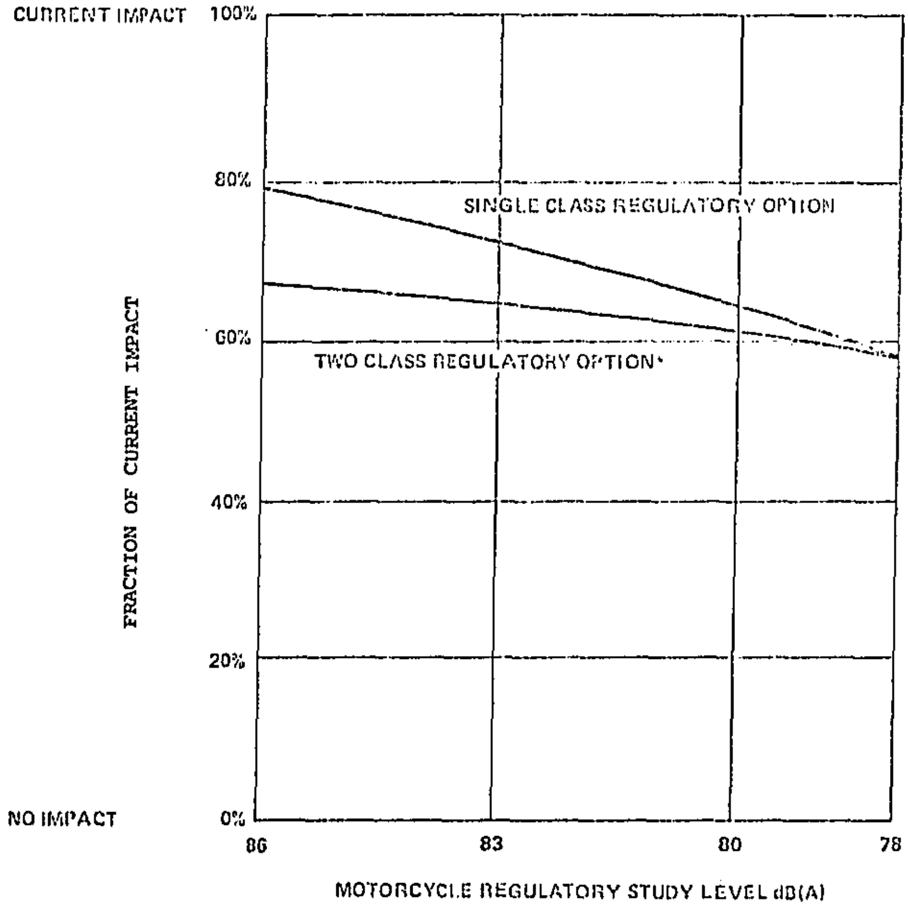
These calculations were repeated for off-road motorcycles. Off-road non-competition motorcycles exhibit J-331a levels of up to 90 dB(A) and above. It is assumed for analysis purposes that 105 dB(A) during rapid acceleration is representative of off-road motorcycles in the 86-88 dB(A) (J331a) range. Two off-road use situations were analyzed: moderately heavy use (2000 miles annually) and heavy use (4000 miles annually). The yearly L_{eq} for these cases exceed 70 dB by 10 and 13 dB respectively.

Figure 5-29. Relative Reduction in Area Impact of Off-Road Motorcycles Only



*FRACTION OF EXHAUST MODIFIED OFF-ROAD MOTORCYCLES

Figure 5-30. Relative Reduction in Area Impact of Off-Road Motorcycles Only, Assuming 8% Exhaust Modified



*MOTORCYCLES LESS THAT 170cc: 78 dB(A) REGULATORY LEVEL.

Operator sound level reductions are expected as motorcycles are redesigned to meet wayside standards. A biproduct of reducing street motorcycles 5 or 6 dB would undoubtedly be a reduction in operator exposure from street motorcycles to very near the protective L_{eq} (24) 70 dB criterion. Reducing off-road sound levels under rapid acceleration to 100 dB(A) would reduce the off-road exposure considerably although not as low as the 70 dB(A) level.

These calculations are for motorcycle (only) contributions. Wind-induced turbulence can add to operator exposure. Use of helmets, however, can abate exposure in some instances although in certain frequencies and at certain head attitudes the sound level can be enhanced. Helmet-induced turbulence may also be significant.

Motorcycle noise exposure may not be the only source of high intensity noise experienced during a motorcyclist's day. A motorcyclist may have a high-noise working environment, may use noisy forms of transportation and may experience other noise exposure. Motorcycle noise would be an addition to this exposure, which in conjunction, may pose a hearing hazard. The second method of analyzing operator impact, therefore, is to compute the combined Leq for motorcycle and non-motorcycle exposure for different yearly durations of motorcycle use as shown in Table 5-20.

The benefit derived from noise reductions at the operator's position was quantified using a method which calculated an Equivalent Noise Impact on Hearing (ENIH) for hearing damage risk (Ref. 4). This concept is based on a nonlinear relationship between hearing loss and daily (24 hour) exposure to equivalent sound levels above 70 dB. The exposure is for a period of 40 years. This method provides a quantitative approach to assess severe health damage and hearing loss for exposure above L_{eq} (24) = 70 dB. The procedure used in this analysis estimates the benefit in terms of reduction of Noise-Induced Permanent Threshold Shift (NIPTS) due to noise reductions from motorcycles. In this analysis NIPTS is defined as the anticipated change in threshold for the average of the frequencies 500, 1000, 2000 and 4000 Hz beyond that change which will occur due to the normal aging process. The average NIPTS for people exposed to noise daily over 40 years is estimated and defined by a fractional index for hearing as:

$$FIH - 0.025\,(L_{eq}(24) - 70)^2$$

Table 5-20

EQUIVALENT SOUND LEVELS FOR OPERATOR EXPOSURE*

	Street Motorcycle			Off-Road Motorcycle	
	Recreation	Commuter	Touring	Moderate Use	Heavy Use
Fifty-foot Acceleration Level (dB(A)-J-331a)	80	82	82	86	86
Sound Level at Operator Ear Position (full-throttle acceleration--dB(A))	98	100	100	105	105
Sound Level at Operator Ear Position (rapid acceleration--dB(A))	95	97	97	102	102
Percent of Operation Time Spent in Acceleration and Cruise Modes (Acceleration/Cruise)	50/50	20/80	10/90	50/50	50/50
Equivilent Sound Level for an Operating Cycle (dB(A))	92	90	87	99	99
Annual Distance Travelled (miles)	1000	4000	10000	2000	4000
Average Speed (miles/hour)	15	25	40	15	15
Annual Time of Operation (hours)	65	160	250	125	250
Yearly Leq (24)--(dB(A))	71	73	72	81	84

*Motorcycle alone contribution--wind turbulence and helmet effects not included.

The fractional index is representative of the average number of decibels of hearing an individual might be expected to permanently lose (averaged over the four reference frequencies) over 40 years of exposure to a given 24-hour L_{eq}. As an example, a person exposed to L_{eq} (24) = 75 dB(A) over 40 years would be expected to lose a little less than 1 dB in hearing; L_{eq} = 80 dB(A) would translate into 2.5 dB loss. The fractional indices of NIPTS contained in Table 5-21, then, can be used to calculate the relative reduction in expected hearing loss at any level of operator exposure reduction. The Table indicates a 5 dB reduction in off-road duty-cycle operator exposure from 100 to 95 dB(A) would reduce the motorcycle-induced portion of NIPTS over 40 years by 50 to nearly 100% for all cases except very heavy use (400 hours annually).

Table 5-21

COMBINED EFFECT OF MOTORCYCLE AND NON-MOTORCYCLE EXPOSURE

Combined L_{eq} (24) for Motorcycle and Non-Motorcycle Exposure (dB(A))

(NIPTS for Combined Exposure)

Motorcycle Exposure over an Operational Cycle (Leq)	Non-Motorcycle Exposure (Leq)	Annual Hours of Motorcycle Operation				
		0	50	100	200	400
100	80	80 (2.5)	82.3 (3.8)	83.8 (4.8)	85.2 (5.8)	87.5 (7.7)
100	70	70 (0.0)	79.0 (2.0)	81.8 (3.5)	87.8 (7.9)	86.6 (6.9)
100	60	60 (0.0)	78.5 (1.8)	81.5 (3.3)	83.6 (4.6)	86.6 (6.9)
95	80	80 (2.5)	80.9 (3.0)	81.6 (3.4)	82.4 (3.8)	83.9 (4.8)
95	70	70 (0.0)	75.1 (0.7)	77.3 (1.3)	79.2 (2.1)	81.9 (3.5)
95	60	60 (0.0)	73.6 (0.3)	76.6 (1.1)	78.7 (1.9)	81.7 (3.4)
90	80	80 (2.5)	80.3 (2.7)	80.6 (2.8)	80.9 (3.0)	81.6 (3.4)
90	70	70 (0.0)	72.3 (0.1)	73.8 (0.4)	75.2 (0.7)	77.4 (1.4)
90	60	60 (0.0)	69.0 (0.0)	71.8 (0.1)	73.8 (0.4)	76.6 (1.1)

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SECTION 6

SOUND REDUCTION TECHNOLOGY

Section 6

SOUND REDUCTION TECHNOLOGY

6.1 Diagnostic Evaluation of Sound Sources

Many of the manufacturers which EPA and its motorcycle technology contractor visited have performed and/or sponsored comprehensive diagnostic studies on motorcycle sound source contributions, and have defined the major sound-producing components and the levels of sound produced by these component sources both singly and in combination. The diagnostic techniques employed for identification of sound source contributions, and the specific sound control methods being employed or studied by the different manufacturers, were presented to the EPA on a confidential basis.* Table 6-1 shows the relative contribution of these sources for 21 1976 model motorcycles (as determined by the manufacturer of the vehicle), in three groupings: exhaust, intake, and mechanical. In this listing, "mechanical" encompasses sound radiated by the engine, power train, frame structure and equipment carried on the frame, and also tire and wind noise, the latter two being generally insignificant at current total vehicle sound levels. The vehicles are listed in descending order of total sound level (as measured by the J331a test); perusal of the table shows that the distribution of noise source contribution varies widely, and is independent of total sound level, use category, and engine type. There is also no relationship or trend between engine displacement and source contribution.

The sound reduction techniques necessary to meet a particular emission standard will vary widely from motorcycle to motorcycle, and are very difficult to place in a generally-applicable matrix of vehicle category/subcategory vs. sound level. For example (referring to the Table), to reduce sound emissions of vehicle "D" currently at 83 dBA to 80 dBA would require attention primarily to the exhaust which is contributing 84% of the sound; this might be attained relatively easily. On the other hand, for vehicle "H", currently at 82 dBA, the attainment of an 80 dBA level would require quieting the mechanical sources, which might constitute a major engineering effort.

*Most data was supplied by: Honda, Yamaha, Kawasaki, Suzuki and Harley-Davidson. Other manufacturers visited also supplied data used in this analysis.

TABLE 6-1 NOISE SOURCE CONTRIBUTION, 1976 MODEL MOTORCYCLES

Total Vehicle Sound Level dBA	Vehicle Ref. Letter	Category		% Contribution of Noise Source		
		Use	Eng. Type	Exhaust	Intake	Mechanical*
84	A	S	4S	60	3	37
83	B	S	4S	35	55	10
83	C	S	2S	24	30	46
83	D	SX	2S	84	5	11
82.5	E	S	4S	47	6	48
82	F	S	4S	30	35	35
82	G	S	2S	24	38	38
82	H	S	2S	6	4	90
82	I	S	2S	6	63	31
81	J	S	2S	11	50	39
80.5	K	SX	2S	28	31	41
80	L	S	4S	10	64	26
80	M	SX	4S	28	18	54
80	N	SX	2S	51	16	33
80	O	SX	2S	33	30	37
79.5	P	S	4S	25	18	57
79.5	Q	SX	2S	1	79	20
79.5	R	S	4S	32	35	33
79	S	S	4S	26	20	54
77.5	T	S	4S	66	20	14
77	U	SX	4S	42	22	36

*"Mechanical" includes engine, transmission, chain, frame, ancillary equipment, tires and wind noise.

6.2 Sound Reduction Technology

A review of the techniques which are in use or which can be selectively used to quiet motorcycles is presented in this section. No consideration is given to cost, nor to the suitability of these various techniques in relation to functional or aesthetic criteria.

Exhaust system quieting methods

Near term control of motorcycle sound emissions centers around the exhaust system, air intake system, and the mechanical/drive components. In approaching the sound reduction problem, manufacturers generally treat the exhaust and intake noise sources first because modification of these sources generally impact the basic model configuration least.

Exhaust noise is generally reduced by using one or more of the following techniques: increasing muffler volume, adding reactive chambers/tubes, adding absorptive materials, restricting exhaust flow by baffles or perforated tubes, and dampening, stiffening, or isolating outer walls. Muffler volume can be increased by: physically enlarging the shell; interconnecting header pipes on multi-cylinder motorcyles (e.g., 4 into 1, 4 into 2 type systems), adding cross-pipes between dual exhaust systems where applicable, or combinations of these techniques. Interconnecting pipes change the impulse frequencies of the muffler in a favorable direction for improved effectiveness, but requires that reactive elements be properly designed for the changed frequency spectrum. In many cases redesign and modification of the muffler interior will reduce sound levels, generally at some penalty in increased backpressure. Such techniques include adding/modifying reactive chambers, adding or sealing baffles, modifying the core pipe, inserting sound absorption lining and retaining walls, revising/constricting exhaust flow, and adding elastic components. Dampening of the shell walls can be accomplished by use of laminated material, different material, or application of semi-viscous coatings. Stiffening of the shell walls can be accomplished by use of ribbing or internal bracing. Isolation can be accomplished by mounting components on elastomer supports. The latter modifications do not reduce sound emitted from the exhaust outlet, but reduce radiated noise from the muffler shell.

These techniques can be summarized:

- o Increase muffler volume
- o Interconnect exhaust pipes
- o Modify interior
- o Add sound absorptive lining

- o Increase shell thickness/rigidity
- o Construct double walls
- o Isolate mounting

Application of these techniques is not at all straight-forward, and is in reality a very complex design problem. As an example, motorcycles with 2-stroke engines require optimally designed expansion chambers to assure proper exhaust scavenging and charging of cylinders. Modification of the exhaust system if improperly done could reduce performance drastically. Other modifications could create excessive back pressure, increase weight and fuel consumption or reduce motorcycle lean angle, balance, or ground clearance.

Intake system quieting methods

Air intake noise can be reduced by shielding or modifying the inlet duct, restricting or lengthening the intake path, increasing shell volume, adding baffles or absorptive materials, and dampening and/or isolating the intake shell. The shell dampening can be accomplished by the use of thicker or different material, reinforcement, or double wall construction. The techniques used to control air intake systems can be summarized:

- o Increase volume
- o Modify inlet
- o Modify interior
- o Add sound absorption lining
- o Increase wall thickness
- o Construct double walls
- o Shield inlet
- o Reduce inlet area

Mechanical system quieting methods

The objective of mechanical redesign and rework is generally to reduce or contain engine and drive interaction noise (i.e., piston slap, valve clatter for 4-stroke models, gearing mesh, chain noise, etc.) and to reduce vibration (resonance) noise. The effort can be minor or major, depending on model peculiarities and degree of sound reduction required. Various techniques currently in use and mentioned by manufacturers as possibilities for future models are summarized as follows; and are described in the following paragraphs:

- o Stiffen/dampen fins and case webs
- o Change fin shapes
- o Thicken/reinforce components
- o Improve component mounting
- o Thicken/reinforce case covers
- o Isolate case covers
- o Increase lubrication
- o Modify piston/cylinder
- o Reduce tolerances/improve finish
- o Modify bearings
- o Modify timing/drive belts/chains
- o Modify camshaft
- o Reduce valve clatter
- o Increase flywheel mass
- o Stiffen crankshaft
- o Redesign clutch and transmission
- o Improve chain tensioner
- o Enclose drive chain
- o Dampen/ioslate chain cover
- o Stiffen/frame; isolate engine
- o Lower engine speed
- o Reduce specific horsepower
- o Liquid cooling
- o Convert 2-stroke to 4-stroke engine
- o Reconfigure engine to reduce dynamic unbalance forces
- o Use hydraulic torque converter
- o Convert to shaft drive
- o Enclose engine

Stiffen/dampen fins and webs--Insertion of elastomer pads or metal dowels between radiating fins to reduce fin vibration.

Change fin shapes--modification or reinforcement of fins to reduce vibration.

Thicken/reinforce components--Modification or reinforcement to reduce vibration.

Improve component mounting--Use of gaskets and elastomer pads to isolate components to reduce vibration through metal to metal contact.

Thicken/reinforce case covers--Includes use of thicker material, reinforcement ribbings or double covers on such elements as gear covers, crankcase covers, camshaft covers and so forth.

Isolate case covers--Use of elastomers to reduce vibration and radiated noise.

Increase lubrication--Providing additional pressure lubrication to reduce mechanical interaction noise.

Modify piston/cylinder--Modify piston/cylinder configuration to reduce piston slap.

Reduce tolerances/improve finish--Reduce tolerances, or improve finishes of gears, bearings and so forth to reduce mechanical interaction noise.

Modify bearings--Replace ball and roller bearings with journal type bearings to reduce mechanical interaction noise.

Modify timing/drive belts/chains--Convert from chain drives to Hy-Vo, rubber or other types of quiet belts where applicable (e.g., timing belt change applicable to overhead cam engines).

Modify camshaft--Modify cam shape and increase shaft rigidity to reduce mechanical interaction noise.

Reduce valve clatter--Use of hydraulic lifters to eliminate tappet clearance (where applicable); incorporate elastomers to cushion tappet noise in overhead cam engines.

Increase flywheel mass--To reduce engine vibration.

Stiffen crankshaft--To increase rigidity and reduce mechanical interaction noise.

Redesign clutch and transmission--Use of helical gears instead of spur gears to reduce mechanical interaction noise; use of journal type bearings.

Improve chain tensioner--To reduce chain/sprocket interaction noise and chain tensioner noise.

Enclose drive chain--To attenuate drive chain noise.

Dampen/isolate chain cover--To eliminate cover vibration and radiated noise.

Stiffen/dampen frame; isolate engine--To prevent radiated noise due to engine vibration transmitted to the frame and to components mounted on the frame.

Lower engine speed—To reduce mechanical interaction noise.

Reduce specific horse power--To reduce the excitation forces which result in engine noise radiation.

The above sound reduction techniques range from detail changes to significant redesign. For some models reductions in mechanical/drive sound levels to meet stringent sound standards would require techniques involving complete redesign of the engine and drive train. In addition, some of the techniques would result in reduced engine performance. As discussed in Section 4.1, it is impossible to predict by product categories which specific proposed regulatory levels will require major model changes. The lowest levels that any of the manufacturers have reported as being feasible for the near-term is 80 dBA for street motorcycles, 84 dBA for off-road motorcycles. Other manufacturers question that an 80 dBA sound standard can be met without major redesign on some models. Major model configuration changes could include the use of such techniques as conversion to liquid cooling, enclosing or covering the engine, conversion from a 2-stroke to 4-stroke engine (where applicable); use of a hydraulic torque converter for power transmission, conversion to shaft drive, engine re-configuration to reduce unbalance forces, or any other major engine/ drive redesign not specified here. These techniques would all require major changes in manufacturing operations, and extensive lead time. These techniques, not necessarily feasible in all use categories, are discussed in the following paragraphs.

Liquid Cooling--Liquid cooling, because it allows reduced clearances in engine parts, and because it provides added shielding around the engine cylinders, can materially reduce engine radiated noise. Conversion to liquid cooling would require re-engineering and re-tooling of the engine, add significant weight, and add to unit manufacturing costs. Additional hardware is required to implement liquid cooling, including a pump, radiator, thermostat, coolant, plumbing, instrumentation and recasting of the cylinder head and walls. Feasibility of liquid cooling for off-road motorcycles is very questionable because of vulnerability of the radiator to damage from rocks and spills.

4-Stroke vs. 2-Stroke Engines--Some manufacturers feel that 4-stroke engines are easier to quiet than 2-stroke engines. Because of this, conversion of engine types is a potential option. This alternative is also weighted by the fact that exhaust chemical emissions are more difficult to control in two-stroke engines, a factor currently of great concern to many manufacturers. It is unlikely that engine conversions would be made for noise control alone, due to the considerable engineering development and plant and equipment expenditures that would be required. In addition, direct manufacturing unit costs of 4-stroke engines are estimated by manufacturers to be more than those of equivalent sized 2-stroke engines.

Reduction of Unbalanced Forces--Unbalanced forces which cause engine and frame vibration are more severe in some engine configurations than in others. For example, unbalanced forces can be reduced by use of opposed cylinders, counter-rotating crankshafts, or balanced "V" configurations. These methods can involve dynamic vibration absorbers or counter-rotating balancing elements.

Shaft Drive--Shaft drive is an option that would reduce drive train noise on large (over 750cc) and possibly medium sized (450-749cc) on-road motorcycles. Shaft drive on models intended for some off-road use is less attractive, because of weight constraints and flexibility requirements in the drive train that are required for these models. Shaft drive affects many of the other components on the motorcycle, and is a relatively expensive option. A more cost-effective method of reducing drive noise in most cases would be to fully enclose the chain, which was identified previously as a sound reduction measure.

Hydraulic Torque Converter--Another technique that would involve major model configuration change is converting from a standard transmission to a hydraulic torque converter and a hydraulic gear engagement clutch, as exemplified by the transmission on the Honda CB 750A. Torque conversion by hydraulic means is basically quieter than by gears.

Engine Enclosure--Manufacturers indicated that if engine enclosure is considered as a noise control measure, it would generally be used in conjunction with liquid cooling. Enclosure or covering of air-cooled engines could create significant engine temperature control problems. In addition, some of the manufacturers feared that enclosure could drastically affect the marketability of motorcycles, since styling is an important factor affecting demand for motorcycles. Engine enclosure would entail added weight, and could hamper access for servicing.

Although there is no generally-applicable set of techniques that will achieve specified regulatory levels for a specific motorcycle, a matrix of techniques based on manufacturer-supplied information was developed for costing purposes. This matrix is presented in Table 6-2. For each regulatory level below 83 dB(A), a schedule of techniques other than major model changes are shown for each product class. Manufacturer information generally indicates that all techniques discussed above would be necessary to achieve a 75 dB(A) level for models above 170c.c. Fewer of these techniques, or less extensive use of these techniques, are expected to be necessary at higher levels. For costing purposes two estimates were made at each study level below 83 dB(A): one assuming no major model change necessary, and one assuming a major model change. As shown, the major model change assummed for street motorcycles is the use of liquid cooling. For off-road motorcycles, conversion to 4-stroke engines is assumed. Different individual models will of course require major model changes at different regulatory levels. A few are expected to require them at an 80 dB(A) level, a substantial number are expected to need them at 78 dB(A), and virtually all are expected to need them at a 75 dB(A) level. This is discussed in more detail in Section 7.

TABLE 6-2

SOUND REDUCTION TREATMENTS ASSUMED FOR EACH STUDY LEVEL
(J331a - NOT-TO-EXCEED BASIS)

EXHAUST SYSTEM	750 + c.c.				350 - 749 c.c.				170 - 349 c.c.				100 - 169 c.c.				100 c.c.			
	83	80	78	75	83	80	78	75	83	80	78	75	83	80	78	75	83	80	78	75
INCREASE MUFFLER VOLUME	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x
CROSS CONNECTIONS	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
MODIFY INTERIOR	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
SOUND ABSORPTIVE LINING		x	x	x		x	x	x		x	x	x			x	x				
INCREASE SHELL THICKNESS		x	x	x		x	x	x			x	x			x	x			x	x
DOUBLE WALLS				x				x												
AIR INTAKE SYSTEM																				
INCREASE VOLUME	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x
MODIFY INLET	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x
MODIFY INTERIOR		x	x	x		x	x	x	x	x	x	x			x	x			x	x
SOUND ABSORPTIVE LINING		x	x	x		x	x	x		x	x	x				x				
INCREASE WALL THICKNESS		x	x	x		x	x	x		x	x	x				x				
MECHANICAL/DRIVE SYSTEM																				
STIFFEN/DAMPEN FINS/WEBS		x	x	x		x	x	x		x	x	x			x	x				
IMPROVED COMPONENT MOUNTING		x	x	x		x	x	x		x	x	x			x	x				
THICKEN/REINFORCE CASE COVERS		x	x	x		x	x	x		x	x	x			x	x				
INCREASE LUBRICATION			x	x			x	x			x	x				x				
MODIFY PISTON/CYLINDER			x	x			x	x			x	x				x				
REDUCE TOLERANCES/IMPROVE FINISH			x	x			x	x			x	x			x	x				
MODIFY BEARINGS			x	x			x	x			x	x				x				
MODIFY TIMING/DRIVE BELTS/CHAINS			x	x			x	x				x				x				
REDUCE VALVE CLATTER (4 STROKE)				x				x												
INCREASE FLYWHEEL MASS			x	x			x	x			x	x								
MODIFY CRANKSHAFT/CAMSHAFT				x				x												
MODIFY GEARS/TRANSMISSION				x				x				x								
TIGHTEN CHAIN				x				x				x								
ENCLOSE CHAIN				x				x				x								
MODIFY FRAME				x				x				x								

6.3 Impacts of Sound Reduction Technology

6.3.1 Performance Impacts

Each of the techniques cited above can have impacts on motorcycle performance characteristics. Engine horsepower (including width of power band), torque, weight, lean angle, center of gravity, ground clearance and suspension characteristics can all be affected.

Power

All manufacturers cited engine power losses resulting from achieving current sound levels. Increasing power loss is expected at the lower levels studied. The power loss is generally attributable to restricted air intake and exhaust system back pressure. Table 6-3 indicates some of the data submitted to EPA pertaining to power losses involved in achieving current sound levels. From these data it is apparent that additional sound reduction measures will result in further power losses. Liquid cooling, with its potential for decreased engine tolerances, can abate this trend somewhat. Conversion from 2-stroke to 4-stroke engines will result in additional specific horsepower loss.

Weight

Many of the techniques cited may cause additional weight penalities. Modifications to the exhaust system could result in doubling current muffler weight or more, although the increasing use of 2 into 1, 3 into 1 and 4 into 1 exhaust systems on multicylinder motorcycles could abate this considerably. Similarly, more complex air intake systems might be expected to weigh more than current systems by factors of two or more. Mechanical noise quieting can be achieved through the use of thicker covers, improved mounting and increased mass of moving parts. The combination of these measures could increase engine weight by 10 to 15%. In addition, major engine modifications can result in a significant vehicle weight increase. One manufacturer estimated an increase of 10% in vehicle weight for liquid cooling (about 50 lb. for large motorcycles). Conversion of single cylinder 2-stroke engines to single-cyclinder 4-stroke engines could cause an increase of up to 30% in total engine weight. Shaft drive mechanisms are quite heavy, but the lighter and less costly alternative of enclosure of the final drive chain will be assumed for the assessment of weight penalty.

Table 6-3

POWER LOSS ASSOCIATED WITH

ACHIEVING CURRENT LEVELS

Motorcycle	Sound Level Reduction (dB)	Power Loss
a	4	12% over 6,000 RPM
b	4	2%
c	2	30%
d	2	30%
e	0.6	3%
f	2	1%
g	2	3%
h	2.5	28%
i	1.6	1%
j	3.5	10%
k	1	6%
l	8	up to 28%, 10% at peak
m	6 (approx)	12-15% (peak; very little below 4,000 RPM, severe roll off past peak)

SOURCE: Confidential Manufacturer Data

6.3.2 Operation Impacts

The only significant impact of sound level reduction on operation costs should be a reduction in fuel economy. Increased weight, increased back pressure, power loss, and power required to drive auxiliary equipment (e.g., radiator pump) may all exact a fuel consumption penalty.

It should be noted, however, that conversion from 2-stroke to 4-stroke engines could be expected to reverse this trend somewhat due to the slightly better fuel efficiency of 4-stroke engines.

From the previous section, the following vehicle weight increases are assumed (as a fraction of total vehicle weight):

		Regulatory Level				
	Over 170c.c.	86dB	83dB	80dB	78dB	75dB
Street:	Straight forward change		0	2%	5%	10%
	Major model change		–	10%	15%	20%
Off-Road:	Straight forward change	0	2%	5%	10%	–
	Major model change	–	10%	15%	20%	–

100-169c.c.: One-half of above figures
Less than 100c.c.: 0% at all levels

Manufacturers supplied very little data on fuel economy impacts of achieving current or future sound levels. The little data that was furnished indicated that the 3 to 4 dB reductions to achieve current levels resulted in up-to-15% loss in fuel economy, although some models showed no change or an improvement. Experience with trucks and automobiles indicates that a 10% decrease in fuel economy for a 10% weight increase is a good assumption, but one which may tend to overstate the fuel economy penalty. Using this assumption, however, the above table can also serve to indicate the assumed fuel economy losses at the various regulatory levels when backpressure and other penalties are included.

6.3.3 Maintenance Impacts

Several of the quieting techniques cited either require additional maintenance or make currently required maintenance somewhat more costly or more time consuming. Principal among the first of these are the minimal attention needed to keep a liquid cooling system in working order, and the additional maintenance associated with a switch from 2-stroke to 4-stroke engines. Complex mounting techniques, additional covers, reduced engine tolerances, valve train complexities and enclosed final drive will complicate routine maintenance. No definitive data on the maintenance impacts of these techniques are available. For the pusposes of analysis the following additional annual maintenance time (in hours) is assumed:

		Regulatory Level				
	Over 170c.c.	86dB	83dB	80dB	78dB	75dB
Street:	Straight forward change	-	0	1/4	3/8	1/2
	Major model change	-	-	3/4	7/8	1
Off-Road:	Straight forward change	0	1/4	3/8	1/2	--
	Major model change	-	3/4	7/8	1	--

100-170c.c.: One-half of above figures
Under 100c.c.: Zero at all levels

Sound reduction will affect cost of maintenance and replacement parts only through increased cost for replacement exhaust systems.

6.3.4 Aesthetic Factors

To many motorcyclists the aesthetic impacts of sound reduction technology may be even more important than performance or cost impacts. Many of the above techniques can be expected to have an adverse impact on the sleek and sporty styling of current models. Larger mufflers, frame reconfigurations to accomodate larger air intake systems, bulkier engines and liquid cooling all pose styling problems. Although these factors are unquantifiable, they are felt to have potential sales impacts independent of the cost and performance factors cited above.

6.4 Production Variations

The sound levels of all nominally identical surface transportation products exhibit a distribution covering a range of several decibels. Since EPA's regulations are on a not-to-exceed basis, manufacturer design and production must account for this distribution of sound levels to assure compliance with the standards. This is in addition, of course, to factors accounting for testing variables. Manufacturers supplied EPA with data on the production variation exhibited by certain of their models. These data are displayed in Table 6-4. From these data it is concluded that manufacturers will have to produce vehicles at least 1 1/2dB below an applicable standard to account for production variations.

Table 6-4

PRODUCTION VARIATION

Manufacturer	Production Variation (dB)
a	2σ = 3-4
b	1.5 - 2.5
c	1σ = 0.25 - 0.6
d	2-stroke: 1.5 4-stroke: 2.0
e	1.5

SOURCE: Manufacturer Confidential Data

6.5 "Best Available Technology"

Each of the quieting techniques discussed in Section 6.2 exist either in current production models or in prototypes in advanced states of development. As such, their combined use represents "best available technology" for motorcycles. Large and complex exhaust and intake systems have been demonstrated on a wide variety of production vehicles. Weight, positioning, and performance penalties are the only technological limits to larger and more complex units. There are numerous examples of current motorcycles either with large muffler volume in relation to engine displacement or sophisticated muffling of multicylinder engines. Double-wrapped mufflers have been used in several models and prototypes, and at least one prototype known to EPA uses a major engine frame member for its air intake reservoir.

Many of the engine quieting techniques discussed previously exist in current production engines. Recent models from the major manufacturers have demonstrated significantly reduced engine mechanical noise. Balanced (90-degree) V-twin engines have been well demonstrated.

The past five years of motorcycle development has seen an increasing number of multi-cylinder engines with high specific horsepower. This specific horsepower has often been achieved by increased engine speed, which has resulted in increased engine mechanical noise. The testing program data base shows the critical importance of engine speed to engine noise. Decreased engine speed at a loss of specific horsepower is available to all manufacturers of high RPM engines.

Liquid cooling has been well demonstrated on several production models, both 2-stroke and 4-stroke. Liquid cooling for a complete line of smaller 2-stroke motorcycles (down to 50c.c.) has been demonstrated by one European manufacturer.

Shaft-drive has been well demonstrated on motorcycles 500 c.c. and above.

Based on an examination of motorcycle models incorporating the techniques discussed above, EPA has concluded that the 78 dB(A) regulatory level (J-331a), requiring a 75 dB(A) design level, is the level representative of "best available technology" for street motorcycles in the meaning of the Noise Control Act. The Honda GL-1000, generally acknowledged to be the quietest large motorcycle ever produced, already incorporates many of the major techniques listed above (liquid cooling, shaft drive, very large intake and exhaust systems). Even this motorcycle would require some small additional quieting to meet a 78 dB(A) level on a production basis.

Lower levels could be achieved with the probable elimination of many large motorcycles and many smaller 2-stroke motorcycles. Although four-stroke motorcycles in the smaller displacement classes would undoubtedly be able to achieve a 75dB(A) (J-331a) regulatory level (requiring a 72dB(A) design level) EPA has concluded that this limited class of vehicles does not represent "best available technology" in the meaning of the Act.

"Best available technology" for off-road motorcycles is a question both of technology and performance. Although motorcycles with off-road capability can be built at levels almost as low as for street motorcycles, such motorcycles demonstrate significant performance penalties. Weight, power, power band width and ground clearance are all of crucial importance to off-road motorcycles. Each of these factors on an off-road motorcycle can be more significantly impacted at lower sound levels than for street motorcycles of comparable displacement. The inappropriateness of applying liquid cooling to off-road motorcycles leads to different levels of "best abailable technology" for large and small off-road motorcycles. Small off-road motorcycles (under 170c.c.) are expected to be able to achieve the same levels achievable by their street counterparts. Large off-road motorcycles, however, without the option of liquid cooling cannot achieve the same levels as their street counterparts (exacerbated by the fact that most street motorcycles over 170c.c. have multi-cylinder engines, whereas off-road motorcycles must be single cylinder). Manufacturers indicated that given enough lead time, an 83 dB(A) regulatory level might be achievable with large 2-stroke off-road motorcycles. They were unanimous, however, in stating that the 80 dB(A) regulatory level would require 4-stroke engines for most large models. Since liquid cooling is not viable for off-road motorcycles, EPA has concluded that this 80 dB(A) regulatory level constitutes "best available technology" for this class of off-road motorcycles. It is understood that although these levels are achievable, the performance of large 4-stroke off-road motorcycles will be inferior to current models, significantly so in many cases.

Although all of the techniques consitituting "best available technology" exist in production or prototype motorcycles, not all manufacturers have the capability of incorporating them into their motorcycles. Particular problems exist with manufacturers that have uniquely identifiable engine types that can be fundamentally changed only with a serious impact on marketing position (Harley-Davidson, BMW, Moto Guzzi, Ducati), manufacturers whose products have been developed from racing motorcycles and depend on high performance (Laverda, MV Agusta), smaller manufacturers of high-performance off-road motorcycles (Can-Am, Husqvarna, Bultaco, etc.) and small manufacturers without large R&D capability (NVT Motorcycles, Rokon, other very small U.S. manufacturers).

6.6 Lead Times

In the absence of certification for air emissions, manufacturers generally indicated the following lead times were necessary to make changes on an individual motorcycle model (total time, drawing to production): Changes to exhaust or air intake system that do not require frame or engine redesign--one year; changes requiring frame redesign or minor engine redesign--two to three years; major engine redesign--four to five years; new engine model, new engine concept, conversion to 4-stroke engine--five to six years (and up). Limited R&D resources, however, allow redesign of only a few models per year. Major manufacturers with extensive product lines would require additional time to be able to redesign models on a more or less orderly basis. In addition, air emission certification can add one half to one year to required lead times for major manufacturers due to required durability runs. Manufacturers emphasized the need to coordinate effective dates of these regulations to eliminate unnecessary recertification for air emissions when redesign for noise purposes takes place.

Based on this information the following lead times are felt to be achievable by major manufacturers, consistent with orderly redesign of an extensive product line (years from promulgation):

		Regulatory Level (J-331a)				
		86	83	80	78	75
Street:	Straight forward change	—	1	2	4	6
	Major model change	—	—	4	6	10
Off-Road:	Straight forward change	1	2	4	6	—
	Major model change	—	4	6	10	—

An accelerated schedule of lead times can be considered which would require simultaneous redesign of many models. Manufacturers insisted that resources were unavailable for orderly redesign on this basis. The following is an "accelerated" schedule of lead times which might be achievable at considerably increased R&D costs:

		Regulatory Level (J-331a)				
		86	83	80	78	75
Street:	Straight forward change	—	—	1	3	5
	Major model change	—	—	3	5	7
Off-Road:	Straight forward change	1	2	3	5	—
	Major model change	—	3	5	7	—

Different manufacturers, of course, have different lead time requirements. Sound levels of current models (particularly the mechanical contributions), available funds for R&D, size of product line, and familiarity with 4-stroke or liquid cooling technology, all have a bearing on individual lead time requirements. The "normal" lead time schedule cited above is most appropriate for the major Japanese manufacturers other than Honda. The sound levels of Honda's current product line would probably allow somewhat shorter times. Harley-Davidson, Can-Am and the European manufacturers would all be severely tested to meet the same time schedule as the major Japanese manufacturers, for a variety of reasons relating to unique engine designs, exclusive use of 2-stroke engines or company size (availability of R&D capital). If these other manufacturers would be strained at the "normal" schedule, it is reasonable to conclude that they would probably not be able to comply with the "accelerated" schedule.

6.7 Deterioration of Motorcycle Sound Levels

Most manufacturers supplied limited data on experience with motorcycle sound levels during mileage and time accumulation. Several engineering reasons were discussed as to why motorcycle sound levels ought to decrease with usage, at least at first. After the initial break-in period, mechanical interaction noise can abate as parts fit together better. Muffler noise can decrease as carbon build-up seals small openings left from the manufacturing process.

Properly designed all-metal mufflers can last a considerable period of time before sound level deterioration occurs, depending on climate and operating conditions. Properly designed mufflers with glass inserts can also last a significant length of time, although poorly designed ones can deteriorate rapidly. European standards make a distinction between mufflers that direct exhaust gases through fibrous material and mufflers that reflect exhaust gases into but not through the fibrous elements. Some manufacturers specify replacement of fibrous elements or replacement of the exhaust system when deterioration occurs. At least one manufacturer supplies free replacement fiberglass for his mufflers.

In general, manufacturers supplied no engineering reasons why a properly maintained and operated motorcycle should experience significant sound emission deterioration over its lifetime. "Properly maintained" in this context means replacement of parts (including such major parts as mufflers) as needed according to the operation instruction. Deterioration data for a few models is displayed in Table 6-5.

Table 6-5

DETERIORATION OF MOTORCYCLE SOUND LEVELS

Model	Deterioration (dB)	Mileage
a	2-4	10,000
b	±1	6,250
c	∓1 1/2	6,250
d	±1 (peak +2)	6,250
e	-0-	6,250
f	right side: 0	6,250
	left side: +1	6,250
g-k (muffler only, 5 models)	-0.33* to -1.6/6,250 mi	up to 19,000
l	-1 1/2 (+1; -1/2)	7,160
m	-1 1/2 (±1/2)	3,240

* A negative number indicates a reduction in sound level.

SOURCE: Manufacturer Confidential Data

6.8 Relationship to Air Emission Control

A number of manufacturers expressed serious concerns that at strict levels of air emission controls there may be a significant trade-off between air pollution control and noise control. At the levels established in EPA's final rule on motorcycle air emissions this concern has abated somewhat.

The higher temperatures of exhaust gases due to air emission control may have a dual effect on exhaust noise emissions. Higher temperature gas is less dense, requiring a higher rate of flow for equivalent performance. In addition, the higher temperature gas has more inherent energy which must be dissipated. Both of these effects would tend to raise exhaust noise. One manufacturer cited a study on automotive air emission and noise control which showed sound level increases of up to 4 dB at strict levels of emissions control.

A second effect of higher engine temperatures is the need for larger surface areas to dissipate heat from an air cooled engine. These larger surfaces, in turn, can increase sound radiation. Liquid cooling, of course, would in large part counteract the higher engine and exhaust temperature increases due to air emission control.

One manufacturer indicated that the increased length and complexity of an air intake path could cause fluctuations in air/fuel mixture with a corresponding adverse impact on air emissions.

6.9 Technology to Achieve Sound Levels Based on Different Measurement Methodologies

Technology and costing information supplied to EPA by manufacturers and developed by EPA contractors have been based on study levels specified in terms of the J-331a test procedures. As discussed in Section 3, the F-76a test procedure is felt to be statistically equivalent to J-331a across a broad range of motorcycles although individual models may vary up or down by several dB(A). The manufacturer-supplied information was based on several models of each of the manufacturer's lines. The J-331a and F-76a sound levels of each of the models used for these purposes were compared to determine whether these vehicles represented anomolous cases in the J-331a/F-76a relationship. Of 15 models used for technology and costing purposes, ten showed differentials of less than 2 dB(A), one showed a differential of 2 dB(A), anf four showed differentials of 3 dB(A). However, the models displaying differentials of 2 dB(A) or greater showed no consistent pattern with as many higher under one procedure as the other. The cost information in the succeeding chapters was checked carefully and it was found that overall values do not change significantly as a study level specified in terms of J-331a is translated into a study level specified in terms of F-76a.

SECTION 7

COSTS OF COMPLIANCE

Section 7

COSTS OF COMPLIANCE

7.1 Unit Cost Increases

7.1.1 Manufacturer Estimates for Specific Models

Each major manufacturer supplied EPA with estimates of manufacturing unit cost increases for specific models to meet specified study levels (not-to-exceed basis). The manufacturer data was based on the J-331a and CHP procedures. Manufacturers generally cited the techniques summarized in Table 7-1 as the ones necessary to meet the lower study levels. The major model distinctions were made by the manufacturers. Each manufacturer emphasized that most estimates at the lower levels were based on engineering judgment alone, and not on operational prototype models. They indicated that there was no guarantee that individual techniques cited would achieve the specified study level. Manufacturers addressed different ultimate levels of control depending on their assessment of feasibility or ability to judge the effectiveness of individual techniques. Manufacturer estimates are summarized in Figure 7-1.

Manufacturers also provided cost estimates for various discrete steps in reductions in exhaust, air intake and mechanical/drive sources. Figures 7-2, 7-3 and 7-4 show costs associated with each of the subsources, where available.

There are a number of explanations for the scatter shown in Figure 7-1:

(a) In general, costs increase with motorcycle size, because noise generating capability tends to increase with size, and the costs of affected components (e.g., exhaust systems, mechanical components) increase with size.

(b) Since subsource noise level contributions differ widely from model to model (see Section 6) the techniques required to meet specified levels vary considerably.

TABLE 7-1

NOISE CONTROL TECHNIQUES

EXHAUST SYSTEM	INCREASE MUFFLER VOLUME CROSS CONNECTION MODIFY INTERIOR SOUND ABSORPTION LINING INCREASE SHELL THICKNESS CONSTRUCT DOUBLE WALLS ISOLATION MOUNTING
AIR INTAKE SYSTEM	INCREASE VOLUME MODIFY INLET MODIFY INTERIOR ADD SOUND ABSORPTION LINING INCREASE WALL THICKNESS DOUBLE WALLS SHIELD INLET REDUCE INLET AREA
MECHANICAL/DRIVE SYSTEM	STIFFEN/DAMPEN FINS AND WEBS CHANGE FIN SHAPES COMPONENT MOUNTING THICKEN/REINFORCE CASE COVERS INCREASE LUBRICATION MODIFY PISTON/CYLINDER REDUCE TOLERANCES/IMPROVE FINISH MODIFY BEARINGS MODIFY TIMING/DRIVE BELTS/CHAINS REDUCE VALUE CLATTER (4-stroke) INCREASE FLYWHEEL MASS MODIFY CRANKSHAFT/CAMSHAFT MODIFY CLUTCH MODIFY GEARS/TRANSMISSION TIGHTEN DRIVE CHAIN ENCLOSE DRIVE CHAIN MODIFY FRAME ISOLATE CHAIN COVER LOWER ENGINE SPEED REDUCE SPECIFIC HORSEPOWER
MAJOR MODEL CONFIGURATION CHANGES (REPRESENTATIVE EXAMPLES)	CONVERT 2-STROKE TO 4-STROKE LIQUID COOLING ADD HYDRAULIC TORQUE CONVERTER CONVERT TO SHAFT DRIVE ENCLOSE/COVER ENGINE

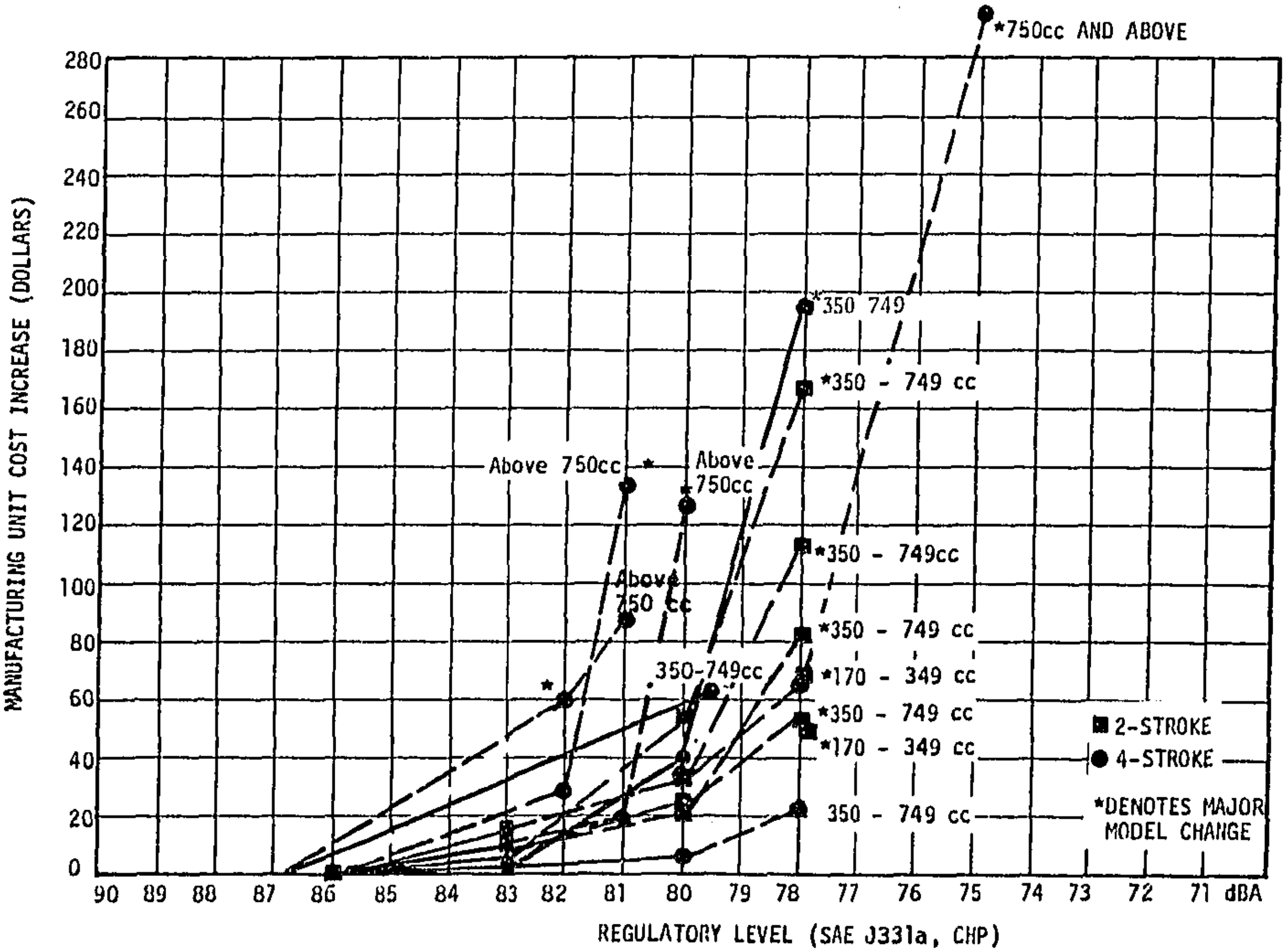

FIGURE 7-1 MANUFACTURING UNIT COST INCREASE VS. REGULATORY LEVEL (MANUFACTURER SUPPLIED DATA)

(c) Since there are a wide variety of techniques which can be utilized in reducing the sound level from a given subsource, manufacturers projected differing techniques to be used, with attendant differences in costs.

(d) Major model changes were deemed necessary at different study levels. Data points denoted by an asterisk indicate the study level for which major model changes were assumed.

Costs associated with the reduction of exhaust system sound levels are shown in Figure 7-2. Again the large scatter in data indicates that for some exhaust systems, large reductions in sound levels are relatively inexpensive while others are considerably more expensive for the same degree of noise reduction. For example, for one model in the 350 to 749cc category, a reduction in exhaust sound level from 82 dBA to 70 dBA was projected by the manufacturer to increase the manufacturing unit cost of the exhaust system by only $4. For another model in the 750cc and above category, exhaust noise reduction from 82 to 70 dBA was projected to increase manufacturing costs by $60. Almost all of the techniques listed for exhaust systems in Table 7-1 were used to achieve the reduction in this case.

Air intake sound reductions and associated cost increases are shown in Figure 7-3. There is less scatter in this data, although two of the models demonstrate wide variance. Most of the other data points fell on a curve with the following values:

Air Intake Noise Level	Associated Manufacturing Unit Cost Increase
84	—
78	$ 3.0
76	$ 8.0
74	$15.0
72	$30.0

The estimated cost increases of mechanical/drive components versus degree of noise reduction are shown in Figure 7-4. The scatter here is due primarily to the use of major model changes and the study levels at which they were deemed to be necessary.

7.1.2 Manufacturing Unit Cost: Generalized Estimate

The manufacturer-supplied data in the previous section referred to individual models and techniques. These data were consolidated to obtain a generally applicable set of techniques at each study level and to assign a generally applicable cost estimate to each study level, for each class of motorcycle. In addition, EPA's motorcycle technology contractor independently estimated the cost of individual techniques for comparison with the manufacturer-supplied data.

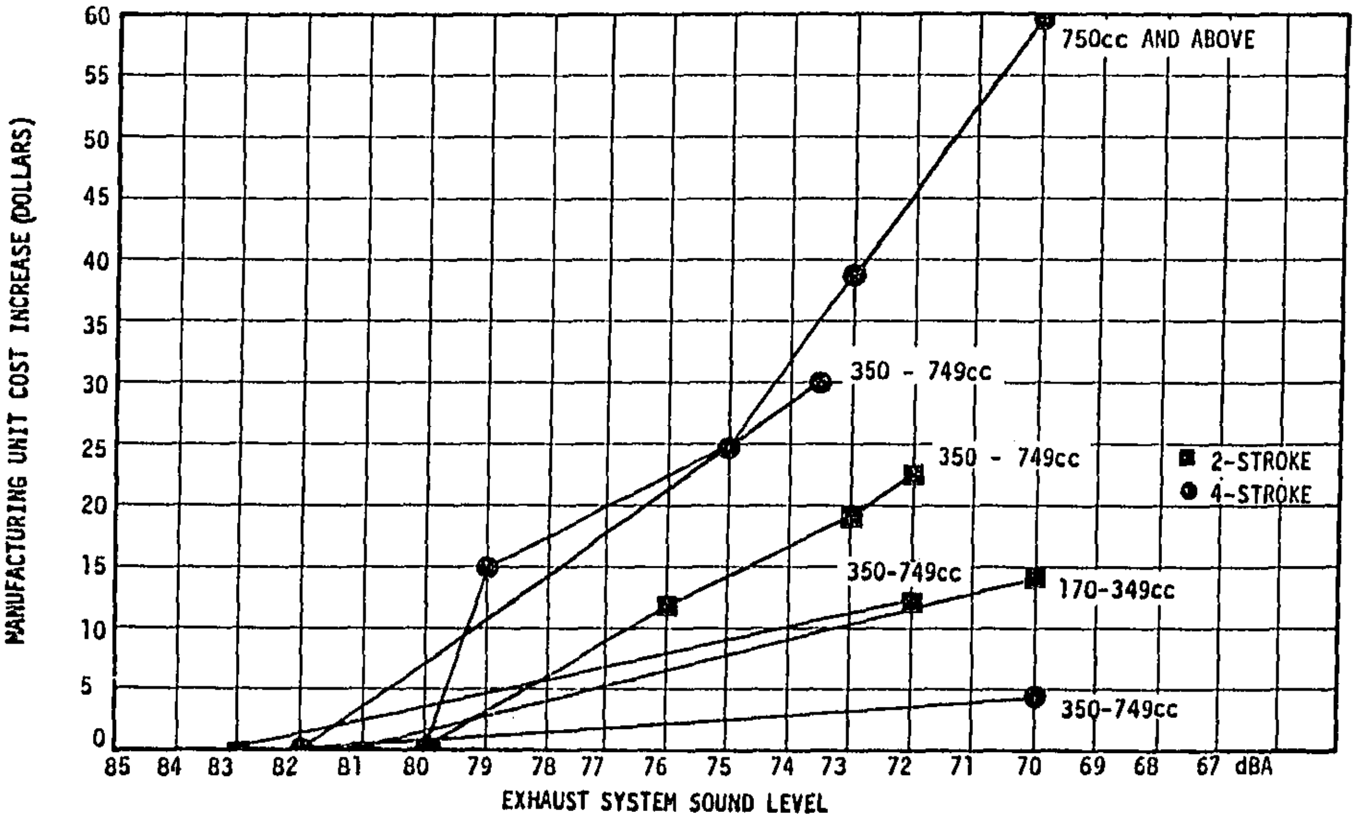

FIGURE 7-2 EXHAUST SYSTEM MANUFACTURING UNIT COST INCREASES VS. SOUND LEVEL REDUCTION (MANUFACTURER SUPPLIED DATA)

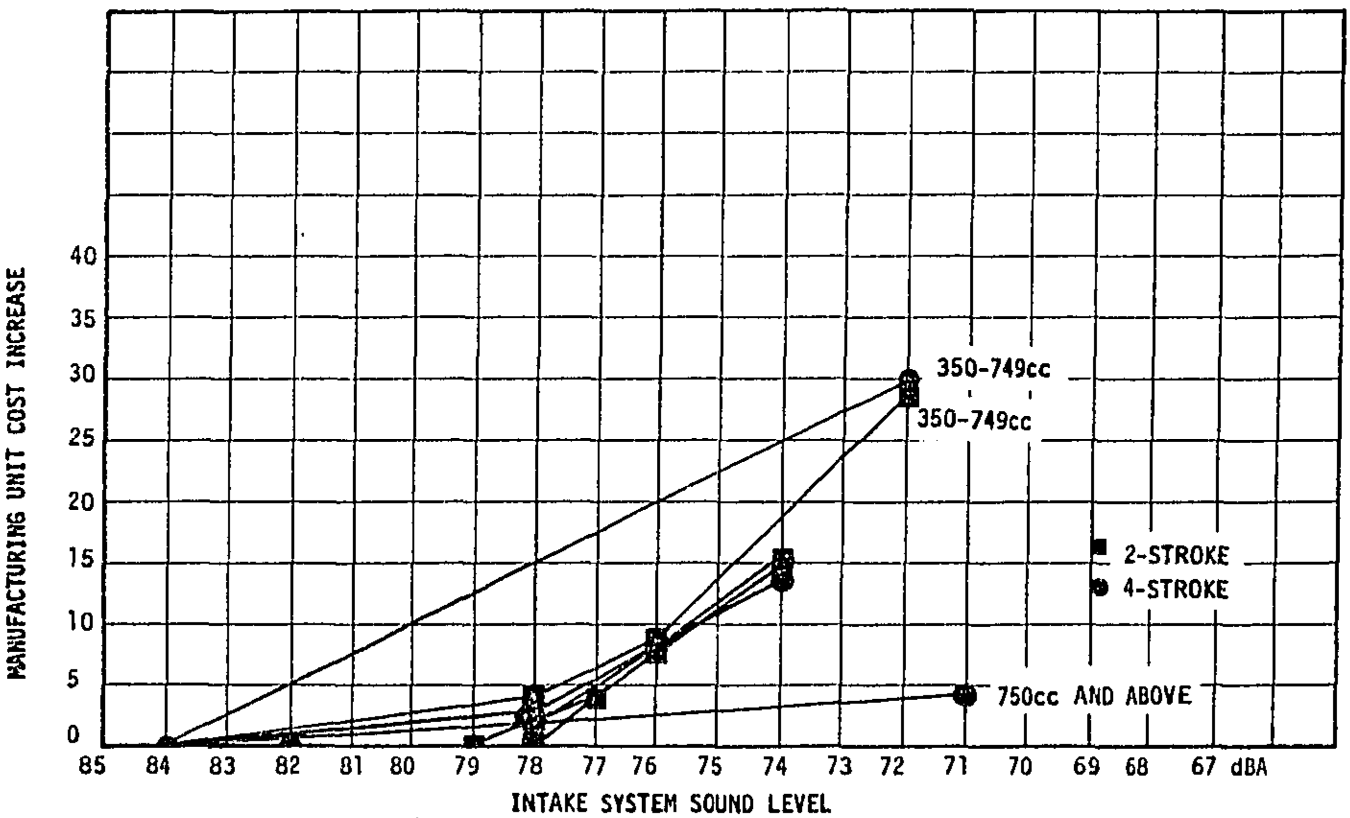

FIGURE 7-3 INTAKE SYSTEM MANUFACTURING UNIT COST INCREASE VS. SOUND LEVEL REDUCTION (MANUFACTURER SUPPLIED DATA)

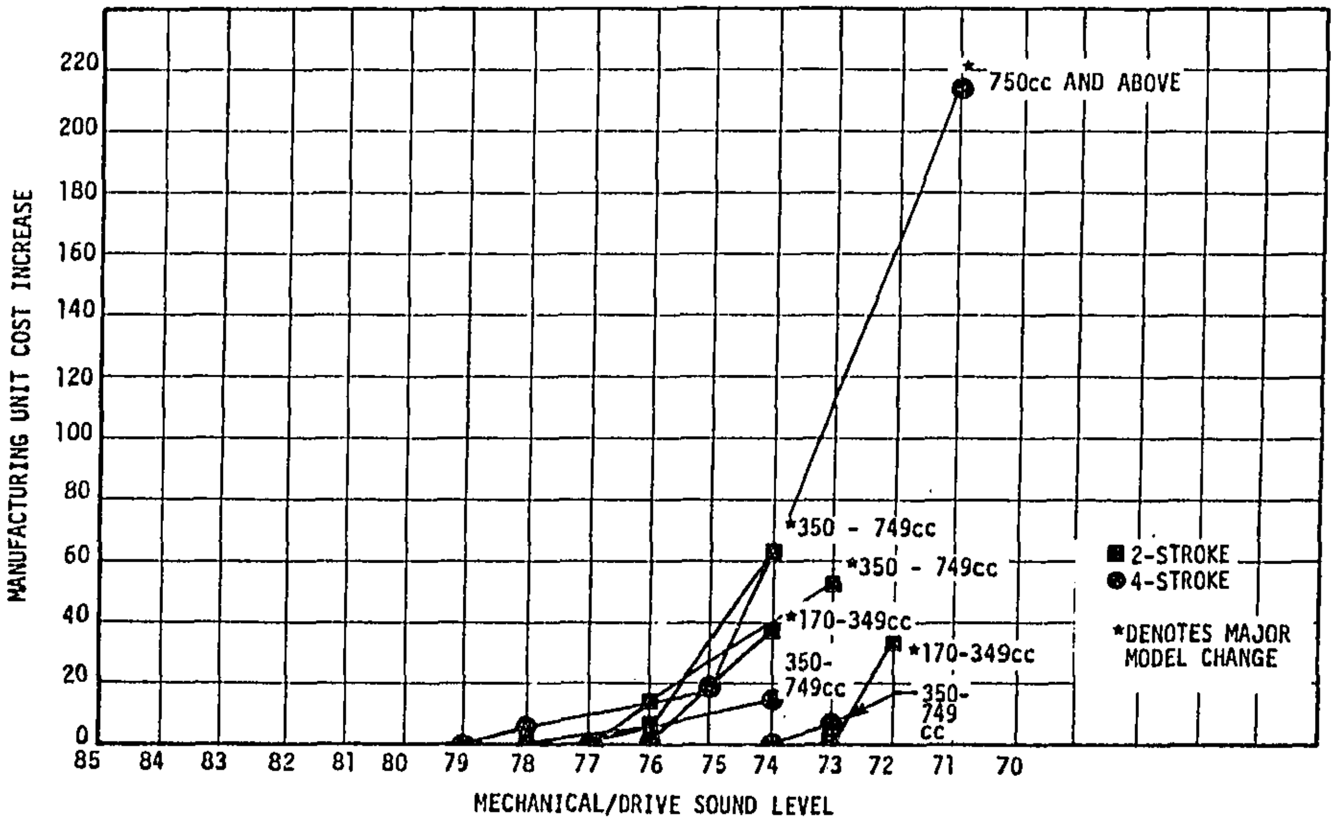

FIGURE 7-4 MECHANICAL/DRIVE MANUFACTURING UNIT COST INCREASE VS. SOUND LEVEL REDUCTION (MANUFACTURER SUPPLIED DATA)

The independent estimates of manufacturing cost increases attributable to the meeting of not-to-exceed regulatory levels were developed by cost estimating personnel familiar with the machining, casting, welding and other production processes involved. However, the estimates must be considered gross engineering estimates only because of the extreme difficulty in predicting the noise reducing effectiveness of the techniques used in the analysis. As indicated earlier, the latter problem is encountered by motorcycle manufacturers as well. The independent estimates were in general agreement with the manufacturer data and are used in the generalized estimates.

For exhaust and air intake modifications baseline estimates were developed for the cost elements of representative systems, and reasonable cost ranges were developed for each technique and its associated cost elements. Direct cost estimates were made for appropriate techniques affecting mechanical/drive components. These techniques were summarized in Table 7-1. Independent cost estimates for exhaust system, air-intake system and mechanical/drive system techniques are summarized in Tables 7-2, 7-3 and 7-4 respectively.

Modification of exhaust and air intake systems are primarily a matter of degree. For example, one of the most fundamental noise attenuation techniques available for reducing exhaust system sound levels is increasing muffler volume. Increasing the muffler shell size can increase shell and finish (e.g., paint or chroming) costs from an estimated $1 to $6 dollars depending on the size of the original muffler and the increase in volume. Probable practical limits are a 75 to 100 percent volume increase for large on-road motorcycles, down to a 25 to 50 percent increase for small off-road motorcycles. Off-road motorcycles in particular have very distinct size and weight limitations because of their functional characteristics. Other techniques that can increase the "equivalent" volume of mufflers are the use of (for example) 4 into 1, and 2 into 1 exhaust systems, which can increase cost from $7 to $14, and adding cross-pipes between dual exhaust systems, which can add an estimated $10 to $12 to unit costs. These latter techniques are applicable to motorcycles with multicylinder configurations only.

Modifying the muffler interior can range from adding a few baffles, which has a minimal cost impact (generally much less than $1), to elaborate and complex exhaust flow control and absorption techniques that can add up to $16 dollars to the cost of the muffler. Exhaust flow control techniques include actions such as adding and modifying reactive chambers, modifying the core, and so forth. Absorption can be effected by adding exhaust silencers and/or sound absorption linings of various materials,

TABLE 7-2
EXHAUST SYSTEM NOISE REDUCTION TECHNIQUES AND ESTIMATED COSTS
(INDEPENDENT ESTIMATES)

TECHNIQUE	SPECIAL APPLICABILITY	AFFECTED COMPONENTS AND COST ELEMENTS	MANUFACTURING UNIT COST INCREASES (DOLLARS)					COST VARIABILITY FACTORS	COMMENTS
			UNDER 100cc	100-169cc	170-349cc	350-749cc	750- & Above		
•INCREASE MUFFLER VOLUME		•MUFFLER SHELLS & FINISH (CHROME, PAINT	1-2	1-3	1-4	1-5	1-6	•DEGREE OF VOLUME INCREASE •PRODUCT CLASS	GENERALLY PRACTICAL LIMIT - 100% INCREASE
•INSTALL CROSS-PIPES BETWEEN HEADERS	DUAL EXHAUST SYSTEM ONLY	•HEADERS •CROSS PIPES	N/A	N/A	N/A	10	12		•LABOR INTENSIVE
•MODIFY HEADER INTERCONNECTIONS (COLLECTIVE MUFFLERS) 4 into 1 4 into 2 3 into 1 2 into 1	MULTI-CYLINDER MOTORCYCLES ONLY	•HEADER PIPES •COLLECTOR BOXES	N/A	N/A	N/A	 14 14 11 7	 14 14 11 7		•LABOR INTENSIVE
•MODIFY INTERIOR		•ASSEMBLY •CORE PIPES •BAFFLES •REACTIVE CHAMBERS	1-4	1-8	1-12	1-14	1-16	•DEGREE OF MODIFICATION •PRODUCT CLASSIFICATION	•GENERALLY MORE COMPLEX ASSEMBLY
•ADD SOUND ABSORPTION LINING		•LINING MAT'L •LINING HOLDERS, SCREENS, ETC.	1-3	1-3	1-4	1-5	1-7	•TYPE OF LINING MATERIAL •COMPLEXITY OF INSTALLATION	
•THICKER/REINFORCE SHELL MATERIAL		•MUFFLER SHELL •REINFORCEMENT HARDWARE		1-8	1-10	1-12	1-14	•DEGREE OF THICKNESS INCREASE •DEGREE OF VOLUME INCREASE	
CONSTRUCT DOUBLE WALLS									

N/A NOT APPLICABLE

TABLE 7-3
AIR INTAKE SYSTEM NOISE REDUCTION TECHNIQUES AND ESTIMATED COSTS
(INDEPENDENT ESTIMATES)

TECHNIQUE	SPECIAL APPLICABILITY	AFFECTED COMPONENTS AND COST ELEMENTS	MANUFACTURING UNIT COST INCREASES (DOLLARS)					COST VARIABILITY FACTORS	COMMENTS
			BELOW 100cc	100-169cc	170-349cc	350-749cc	750cc & ABOVE		
•INCREASE VOLUME		•INLET DUCTING •AIR CLEANER BODY	1-2	1-2	1-2	1-3	1-3	•DEGREE OF VOLUME INCREASE •PRODUCT CLASS	
•MODIFY INTAKE INLET		•INLET DUCTING	1-3	1-3	1-6	1-6	1-7	•DEGREE OF MODIFICATION •PRODUCT CLASS	
•MODIFY INTERIOR		•ASSEMBLY •BAFFLES •SILENCERS	1-5	1-5	1-6	1-8	1-10		
•ADD SOUND ABSORP-TION LINING			-	1	1-2	1-2	1-3		
•INCREASE MATERIAL THICKNESS		•AIR CLEANER BODY	-	1-3	1-4	1-6	1-7		
•CONSTRUCT DOUBLE WALLS		•AIR CLEANER BODY	-	-	-	-	-	NOT USED IN COST ANALYSIS	
•SHIELD INLET		•INLET OPENING	-	-	-	-	-	•NO COST IMPACT	
•REDUCE INLET AREA		•INLET OPENING	-	-	-	-	-	•NO COST IMPACT	

TABLE 7-4 MECHANICAL
NOISE REDUCTION TECHNIQUES AND APPROXIMATE COSTS
(INDEPENDENT ESTIMATES)

TECHNIQUE	APPLICATION	APPROXIMATE MANUFACTURING UNIT COST INCREASE (DOLLARS) BELOW 100cc	100-169cc	170-349cc	350-749cc	750cc & ABOVE	COST VARIABILITY FACTORS	COMMENTS
STIFFEN FINS AND CASE WEBS	RUBBER OR METAL DOWELL BETWEEN FINS	1	1	1	1	1		
CHANGE FIN SHAPES	MODIFY DESIGN	-	-	-	-	-		NO COST IMPACT
ISOLATE/REINFORCE COMPONENTS	ADD GASKETS, BUSHINGS, ETC.	-	2	2	2	2		
THICKEN/REINFORCE CASE COVERS	MODIFY ENGINE, GEAR, CRANKCASE COVERS	-	1-6	1-10	1-14	1-15	*NO. OF COVERS *DEGREE OF MODIFICATION	
INCREASE LUBRICATION	INCREASE PRESSURE LUBRICATION	-	1	2	2	2		
MODIFY PISTON/CYLINDER	MODIFY PISTON/CYLINDER DESIGN AND CLEARANCE	1	1	1	1	1		
REDUCE TOLERANCES/IMPROVE FINISH	REDUCE TOLERANCES, IMPROVE FINISH OF MACHINED PARTS	-	1-2	1-2	1-3	1-3		
MODIFY BEARINGS	MODIFY BEARING AREA, MATERIAL		2	2	2	2		
MODIFY ENGINE TIMING AND DRIVE BELTS/CHAINS	CONVERT FROM CHAIN DRIVE TO HY-VO OR OTHER TYPE		4	5	6	6		
REDUCE VALVE CLATTER	USE HYDRAULIC LIFTERS ON 4-STOKE ENGINES	-	-	-	-	-	NOT USED IN COST ANALYSIS*	
INCREASE FLYWHEEL MASS	CRANKSHAFT FLYWHEEL	1	1	1	1	1		
MODIFY CRANKSHAFT/CAMSHAFT	MODIFY CAMSHAFT DESIGN	-	-	-	-	-		GENERALLY NO COST
MODIFY CLUTCH		-	-	-	-	-	NOT USED IN COST ANALYSIS	TECHNICAL EFFECTIVENESS UNCLEAR
MODIFY GEAR/TRANSMISSION	USE OF HELICAL GEARS INSTEAD OF SPUR GEARS	-	5	8	9	10		
TIGHTEN DRIVE CHAIN	INSTALL, MODIFY IDLER ARMS	-	-	-	-	-	NOT USED IN COST ANALYSIS	SHOULD HAVE MINIMAL COST IMPACT
ENCLOSE DRIVE CHAIN	INSTALL STEEL CASE	-	6	9	10	11		
MODIFY FRAME	REDESIGN, INSULATE FRAME	-	-	-	2	2		

* BECAUSE OF SPECIAL APPLICABILITY

holders, and configurations with increasing assembly complexity. The unit cost of sound absorption lining techniques is estimated to range from less than $1 to $7.

Increasing shell rigidity by using thicker material or different material can add an estimated $1 to $14 dollars to muffler costs depending on the extent to which the techniques are used (e.g., how much thicker in the case of thickening the muffler shell), the size of the original muffler, and also by how much the muffler volume is increased (if increasing muffler volume is used as a noise control technique).

Isolation, by mounting the exhaust systems on elastomer pads should have minimal cost impact.

Exhaust systems of 2-stroke and 4-stroke motorcycles have different configurations, but the basic sound attenuation techniques and cost impacts are similar, with some small variations.

An estimate of the impact exhaust system noise control techniques have on unit costs is provided in Table 7-5, where baseline costs and added costs are listed for four discrete steps in sound level reduction of a representative motorcycle in the 750cc and above street legal category. This was the type of procedure which was used in developing the cost estimates. In some cases, when estimates were developed for a specific product category, estimates for other categories were scaled commensurately.

A similar procedure was used for estimating costs associated with noise reduction of the air intake and mechanical/drive systems.

In the case of major model changes, the use of liquid cooling was assumed for street motorcycles. Liquid cooling may not necessarily be the major change that is used in all cases, but it is felt that its cost is representative of the magnitude of costs major model changes will incur. A rough order of magnitude cost estimate for the addition of liquid cooling to a street motorcycle in the 750cc and above category is provided below.

TABLE 7-5

COSTS OF EXHAUST SYSTEM NOISE CONTROL TECHNIQUES (SAMPLE)

CASE	BASELINE	MODIFIED		
SOUND LEVEL	75 dBA	70 dBA		
COST ELEMENT	COST	MODIFICATION	ADDED COST	COMMENT
SHELL	$4.5	• Volume Increased 100% • Thickness Increased 100%	$3.0 $7.0	Approx. 250% Increase In Material Cost
INTERIOR	$5.0	• Interior Modified	$5.0	Larger and More Complex Core
MUFFLER LINING	$1.0	• Sound Absorption Lining Increased	$3.0	Different Material, More Complex Lining Scheme
FINISH (Chrome, Paint)	$4.5	• Volume Increased	$3.0	Finish Surface Area Increased By Volume Increase
ASSEMBLY	$3.0	• Interior Modified	$3.0	More Complex Assembly
OTHER				
TOTAL	$18.0		$24.0	
MODIFIED MUFFLER COST			$42.0	

LIQUID COOLING: Street Motorcycle, 750cc and Above
(rough order cost approximation)

ITEM	COST
Sheet Metal Material	$10
Radiator	10
Plumbing	2
Pump	7
Miscellaneous Hardware	4
Fabrication Labor*	47
Total	$80

*Includes welding, machining, and assembly.

Summary of Manufacturing Unit Cost Increases (Independent Estimate)

The independent estimate of manufacturing unit cost increases attributable to meeting not-to-exceed regulatory levels for specific product categories are summarized in Table 7-6. Table 7-7 offers a comparison between manufacturer-supplied cost increase data with the independent estimates, for street motorcycles.

These estimates were derived by using the methodology described in the previous section. The analysis utilized the assumptions shown in Table 6-2 for the technology required at each study level.

The data contained in Table 7-6 is shown in Figures 7-5 and 7-6. Two cases are shown for each product category: (1) cost curves assuming that relatively straight forward noise reduction techniques can be used to meet regulatory levels; and (2) cost curves assuming that major model changes are necessary to meet 80 dBA and lower regulatory levels. In the case of major model changes, the use of liquid cooling was assumed for street motorcycles. Conversion to 4-stroke engines was assumed for pure off-road motorcycles, at the same cost (up to $80 depending on engine size).

In the independent cost estimate very small differences were predicted in cost impacts between motorcycles with 2-stroke and 4-stroke engines, with the exception of those cases requiring 2-stroke to 4-stroke conversion. As a result, except for the conversion costs (off-road models), 2-stroke and 4-stroke cost impacts are considered equivalent in the independent cost analysis. Note also that no major model changes were forecast for motorcycles under 100cc in size, for the following reasons: (1) none of the manufacturers indicated that models in this category would require major redesign to meet specified regulatory levels; and (2) the existing sound levels of motorcycles in this category are relatively low.

TABLE 7-6

MANUFACTURING UNIT COST INCREASES VERSUS REGULATORY LEVELS - BASELINE INDEPENDENT ESTIMATE

PRODUCT CLASSIFICATION	MANUFACTURING UNIT COST INCREASE REGULATORY LEVEL (J331a)				
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
STRAIGHT FORWARD DEVELOPMENT					
Street-Legal					
99cc and Below	0	0	0	7	17
100-169cc	0	2	8	25	61
170-349cc	0	4	16	38	92
350-749cc	0	8	22	55	129
750cc and Above	0	10	30	63	146
Off-Road					
99cc and Below	0	0	0	7	
100-169cc	0	2	8	25	
170-349cc	4	8	20	42	
350-749cc	4	12	26	59	
MAJOR MODEL CHANGES					
Street-Legal					
100-169cc			47	61	87
170-349cc			55	74	118
350-749cc			85	108	174
750cc and Above			103	135	198
Off-Road					
100-169cc			47	61	
170-349cc			59	78	
350-749cc			89	112	

TABLE 7-7
COMPARISON OF MANUFACTURER SUPPLIED COST DATA
WITH INDEPENDENT NOMINAL CASE ESTIMATES

DISPLACEMENT CATEGORY (Street Motorcycles)	MANUFACTURING UNIT COST INCREASE REGULATORY LEVEL (J331a) 83 dBA		80 dBA		78 dBA		75 dBA	
	MFR.	IND.	MFR.	IND.	MFR.	IND.	MFR.	IND.
100-169cc	$ 5.0 .6	$ 5.0	$ 9.0	$15.0	$ 7.3 3.5	25.0	$	87.0*
170-349cc	2.4 3.1 14.0	13.0	8.0 14.0 16.6	43.0	54.5 66.0	38.0		118.0*
350-749cc	6.5 7.3 8.7 13.5 15.5	17.0	6.5 21.5 26.3 33.5 36.0 39.0 54.0	50.0	22.5 57.0 66.5 77.5* 83.5* 115.5* 168.4* 192.0*	59.0 108.0*		174.0*
750 and Above	15.0	19.0	35.0 122.0*	30.0 103.0*	66.5	63.0 135.0*	286.0*	198.0*

* Denotes major model change necessary

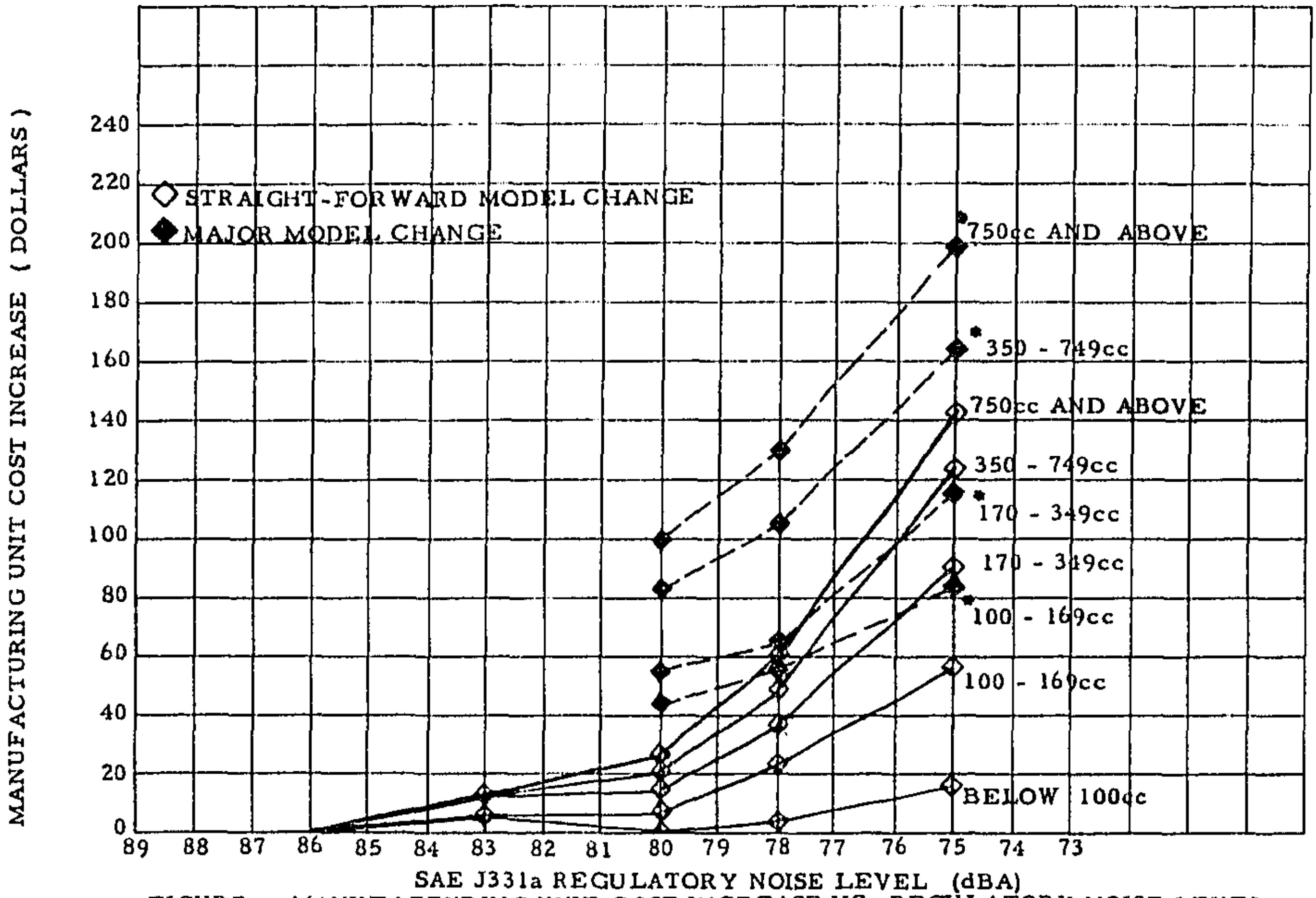

FIGURE 7-5 MANUFACTURING UNIT COST INCREASE VS. REGULATORY NOISE LEVEL (BASELINE INDEPENDENT ESTIMATE) FOR STREET LEGAL MOTORCYCLES

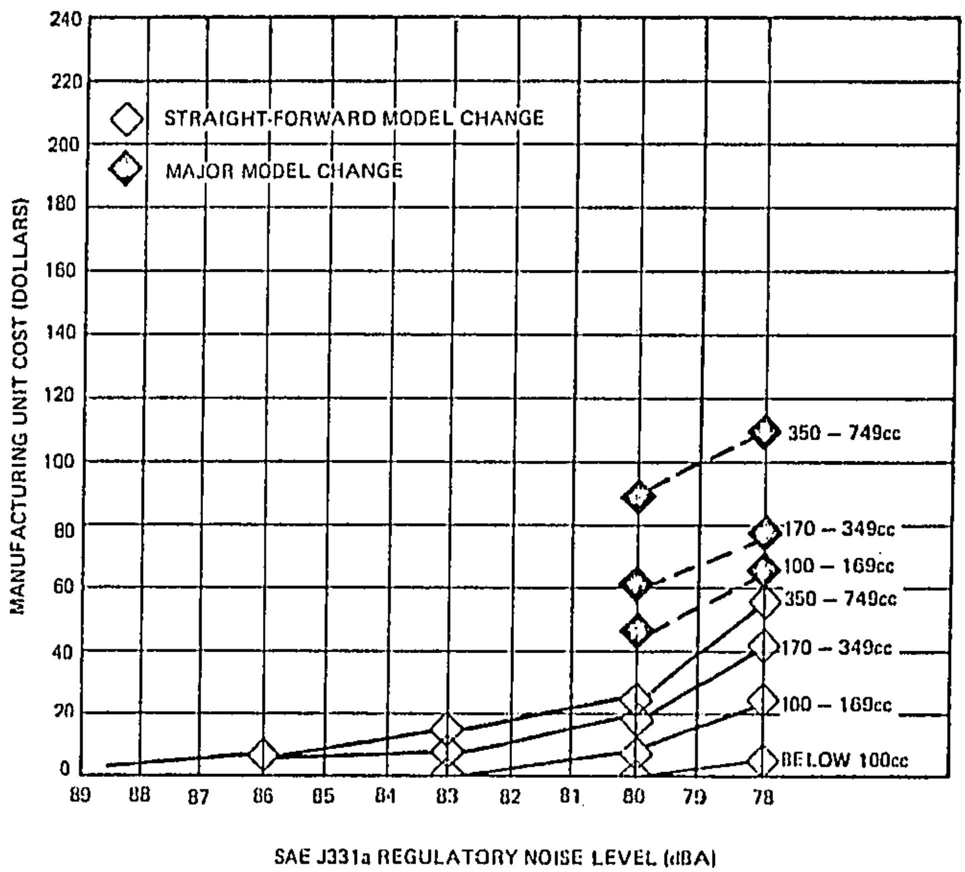

FIGURE 7-6 MANUFACTURING UNIT COST INCREASE VS. REGULATORY NOISE LEVEL (BASELINE INDEPENDENT ESTIMATE) FOR OFF-ROAD MOTORCYCLES

A breakdown by subsource of baseline independent cost estimates is contained in Table 7-8.

Nominal (Expected) and Worst Case Manufacturing Unit Costs

The preceding cost analysis indicates that there is a significant difference in total unit cost impacts for cases involving relatively "straight-forward" model changes, as opposed to cases involving major model changes. There is a high degree of uncertainty as to which models and for which manufacturers major changes will be needed in order to comply with noise standards, and at which regulatory levels these types of changes will be necessary. Therefore this analysis is structured for two cases: (1) the nominal (expected) case; and (2) the worst case. Assumptions were made, based on data from manufacturers, current motorcycle sound levels and sound source data provided by manufacturers, as to what fraction of motorcycle production would require major model changes at each study level. The assumptions made for the nominal (expected) and worst cases are listed below.

ESTIMATED NUMBER OF STREET MOTORCYCLES REQUIRING MAJOR MODEL CHANGES

AS THE RESULT OF SOUND CONTROL REGULATORY ACTIONS

REGULATORY LEVEL (SAE J331a not-to-exceed)	FRACTION OF MOTORCYCLE PRODUCTION REQUIRING MAJOR MODEL CHANGES	
	NOMINAL (EXPECTED) CASE	WORST CASE
86 dBA	0%	0%
83 dBA	0%	0%
80 dBA	10%	50%
78 dBA	50%	100%
75 dBA	90%	100%

For street motorcycles, these assumptions apply to all size categories above 100c.c. (no major model changes are expected below 100c.c.). For off-road motorcycles, however, different assumptions apply for each size category. This is due to the unavailability of liquid cooling for off-road motorcycles and the requirement that off-road motorcycles be single cylinder. Larger off-road motorcycles are expected to require major model changes (4-stroke conversion) at higher levels than smaller off-road motorcycles. The above assumptions for off-road motorcycles are distributed according to the table below (worst case estimate in parentheses):

	Regulatory Level (dB(A)-J331a)	
Displacement Class (c.c.)	80	78
350 and above	100% (100%)	100% (100%)
170-349	50% (100%)	100% (100%)
100-169	0% (100%)	100% (100%)
99 and below	0% (0%)	0% (100%)
Overall (sales weighted)	10% (50%)	50% (100%)

Using these assumptions for major model changes, the nominal and worst case estimates for manufacturing unit cost increases are claculated and presented in Table 7-9.

TABLE 7-8
MANUFACTURING UNIT COST INCREASES VERSUS REGULATORY LEVELS -
BASELINE INDEPENDENT ESTIMATE

DATA POINT	MODEL DESCRIPTION: SIZE CATEG. (CC)	FUNCTION	ENG. TYP.	MSMP PROC.	REGULATORY LEVELS* (DBA) FROM: O	FROM: EX	FROM: IN	FROM: M/D	TO: O	TO: EX	TO: IN	TO: M/D	MANUFACTURING COST INCREASE: OVER-ALL (O)	EX-HAUST (EX)	AIR INTAKE (IN)	MECH/DRIVE (M/D)	CHANGE** CLASS.
	750 and Above	Street-Legal		J331a	86				83	75	75	75	10	6	4	0	SFMC
									80	72	72	73	30	13	10	7	
									78	70	70	71	63	24	16	23	
									75	67	67	68	146	52	30	64	
	350-749	Street-Legal		J331a	86				83	75	75	75	8	4	4	0	SFMC
									80	72	72	73	22	9	6	7	
									78	70	70	71	55	18	12	25	
									75	67	67	68	129	44	25	60	
	170-349	Street-Legal		J331a	86				83	75	75	75	4	2	2	0	SFMC
									80	72	72	73	16	5	5	6	
									78	70	70	71	38	13	9	16	
									75	67	67	68	92	27	20	45	
	100-169	Street-Legal		J331a	86				83	75	75	75	2	1	1		SFMC
									80	72	72	73	8	3	4	1	
									78	70	70	71	25	11	8	6	
									75	67	67	68	61	20	14	27	
	99 and Below	Street-Legal		J331a	80				78	71	71	69	7	3	4	0	SFMC
									75	67	67	69	17	9	8	0	

* Regulatory not to exceed noise level applicable to overall (O) level. Subsources are design level.

** SFMC - Straight Forward Model Change.
MMC - Major Model Change.

TABLE 7-8 (CONT'D)
MANUFACTURING UNIT COST INCREASES VERSUS REGULATORY LEVELS -
BASELINE INDEPENDENT ESTIMATE

DATA POINT	MODEL DESCRIPTION: SIZE CATEG. (CC)	FUNCTION	ENG. TYP.	MGMT PROC.	REGULATORY LEVELS* (DBA) FROM: O	FROM: EX	FROM: IN	FROM: M/D	TO: O	TO: EX	TO: IN	TO: M/D	MANUFACTURING COST INCREASE: OVER-ALL (O)	EX-HAUST (EX)	AIR INTAKE (IN)	MECH/DRIVE (M/D)	CHANGE** CLASS.
	350-749	Off-Road		J331a	89				86	82	82	75	4	2	2	0	SFMC
									83	75	75	75	12	6	6	0	
									80	72	72	73	26	11	8	7	
									78	70	70	71	59	20	14	25	
	170-349	Off-Road		J331a	89				86	82	82	75	4	2	2	0	SFMC
									83	75	75	75	8	4	4	0	
									80	72	72	73	20	7	7	6	
									78	70	70	71	42	15	11	16	
	100-169	Off-Road		J331a	86				83	75	75	75	2	1	1	0	SFMC
									80	72	72	73	8	3	4	1	
									78	70	70	71	25	11	8	6	
	99cc & Below	Off-Road			80				78	71	71	69	7	3	4	0	SFMC
									75	67	67	69	17	9	8	0	

* Regulatory not to exceed noise level applicable to overall (O) level. Subsources are design level.

** SFMC - Straight Forward Model Change.
MMC - Major Model Change.

TABLE 7-8 (CONT'D)
MANUFACTURING UNIT COST INCREASES VERSUS REGULATORY LEVELS -
BASELINE INDEPENDENT ESTIMATE

DATA POINT	MODEL DESCRIPTION: SIZE CATEG. (CC)	FUNCTION	ENG. TYP.	MGMT PROC.	REGULATORY LEVELS* (DBA): FROM O	FROM EX	FROM IN	FROM M/D	TO O	TO EX	TO IN	TO M/D	MANUFACTURING COST INCREASE: OVER-ALL (O)	EX-HAUST (EX)	AIR INTAKE (IN)	MECH/DRIVE (M/D)	CHANGE** CLASS.
	750 and Above	Street-Legal		J331a	86				83	75	75	75	10	6	4	0	MMC
									80	72	72	73	103	13	10	80	@
									78	70	70	71	135	24	16	95	80
									75	67	67	68	198	52	30	116	dBA
	350-749	Street-Legal			86				83	75	75	75	8	4	4	0	MMC
									80	72	72	73	85	9	6	70	@
									78	70	70	71	108	18	12	78	80
									75	67	67	68	174	44	25	105	dBA
	170-349	Street-Legal		J331a	86				83	75	75	75	4	2	2	0	MMC
									80	72	72	73	55	5	5	45	@
									78	70	70	71	74	13	9	52	80
									75	67	67	68	118	27	20	71	dBA
	100-169	Street-Legal		J331a	86				83	75	75	75	2	1	1	0	MMC
									80	72	72	73	47	3	4	40	@
									78	70	70	71	61	11	8	42	80
									75	67	67	68	87	20	14	53	dBA

*Regulatory not to exceed noise level applicable to overall (O) level. Subsources are design level.

** SFMC - Straight Forward Model Change.
MMC - Major Model Change.

TABLE 7-8 (CONT'D)
MANUFACTURING UNIT COST INCREASES VERSUS REGULATORY LEVELS -
BASELINE INDEPENDENT ESTIMATE

DATA POINT	MODEL DESCRIPTION: SIZE CATEG. (CC)	FUNCTION	ENG. TYP.	MSMT PROC.	REGULATORY LEVELS* (DBA) FROM: O	EX	IN	M/D	TO: O	EX	IN	M/D	MANUFACTURING COST INCREASE: OVER-ALL (O)	EX-HAUST (EX)	AIR INTAKE (IN)	MECH/DRIVE (M/D)	CHANGE** CLASS.
	350-749	Off-Road		J331a	89				86	82	82	75	4	2	2	0	MMC @ 80 dBA
									83	75	75	75	12	6	6	0	
									80	72	72	73	89	11	8	70	
									78	70	70	71	112	20	14	78	
	170-349	Off-Road		J331a	89				86	82	82	75	4	2	2	0	MMC @ 80 dBA
									83	75	75	75	8	4	4	0	
									80	72	72	73	59	7	7	45	
									78	70	70	71	78	15	11	52	
	100-169	Off-Road		J331a	86				83	75	75	75	2	1	1	0	MMC @ 80 dBA
									80	72	72	73	47	3	4	40	
									78	70	70	71	61	11	8	42	

*Regulatory not to exceed noise level applicable to overall (O) level. Subsources are design level.

** SFMC - Straight Forward Model Change.
MMC - Major Model Change.

TABLE 7-9

MANUFACTURING UNIT COST INCREASES VERSUS REGULATORY LEVELS
NOMINAL AND WORST CASES

	MANUFACTURING UNIT COST INCREASE REGULATORY LEVEL (J331a)				
PRODUCT CLASSIFICATION	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
NOMINAL (EXPECTED) CASE					
Street-Legal					
99cc and Below	0	0	0	7	17
100-169cc	0	2	10	43	84
170-349cc	0	4	18	56	115
350-749cc	0	8	25	82	170
750cc and Above	0	10	37	99	193
Off-Road					
99cc and Below	0	0	0	7	
100-169cc	0	2	8	61	
170-349cc	4	8	40	78	
350-749cc	4	12	89	112	
WORST CASE					
Street-Legal					
99cc and Below	0	0	0	7	17
100-169cc	0	2	28	61	87
170-349cc	0	4	36	74	118
350-749cc	0	8	54	108	174
750cc and Above	0	10	67	135	198
Off-Road					
99cc and Below	0	0	0	7	
100-169cc	0	2	47	61	
170-349cc	4	8	59	78	
350-749cc	4	12	89	112	

7.1.3 Research and Development Costs

Research and development costs include the cost of: R&D personnel, laboratory facilities and diagnostic equipment, prototype motorcycles, materials and components, and production design and drawings. The impact of research and development cost on unit cost is particularly difficult to determine because of variances in the sizes and characteristics of the companies involved, the differences in depth and breadth of each company's product line, extent of expenditures in the effort that can be considered "sunk" costs and have already been amortized, unknown technical complexities and model peculiarities that will be encountered in the R&D and production design program, differences in available resources and personnel, differences in cost accounting policies, and program variables such as the degree of noise reduction required for each class of motorcycle.

Nevertheless, estimates for amortized R&D cost increases on a unit basis were provided by three manufacturers. Data from two of the companies is relatively consistent and is summarized in Table 7-10. Both are Category I Manufacturers (manufacturers that produce 100,000 units or more annually). Data from the other manufacturer (a manufacturer that produces less than 100,000 units per year) were considerably higher than the other manufacturers. This is to be expected because total R&D expenses were allocated over fewer units when estimating costs on a per unit basis. Based on the available information, a reasonable estimate would be that the R&D costs on a unit basis for a Category II manufacturer would be approximately double the unit R&D costs of a Category I manufacturer.

Data for the Category I manufacturers is shown graphically in Figure 7-7. Data from these manufacturers indicate that R&D costs on a unit basis tend to vary with development categorization. R&D costs are significantly higher in those cases where major model changes are indicated, as would be expected. The "best-fit" line for the data points exhibited are indicated by diamond symbols (◆), and identified as generalized cost estimates in the figure.

The slope of the line for the generalized cost estimate associated with major model changes is assumed to be the same as that for straightforward changes. The generalized cost estimates for Category I manufacturers are summarized in Table 7-11.

The generalized estimates in Table 7-11 for Category I manufacturers were modified by two factors to derive the composite (weighted) average R&D unit cost increases for all manufacturers, shown in Table 7-12. The two factors considered in deriving the weighted composite are: (1) approximately 86% of all motorcycles sold in the U.S. are manufactured by Category I manufacturers, and (2) R&D unit costs for

TABLE 7-10

AMORTIZED R&D COSTS ON A UNIT BASIS -

MANUFACTURER SUPPLIED DATA

MANUFACTURER CATEGORY*	MANUFACTURER	DEVELOPMENT CLASSIFICATION	REGULATORY LEVEL, J331a (dBA)	R&D UNIT COST
I	A	Straight-Forward Development	83 80 78 75	3 10 16 21
		Major Model Configuration Change at 78 dBA	83 80 78	3 10 28 - 35
	B	Straight-Forward Development	83 80 78	1.4 5.9 12.8
		Major Model Configuration Change at 78 dBA	83 80 78	2.0 12.2 38.0

* Category I - Manufacturers that produce 100,000 units or more annually.

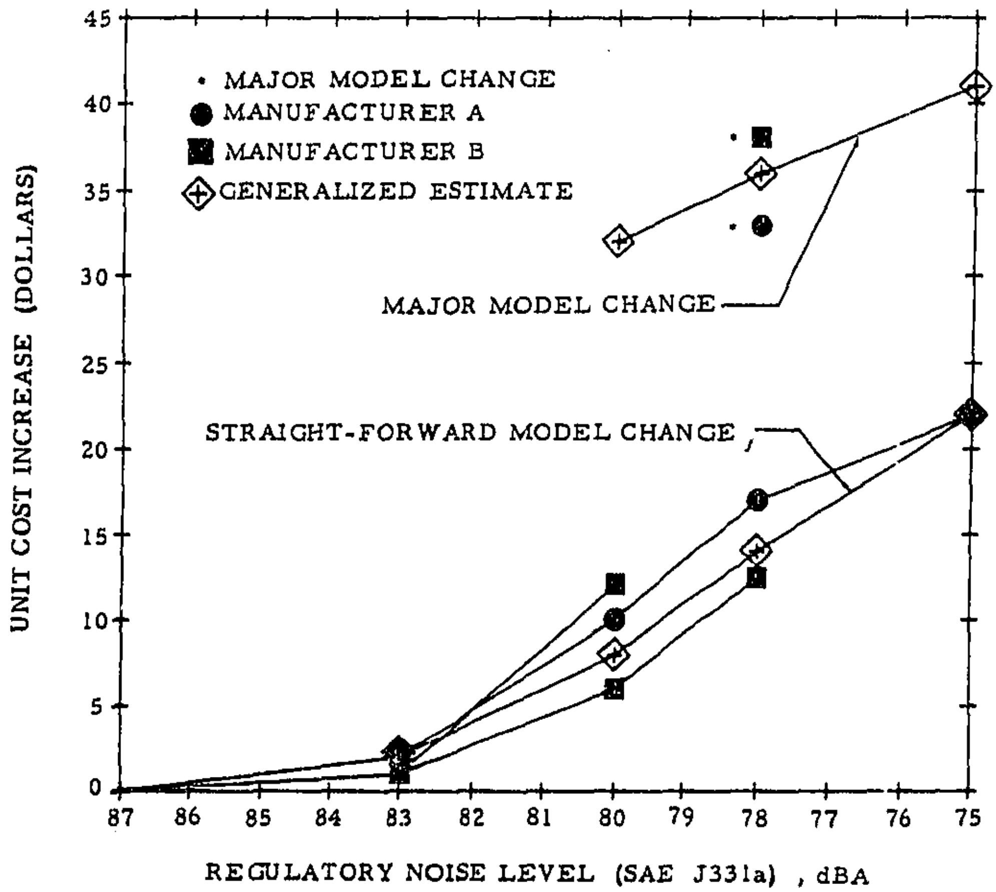

FIGURE 7-7 CATEGORY I . MANUFACTURER'S AMORTIZED R&D COST ON A UNIT BASIS VS. REGULATORY NOISE LEVEL

TABLE 7-11

MOTORCYCLE UNIT COST INCREASE DUE TO AMORTIZED R&D EXPENSES:
GENERALIZED COST ESTIMATE FOR MANUFACTURERS
PRODUCING 100,000 OR MORE MOTORCYCLES PER YEAR

	MOTORCYCLE UNIT COST INCREASE				
	REGULATORY LEVEL (SAE J331a)				
CHANGE CATEGORY	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
• Straight Forward Model Development	$1	$2	$8	$14	$21
• Major Model Configuration Change @ 80 dBA (J331a)			$32	$35	$42

Note: Derived from data - Category I manufacturers shown in Table 7-10

TABLE 7-12

MOTORCYCLE UNIT COST INCREASE DUE TO AMORTIZED R&D EXPENSES:
COMPOSITE WEIGHTED AVERAGE FOR ALL MANUFACTURERS

	MOTORCYCLE UNIT COST INCREASE				
	REGULATORY LEVEL (SAE J331a)				
CHANGE CATEGORY	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
• Straight Forward Model Development	1	2	9	16	24
• Major Model Configuration Change			36	40	48

Derivation Notes:

1. Available information indicates that manufacturers with production rates less than 100,000 units per year are likely to have unit R&D costs that are twice (2) that of manufacturers with production rates of 100,000 or more per year.
2. Manufacturers with production rates less than 100,000 units per year, sell 14% of all motorcycles sold in the U.S.

TABLE 7-13

MOTORCYCLE UNIT COST INCREASE DUE TO AMORTIZED R&D EXPENSES: NOMINAL (EXPECTED) AND WORST CASES

	MOTORCYCLE UNIT COST INCREASE				
	REGULATORY LEVEL (SAE J331a)				
CHANGE CATEGORY	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
• Nominal (Expected) Case	$1	$2	$12	$28	$46
• Worst Case	$1	$2	$23	$40	$48

Category II manufacturers are estimated to be double those of Category I manufacturers. Therefore the composite weighted average for all motorcycle manufacturers should be roughly 1.14 times the cost of Category I manufacturers.

Table 7-13 shows nominal and worst case R&D unit costs associated with different regulatory levels. These values are used in computing total unit cost increases.

7.1.4 Tooling and Other Manufacturing Equipment Costs

The use of sound reduction techniques will impact manufacturing equipment and tooling requirements; most of the impacts are expected to fall into the tooling category. Tooling and equipment cost impacts estimated by different manufacturers for various regulatory levels and modification techniques are summarized in Table 7-14. The estimates of amortized tooling cost on a unit basis show considerable variance, as shown in Figure 7-8. Probable reasons for the wide variance include differences in: (1) regulatory levels requiring major model changes, (2) production bases (number of units over which tooling costs are allocated), and (3) models and production techniques.

Tooling costs on a unit basis tend to be considerably higher for Category II manufacturers (producing 100,000 units per year or less), again because fixed expenses are allocated over fewer units. Generalized cost estimates for Category I manufacturers are indicated by lines in Figure 7-8, and summarized in Table 7-15. Estimates for both straightforward and major model changes are provided. The generalized estimates represent an evaluation of trends indicated in manufacturer-supplied data. The slope for both lines is assumed to be the same. A conservative (high) estimate of unit tooling costs for major model changes was used.

As in the case of R&D expenses, it would appear that unit tooling costs for Category II manufacturers are approximately double that of Category I manufacturers. A composite weighted average for all manufacturers was computed using the 1.14 factor derived in the previous section. The weighted average is summarized in Table 7-16. Composite cost estimates for nominal and worst cases are summarized in Table 7-17.

TABLE 7-14

TOOLING AND PRODUCTION EQUIPMENT COST ESTIMATES
MANUFACTURER SUPPLIED DATA

MANUFAC-TURER CATEGORY	DATA POINT	REGULATORY LEVEL	TOOLING COST	AMORTIZED TOOLING COST ON A UNIT BASIS	MODIFICATIONS
I	1	78 dBA		$23	Major Model Change
I	2	75 dBA		$11	Major Model Change
I	3	83 dBA	$ 70K	$3.5(E)[1]	Straight-Forward
		80 dBA	$140K	$7.0(E)	Modifications
I	4	78 dBA	$2.0M	33.0[2]	Major Model Change

[1]Estimated as follows: $70,000 in tooling amortized over 20,000 units for each of the specified regulatory levels. The $70,000 estimate provided by the manufacturer.

[2]Independent estimate.

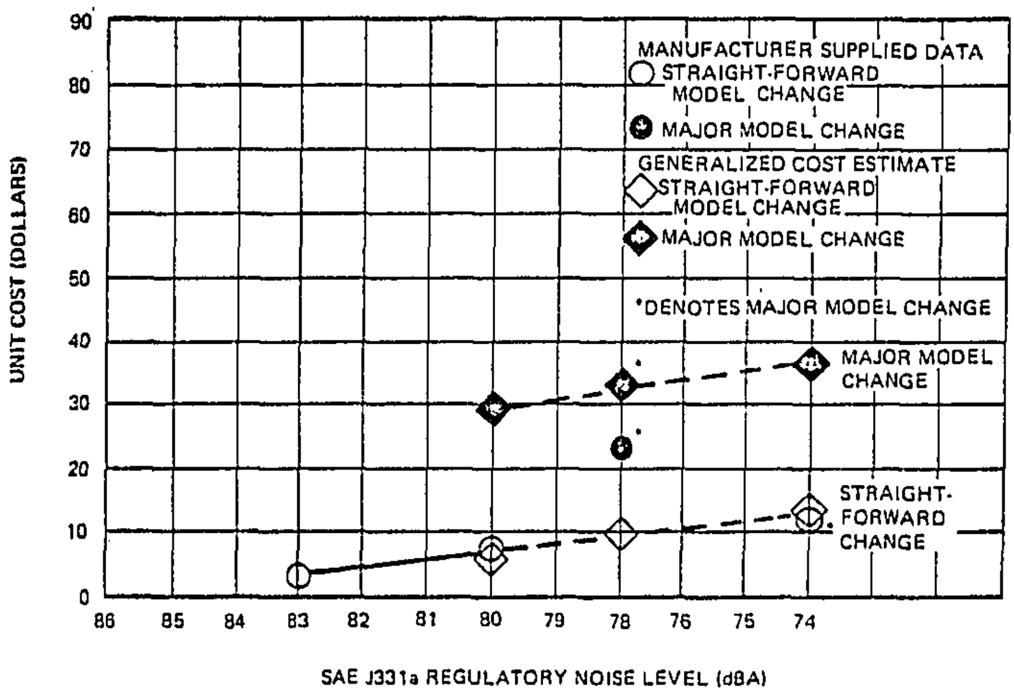

FIGURE 7-8 CATEGORY I MANUFACTURER'S AMORTIZED TOOLING COST ON A UNIT BASIS VS. REGULATORY NOISE LEVEL

TABLE 7-15

MOTORCYCLE UNIT COST INCREASES DUE TO AMORTIZED TOOLING EXPENSES:
GENERALIZED COST ESTIMATE FOR MANUFACTURERS
PRODUCING 100,000 UNITS OR MORE MOTORCYCLES PER YEAR

CHANGE CATEGORY	MOTORCYCLE UNIT COST INCREASE REGULATORY LEVEL (SAE J331a)				
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
• Straight-Forward Model Development	$ 0	$4	$7	$9	$13
• Major Model Change @ 80 dBA (J331a)			$30	$33	$37

TABLE 7-16

MOTORCYCLE UNIT COST INCREASE DUE TO AMORTIZED TOOLING EXPENSES:
COMPOSITE WEIGHTED AVERAGE FOR ALL MANUFACTURERS

CHANGE CATEGORY	MOTORCYCLE UNIT COST INCREASE REGULATORY LEVEL (SAE J331a)				
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
• Straight-Forward Model Development	$ 0	$5	$8	$10	$15
• Major Model Configuration Change			$34	$38	$42

TABLE 7-17

MOTORCYCLE UNIT COST INCREASE DUE TO AMORTIZED TOOLING EXPENSES: NOMINAL (EXPECTED) AND WORST CASES

CHANGE CATEGORY	MOTORCYCLE UNIT COST INCREASE				
	REGULATORY LEVEL (SAE J331a)				
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
• Nominal (Expected) Case	$ 0	$5	$11	$24	$39
• Worst Case	$ 0	$5	$21	$38	$42

7.1.5 Testing and Certification Costs

For standardized acceleration tests, the basic sound level meter and accessories required typically cost between $550 and $2,600 (see Table 7-18). A sound level recorder, if necessary, would cost an additional $2,400. Differences in test types are described for both O.E.M. and exhaust system manufacturers.

(a) Moving Tests

The test facilities of major vehicle manufacturers are generally permanent installations, and cost from $225,000 and up. A common alternative to setting up permanent facilities is to rent or lease test sites. A typical facility rental cost would be $10 per motorcycle, or $100 per day. Based on experience gained in EPA's motorcycle test program, it is estimated that sound levels can be measured on an average of 20 motorcycles per eight-hour period, since the initial set-up time in this case is minimal. The tests require three people (two technicians and a rider), and would include six readings in each direction.

For an aftermarket exhaust system manufacturer, considerably more time would be required to transport motorcycles to rented test facilities, set-up the test site, and exchange exhaust systems as required. Again, based on test experience, it is estimated that the sound levels on an average of eight exhaust system configurations can be measured in an eight-hour period.

(b) Stationary Tests

Stationary tests are the simplest tests to administer and require minimal facilities. In addition, the actual test time is almost negligible. Testing of different exhaust system configurations may require two persons, but the measurement rate is the same.

The two basic elements for estimating test operation costs are the measurement rates and the number of personnel required. Costs can be computed by using an appropriate labor rate combined with the number of measurements required.

TABLE 7-18

TYPICAL COST OF SOUND LEVEL METERS AND ACCESSORIES

COMPONENT	COST
Type I Sound Level Meter (B&K 2209)	$ 1,706
Microphone	343
Pistonphone	475
Accessories (tri-pod, windscreen, etc.)	100
	$ 2,624
Type II Sound Level Meter (B&K 2213)	$ 354
Acoustic Calibrator	177
Accessories	15
	$ 546
Sound Level Recorder (B&K 2306)	$2,400

Source: B&K Catalog (prices as of July 1, 1975).

Compliance testing cost estimates from three manufacturers are summarized in Table 7-19. An EPA estimate appears in Table 7-20. Although EPA estimates of test and administration costs are considerably lower, manufacturer estimates were used in computing unit cost increases for testing and compliance requirements. For major manufacturers, unit costs were figured on the basis of 270,000 unit sales per year, with equipment amortization over a four-year period. A breakdown of the manufacturer estimated costs is as follows:

Cost Element	Cost	Cost on Annual Basis	Unit Cost
o Equipment	$300,000	$ 75,000	0.28
o Test and Administration Costs	$300,000	$300,000	1.11
		Subtotal	1.39

Assuming that unit costs for smaller manufacturers are higher, a reasonable estimate for the composite weighted average for all motorcycles is $1.5 per unit. In addition, Harley Davidson estimates labeling would add approximately $0.5 to unit costs.[1] Compliance testing and certification costs would therefore add approximately $2 to unit costs, and this value is used in computing total unit cost increases.

7.1.6 Total Unit Cost Increases

Total unit cost increases resulting from compliance with noise standards are composed of four major cost elements:

(1) Manufacturing unit cost increases.

(2) Amortized R&D costs on a unit basis.

(3) Amortized tooling costs on a unit basis.

(4) Compliance testing and certification costs on a unit basis.

The total unit cost increases versus study levels for the various motorcycle product categories evaluated in this study are summarized in Table 7-21. The costs are for not-to-exceed regulatory noise levels as measured by the SAE J331a procedure. "Nominal" and "worst"

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[1] AMF/Harley-Davidson's reply to Exhaust Emission Notice of Proposed Rulemaking, January 30, 1976.

TABLE 7-19

ESTIMATED COST OF COMPLIANCE TESTING -

MANUFACTURER SUPPLIED DATA

Manufacturer A

- Additional test equipment and facilities cost:
  1. Additional test site for SAE J331a --- $100,000.
  2. Six sets of equipment for performing ISO stationary vehicle measurements ---- $180,000.

- Test Operations and administration costs:
  1. Sampling inspections by SAE J331a of three units/model/month at 3 units/day ---- $16,000 per year.
  2. ISO stationary inspection of motorcycles for U.S.

100% inspection	$200,000 per year
1% inspection	$ 2,000 per year

Manufacturer B

- Additional Test Equipment and Facilities:
  $250,000 - $400,000 depending on type of testing.

- Test Operations and Administration Costs:
  $100,000 - $300,000 per year depending on required levels of production verification.

Manufacturer C

- Additional Test Equipment and Facilities Cost: $300,000
- Test Operations and Administration Cost: $300,000 per year.

TABLE 7-20

ESTIMATE OF ANNUAL TESTING AND

CERTIFICATION COSTS--MAJOR MANUFACTURER

Cost Component				Cost ($)
Production Verification (see enforcement section)	25 models 3 persons	1 test each 1 hr/test	75 hr	
Selective Enforcement Audit (see enforcement section)	3 models 3 persons	15 vehicles/model 1 hr/test	135 hr	
Label Verification (see enforcement section)	25 models 2 persons	30 tests each 5 min/test	125 hr	
Reporting & Administration			250 hr	
		Total	685 hr	
			@ $20/hr	$11,700
Materials & Miscellaneous				5,000
			Total	$16,700

PROJECTED MOTORCYCLE TOTAL UNIT COST INCREASES
VERSUS REGULATORY LEVELS

PRODUCT CLASSIFICATION	TOTAL UNIT COST INCREASE REGULATORY LEVEL (J331a)				
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
NOMINAL (EXPECTED) CASE					
STREET-LEGAL					
99cc and Below	0	2	2	16	42
100 - 169cc	0	5	15	62	125
170 - 349cc	0	13	43	110	202
350 - 749cc	0	17	50	136	257
750cc and Above	0	19	62	153	280
OFF-ROAD					
99cc and Below	0	2	2	16	
100 - 169cc	0	5	15	80	
170 - 349cc	5	17	65	132	
350 - 749cc	5	21	114	162	
WORST CASE					
STREET-LEGAL					
99cc and Below	0	2	2	16	42
100 - 169cc	0	5	33	124	171
170 - 349cc	0	13	82	154	210
350 - 749cc	0	17	100	188	266
750cc and Above	0	19	113	215	290
OFF-ROAD					
99cc and Below	0	2	2	16	
100 - 169cc	0	5	52	124	
170 - 349cc	5	17	105	158	
350 - 749cc	5	21	135	192	

cases are defined for appropriate categories. For product categories below 100cc, no major model changes are forecasted to meet regulatory levels, so no differences are expected between nominal and worst case costs in this category. Note that the total unit cost increases specified here are used to assess unit price impacts.

A breakdown of total unit costs by major cost element is provided in Tables 7-22 and 7-23. In general, the largest contributor to the unit cost increase is the manufacturing cost, which typically ranges from between 60 to 70 percent of the total, followed by amortized R&D and tooling costs. Certification costs are generally a very small part of total unit costs. The manufacturing unit cost increases were derived from the generalized cost estimates. These estimates showed relatively good agreement with cost estimates provided by manufacturers. Amortized R&D, amortized tooling, and compliance testing and certification costs were derived from manufacturer-supplied data. Manufacturer-supplied data was cross-checked for reasonableness of estimates.

7.2 Purchase Price Impacts

The impact of cost increases on purchase price resulting from noise control measures is a complex action, one which will be determined in the final analysis by free market interplay between supply and demand. Some of the alternatives which may be expected to occur as a result of the interaction of these economic forces as they relate to motorcycle noise control are presented in this Section.

Table 7-24 provides a rough approximation of the existing price mark-up structure as motorcycles go from manufacturer to distributor (if any) to dealer. Distributors for major manufacturers are generally wholly owned subsidiaries.

One manufacturer indicated that typical price mark-ups range between 20 to 40 percent at the retail level. Independent references tend to validate this estimate (see Table 7-24). The worst-case price increase due to an incremental change in cost is therefore assumed to be 50 percent, assuming that unit cost increases are marked up by typical rates at each level.

Ultimately, the impact on price could range all the way from a unit price increase being slightly less than a unit cost increase to a price increase equal to 1.5 times the cost increase. Individual representative cases in which four different levels of mark-up could occur are described below:

TABLE 7-22

TOTAL UNIT COST INCREASE COMPONENTS:

NOMINAL (EXPECTED) CASE

COST ELEMENT	*UNIT COST INCREASE (DOLLARS)* REGULATORY NOISE LEVELS[1] (J331a) 86 dBA	83 dBA	80 dBA	78 dBA	75 dBA	REF. TABLE
STREET LEGAL, 750cc & OVER						
• Manufacturing Cost		10	37	99	193	
• R&D[2]		2	12	28	46	
• Tooling[3] (Mfg. Equipment)		5	11	24	39	
• Compliance Testing & Certification Cost		2	2	2	2	
TOTAL		19	62	153	280	
STREET LEGAL, 350-749cc						
• Manufacturing Cost		8	25	82	170	
• R&D		2	12	28	46	
• Tooling (Mfg. Equipment)		5	11	24	39	
• Compliance Testing & Certification Cost		2	2	2	2	
TOTAL		17	50	136	257	
STREET LEGAL, 170-349cc						
• Manufacturing Cost		4	18	56	115	
• R&D		2	12	28	46	
• Tooling (Mfg. Eqp.)		5	11	24	39	
• Compliance Testing & Certification Cost		2	2	2	2	
TOTAL		13	43	110	202	
STREET LEGAL, 100-169cc						
• Manufacturing Cost		2	10	43	84	
• R&D		1	2	12	28	
• Tooling (Mfg. Equipment)		0	1	5	11	
• Compliance Testing & Certification Cost		2	2	2	2	
TOTAL		5	15	62	125	

1. Not to exceed regulatory levels.
2. Amortized R&D costs on a unit basis.
3. Amortized tooling costs on a unit basis.

TABLE 7-22 (CONT'D)

TOTAL UNIT COST INCREASE COMPONENTS:

NOMINAL (EXPECTED) CASE

COST ELEMENT	UNIT COST INCREASE (DOLLARS) REGULATORY NOISE LEVELS[1] (J331a)					REF.
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA	TABLE
STREET LEGAL, 99cc & BELOW						
• Manufacturing Cost	0	0	0	7	17	
• R&D[2]	0	0	0	2	12	
• Tooling (Mfg. Equipment)	0	0	0	5	11	
• Compliance Testing & Certification Cost		2	2	2	2	
TOTAL	0	2	2	16	42	
OFF-ROAD, 350-749cc						
• Manufacturing Cost	4	12	89	112		
• R&D	1	2	12	28		
• Tooling (Mfg. Equipment)	0	5	11	24		
• Compliance Testing & Certification Cost	0	2	2	2		
TOTAL	5	21	114	162		
OFF-ROAD, 170-349cc						
• Manufacturing Cost	4	8	40	78		
• R&D	1	2	12	28		
• Tooling (Mfg. Equipment)	0	5	11	24		
• Compliance Testing & Certification Cost	0	2	2	2		
TOTAL	5	17	65	132		
OFF-ROAD, 100-169cc						
• Manufacturing Cost	0	2	8	61		
• R&D	0	1	2	12		
• Tooling (Mfg. Equipment)	0	0	1	5		
• Compliance Testing & Certification Cost	-	2	2	2		
TOTAL	0	5	19	80		

1. Not to exceed regulatory levels.
2. Amortized R&D costs on a unit basis.
3. Amortized tooling costs on a unit basis.

TABLE 7-22 (CONT'D)

TOTAL UNIT COST INCREASE COMPONENTS:

NOMINAL (EXPECTED) CASE

COST ELEMENT	UNIT COST INCREASE (DOLLARS) REGULATORY NOISE LEVELS[1] (J331a) 86 dBA	83 dBA	80 dBA	78 dBA	REF. TABLE
OFF-ROAD, 99cc & BELOW					
• Manufacturing Cost	0	0	0	7	
• R&D[2]	0	0	0	2	
• Tooling (Mfg. Equipment)	0	0	0	5	
• Compliance Testing & Certification Cost	0	2	2	2	
TOTAL	0	2	2	16	

1. Not to exceed regulatory levels.
2. Amortized R&D costs on a unit basis.
3. Amortized tooling costs on a unit basis.

TABLE 7-23

TOTAL UNIT COST INCREASE COMPONENTS:

WORST CASE:

COST ELEMENT	UNIT COST INCREASE (DOLLARS) REGULATORY NOISE LEVELS[1] (J331a)					REF.
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA	TABLE
STREET LEGAL, 750cc & OVER						
• Manufacturing Cost	0	10	67	135	198	
• R&D[2]	0	2	23	40	48	
• Tooling (Mfg. Equipment)	0	5	21	38	42	
• Compliance Testing & Certification Cost	0	2	2	2	2	
TOTAL	0	19	113	215	290	
STREET LEGAL, 350-749cc						
• Manufacturing Cost	0	8	54	108	174	
• R&D	0	2	23	40	48	
• Tooling (Mfg. Equipment)	0	5	21	38	42	
• Compliance Testing & Certification Cost	0	2	2	2	2	
TOTAL	0	17	100	188	266	
STREET LEGAL, 170-349cc						
• Manufacturing Cost	0	4	36	74	118	
• R&D	0	2	23	40	48	
• Tooling (Mfg. Equipment)	0	5	21	38	42	
• Compliance Testing & Certification Cost	0	2	2	2	2	
TOTAL	0	13	82	154	210	
STREET LEGAL, 100-169cc						
• Manufacturing Cost	0	2	28	61	87	
• R&D	0	1	2	23	40	
• Tooling (Mfg. Equipment)	0	0	21	38	42	
• Compliance Testing & Certification Cost	0	2	2	2	2	
TOTAL	0	5	33	124	171	

1. Not to exceed regulatory levels.
2. Amortized R&D costs on a unit basis.
3. Amortized tooling costs on a unit basis.

TABLE 7-23 (CONT'D)

TOTAL UNIT COST INCREASE COMPONENTS:

WORST CASE:

COST ELEMENT	UNIT COST INCREASE (DOLLARS) REGULATORY NOISE LEVELS[1] (J331a)				REF.
	86 dBA	83 dBA	80 dBA	78 dBA	TABLE
OFF-ROAD, 350cc-749cc					
• Manufacturing Cost	4	12	89	112	
• R&D[2]	1	2	23	40	
• Tooling (Mfg. Equipment)	0	5	21	38	
• Compliance Testing & Certification Cost	0	2	2	2	
TOTAL	5	21	135	192	
OFF-ROAD, 170-349cc					
• Manufacturing Cost	4	8	59	78	
• R&D	1	2	23	40	
• Tooling (Mfg. Equipment)	0	5	21	38	
• Compliance Testing & Certification Cost	0	2	2	2	
TOTAL	5	17	105	158	
OFF-ROAD, 100-169cc					
• Manufacturing Cost	0	2	47	61	
• R&D	0	1	2	23	
• Tooling (Mfg. Equipment)	0	0	1	38	
• Compliance Testing & Certification Cost	0	2	2	2	
TOTAL	0	5	52	124	

1. Not to exceed regulatory levels.
2. Amortized R&D costs on a unit basis.
3. Amortized tooling costs on a unit basis.

TABLE 7-24

NEW MOTORCYCLE PRICE MARK-UPS

LEVEL	PRICE				MARK-UP PERCENT	
	MFG.	REF. SOURCES			CONSENSUS	
	EST.[1]	A	B	C	Mark-up	Cum. Mark-up
New Motorcycle Manufacturers	6 to 12%	-	-	-	-	-
Distributors	20% to	0-25%	12-15%		0-25%	0-25%
Dealers	40%	33%[2]	20-25%	33%[2]	20-33%	20-66%

Note: [1] Primary Source Used in the Analysis. Other sources were used for reference only.

[2] Significant price discounting can occur at this level.

Sources:

A. International Research and Technology Corporation, "The Impact of Noise Abatement Standards on the Motorcycle Industry".

B. Manufacturer supplied confidential data.

C. Motorcycle Industry Council, "Manufacturer's Shipment Reporting System".

Case	Price Mark-Up Factor	Conditions
I	0.9	This would occur if manufacturer absorbed part of the incremental cost increase, and distributors and dealers reduced their mark-up factors to allow for straight pass-through of cost increase.
II	1.0	This would occur if manufacturers, distributors and dealers passed increased cost straight through to consumers.
III	1.2	This would occur if manufacturer and distributor passed cost straight through to dealer and dealers either used their standard mark-up or discounted their prices somewhat.
IV	1.5	This would occur if unit cost increase is marked-up by standard rates at each level.

Cases I and II would be considered very optimistic, primarily because it is counter to normal pricing mark-up policies, even for "incremental" cost increases. Case III is a more likely possibility because it takes into account both level of demand and profitability. Case IV would be considered worst case, because this is the mark-up factor that would impact demand most. If these mark-up factors reduced demand significantly, discounting and manufacturing rebate actions would likely take place, thereby reducing effective mark-up factors to those shown in Case III. The 1.2 factor is therefore a relatively realistic estimate and is used in the "nominal" case analysis. The 1.5 factor is used in the worst-case analysis.

Total unit cost increases determined in the cost analysis are used as the basis of estimating price increases. In the nominal case, total unit cost increases are factored by the 1.2 price mark-up factor derived in the previous section to determine price increases. In the worst case, total unit costs were factored by a 1.5 price mark-up factor. The results for the two cases and for each product category are summarized in Table 7-25, and shown in Figures 7-9 through 7-12. These price impacts are for regulatory levels as defined by the SAE J331a test procedure.

Average 1975 prices for each of the product categories are shown in Table 7-26. These prices were used as the baseline reference to compute the relative price increases summarized in Table 7-27.

TABLE 7-25

PROJECTED MOTORCYCLE PRICE INCREASES

VERSUS J331a REGULATORY LEVELS

Product Category	Unit Price Increase				
	Regulatory Level (J331a)				
	86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
Nominal (Expected) Case*					
Street-Legal					
99cc and Below	0	2	2	19	50
100-169cc	0	6	18	74	150
170-349cc	0	16	52	132	242
350-749cc	0	20	60	163	308
750cc and Above	0	23	74	184	336
Off-Road					
99cc and Below	0	2	2	19	
100-169cc	0	6	18	96	
170-349cc	6	20	78	158	
350-749cc	6	25	137	196	
Worst Case**					
Street-Legal					
99cc and Below	0	3	3	24	63
100-169cc	0	8	50	186	257
170-349cc	0	20	123	231	315
350-749cc	0	26	150	282	399
750cc and Above	3	29	170	323	435
Off-Road					
99cc and Below	0	3	3	24	
100-169cc	0	8	78	186	
170-349cc	8	26	157	237	
350-749cc	8	32	201	288	

* 1.2 price mark-up factor.

** 1.5 price mark-up factor

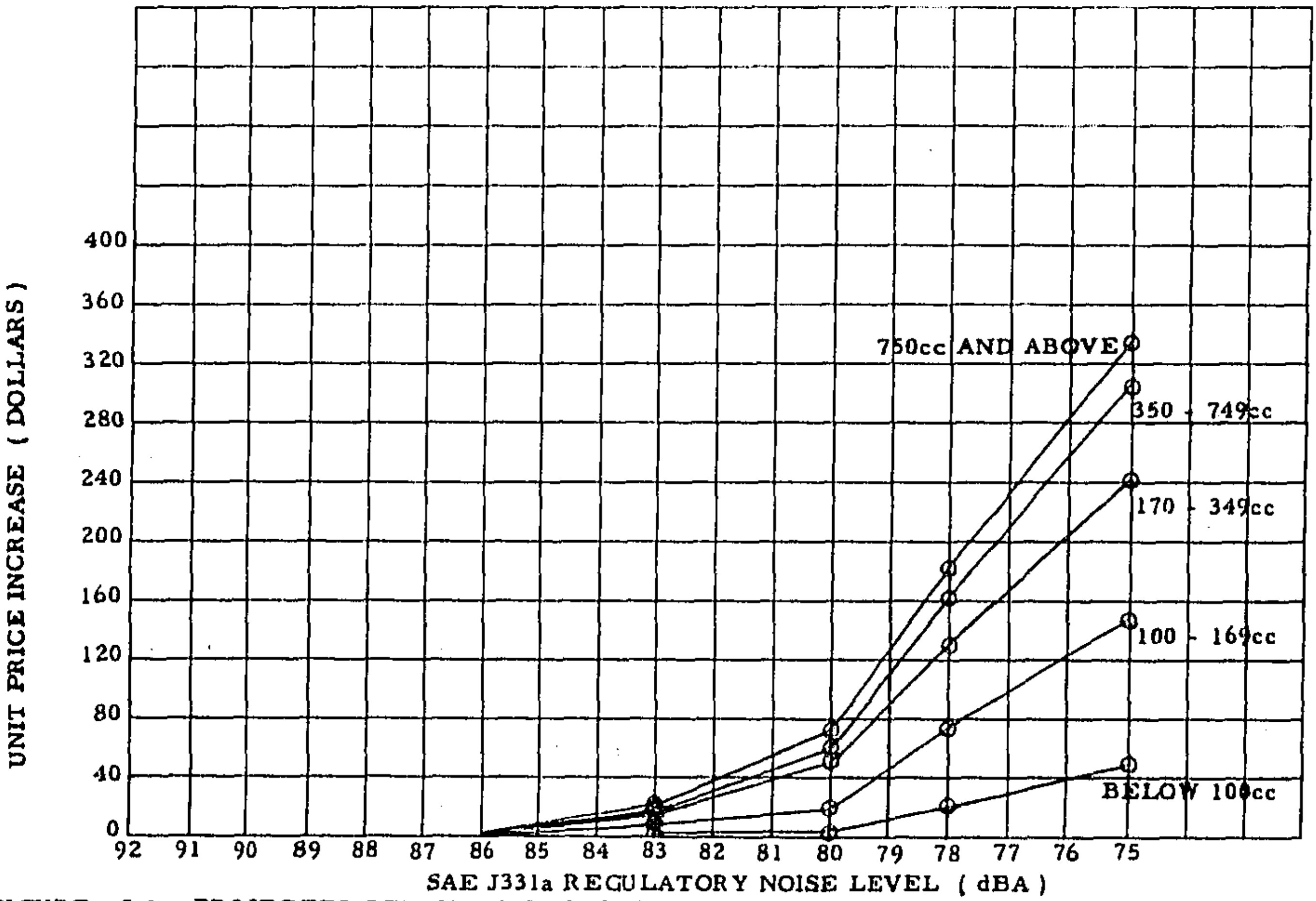


FIGURE 7-9 PROJECTED RETAIL PRICE INCREASES VS. REGULATORY NOISE LEVELS FOR STREET LEGAL MOTORCYCLES (NOMINAL CASE)

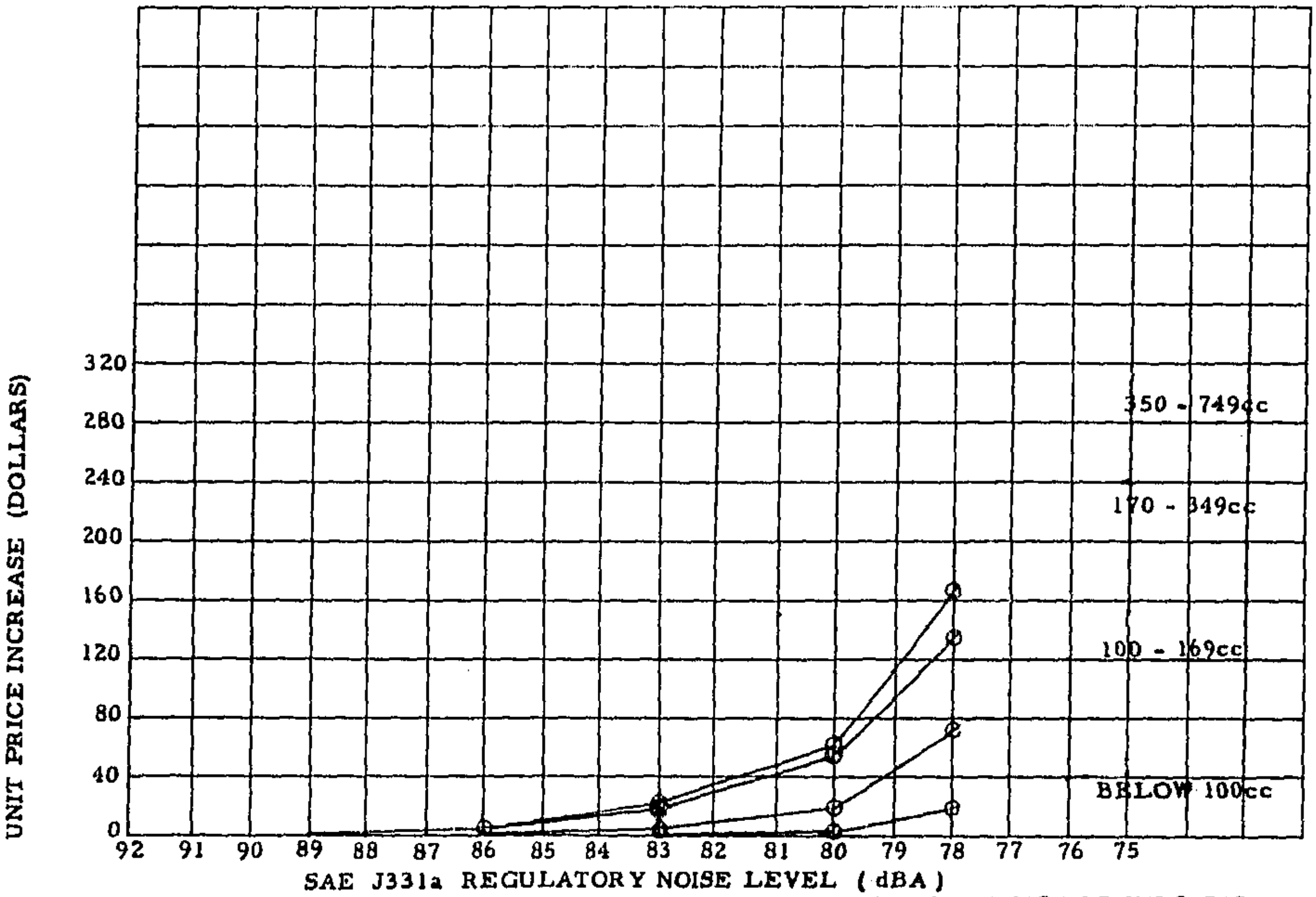


FIGURE 7-10 PROJECTED RETAIL PRICE INCREASES VS. REGULATORY NOISE LEVELS FOR OFF-ROAD MOTORCYCLES (NOMINAL CASE)

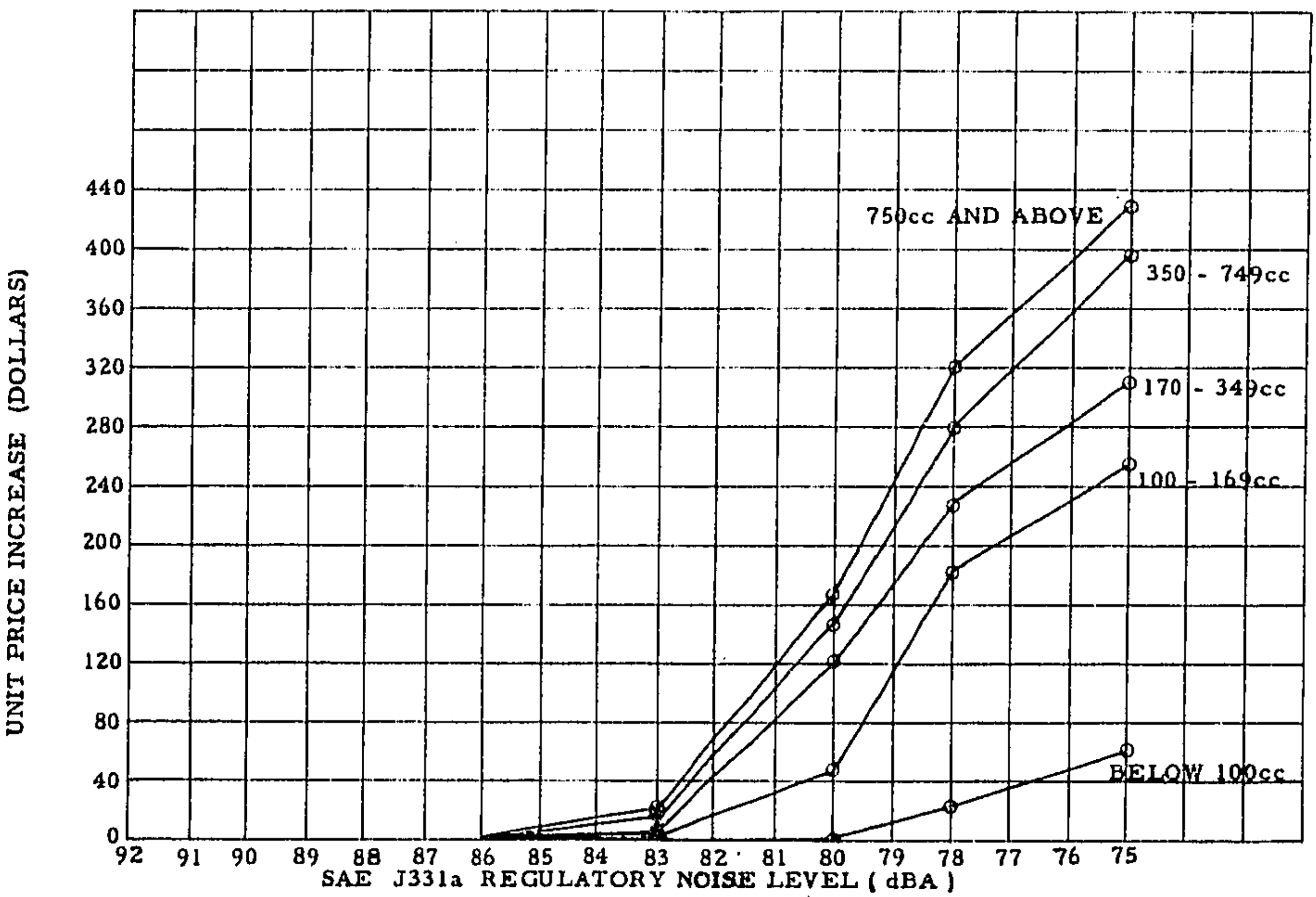


FIGURE 7-11 PROJECTED RETAIL PRICE INCREASES VS. REGULATORY NOISE LEVELS FOR STREET MOTORCYCLES (WORST CASE)

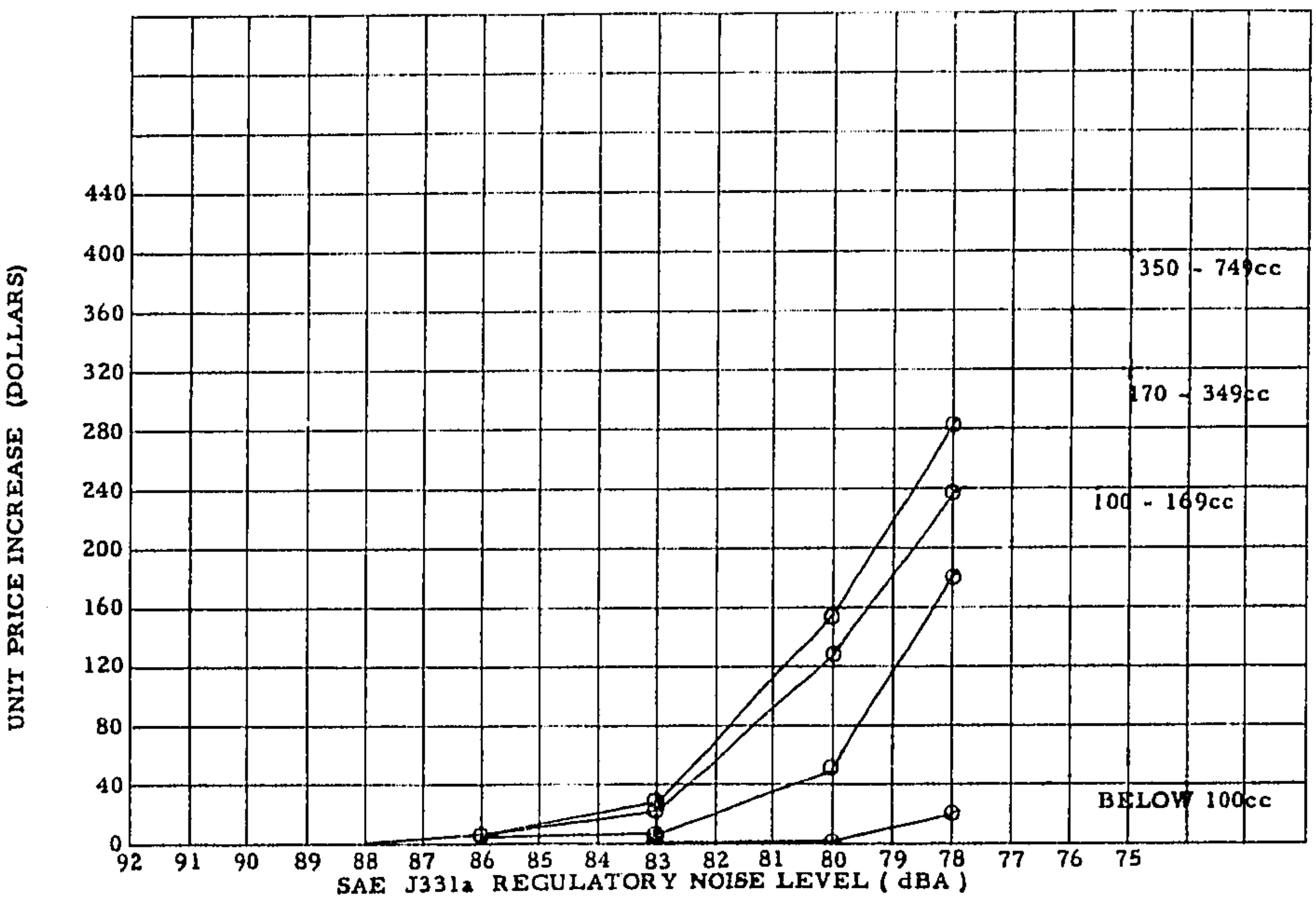


FIGURE 7-12 PROJECTED RETAIL PRICE INCREASES VS. REGULATORY NOISE LEVELS FOR OFF-ROAD MOTORCYCLES (WORST CASE)

TABLE 7-26

AVERAGE 1975 RETAIL PRICE FOR EACH PRODUCT CATEGORY

PRODUCT CATEGORY		AVERAGE RETAIL PRICE
FUNCTIONAL CATEGORY	SIZE CATEGORY	(1975 Sales)
Street-legal	750 cc and over	$ 2,571
Street-legal	350-749 cc	1,429
Street-legal	170-349 cc	997
Street-legal	100-169 cc	680
Street-legal	Under 100 cc	484
Off-road	350-749 cc	1,379
Off-road	170-349 cc	1,128
Off-road	100-169 cc	851
Off-road	Under 100 cc	491

Derived from Motorcycle Industry Council's Manufacture Shipment Reporting System

TABLE 7-27

PROJECTED MOTORCYCLE PRICE INCREASES

ON A RELATIVE BASIS

Product Category	Baseline '75 Price (Dollars)	Relative Price Increase (%) 86 dBA	83 dBA	80 dBA	78 dBA	75 dBA
<u>NOMINAL CASE</u>						
<u>Street-Legal</u>						
99cc and Below	$ 484	0	0.4	0.4	3.9	10.3
100-169cc	$ 680	0	0.9	2.6	10.9	22.1
170-349cc	$ 997	0	1.6	5.2	13.2	24.2
350-749cc	$1,429	0	1.4	4.2	11.4	21.6
750cc and Above	$2,571	0	0.9	2.9	7.2	13.1
<u>Off-Road</u>						
99cc and Below	$ 491	0	0.4	0.4	3.9	
100-169cc	$ 851	0	0.7	2.1	11.2	
170-349cc	$1,128	0.5	1.8	6.9	14.0	
350-749cc	$1,379	0.4	1.8	10.0	14.3	
<u>WORST CASE</u>						
<u>Street-Legal</u>						
99cc and Below	$ 484	0	0.6	0.6	5.0	13.0
100-169cc	$ 680	0	1.1	7.4	27.4	37.8
170-349cc	$ 997	0	2.0	12.3	23.1	31.5
350-749cc	$1,429	0	1.8	10.5	19.7	27.9
750cc and Above	$2,571	0	1.1	6.6	12.6	16.9
<u>Off-Road</u>						
99cc and Below	$ 491	0	0.6	0.6	4.9	
100-169cc	$ 851	0	0.9	9.2	21.9	
170-349cc	$1,128	0.7	2.3	14.0	21.0	
350-749cc	$1,379	0.5	2.3	14.6	20.9	

7.3 Replacement Exhaust System Price Impacts

Using manufacturer-supplied data and an independent estimate, the purchase price increases expected for 4 into 1 and 2 into 1 exhaust systems were calculated. These figures, shown in Tables 7-28, 7-29, and 7-30 indicate that replacement exhaust systems would cost nearly as much as original equipment replacement systems sold by the vehicle manufacturer.

TABLE 7-28

EXHAUST SYSTEMS

TYPICAL PRICE MARK-UPS

Cost/Price	Source	4 into 1 Exhaust System		2 into 1 Exhaust System	
		Dollars	Mark Up	Dollars	Mark-Up
Muffler Cost	1	$19		$17	
Header Cost	1	$38		$19	
Total Cost		$57	X	$36	X
Profit Margin	2	$ 7		$ 4	
Net Price to Distributor	2	$64		$40	
Net Price to Dealer	2	$90		$60	
Suggested Retail Price	2	$140	2.45X	$90	2.5X

Source:

1. Independent cost estimate.
2. Manufacturer Supplied Data.

TABLE 7-29

INCREASE IN MUFFLER COSTS VERSUS

REGULATORY LEVELS

Muffler	Baseline Cost	REGULATORY LEVEL (J331a)			
		83 dBA	80 dBA	78 dBA	75 dBA
4 into 1* Cost	$18	$24.0	$31.0	$42.0	$70.0
Percentage Increase	-	+33%	+72%	+133%	+289%
2 into 1** Cost	$17	$21.0	$26.0	$35.0	$58.0
Percentage Increase	-	+24%	+52%	+106%	+241%

* Motorcycle 750cc and above assumed.

** Motorcycle 350-749cc Assumed.

Source: Independent Estimate

TABLE 7-30
INCREASE IN EXHAUST SYSTEM PRICES
VERSUS REGULATORY LEVELS

Exhaust System	Baseline Price	Regulatory Levels 83 dBA	80 dBA	78 dBA	75 dBA
4 into 1 Price	140	$152	$169	$196	$265
Percent Increase		+9%	+21%	+40%	+89%
2 into 1 Price	90	$100	$113	$135	$193
Percent Increase		+11%	+26%	+50%	+114%

Source: Independent Estimate.

7.4 Operation Costs

As discussed in Section 6.3 the principal operation cost associated with lower levels of sound control is the impact on fuel economy. Based on the fuel penalties in Section 6.3.2, the "nominal" and "worst" case estimates for fractional reduction in fuel economy are listed below (all size categories combined):

		Regulatory Level (dB(A), J-331a)			
		Percent			
		83	80	78	75
Street:	Nominal Case	0	2	7.5	14
	Worst Case	0	4	12	15
Off-road:	Nominal Case	0.5	4	7	—
	Worst Case	1	5	8	—

Several motorcycle review magazines routinely measure fuel economy of motorcycles tested. Testing sequences are not specified and undoubtedly vary from test to test and magazine to magazine. However, a review of recently published data from Cycle and Cycle Guide magazines indicate that estimates of 45 m.p.g. for street motorcycles over 170c.c. and 70 m.p.g. for street motorcycles 170c.c. and under are reasonably consistent with reported results. These estimates generally agree with manufacturer-supplied information. The data in Section 5 indicate that motorcycles under 170c.c. travel about 2/3 the annual distance of motorcycles over 170c.c. Further, the data in Section 2 indicate that motorcycles under 170c.c. make up approximately six percent of the street motorcycle population. These figures can be combined for a composite fuel economy of current street motorcycles of about 47 m.p.g. Two-stroke engines generally display somewhat lower fuel economy than 4-stroke models, but large consistent differences were not noted. From these same reports, 35 m.p.g. for pure off-road motorcycles over 170c.c. and 70 m.p.g. for off-road motorcycles under 170c.c. is assumed. Mileage data indicate no significant difference in annual mileage between large and small motorcycles, so these can be combined for a composite 60 m.p.g. figure.

Based on 1500 miles per year for street and combination motorcycles, 530 miles for off-road motorcycles and $0.60/gallon of gasoline, the annual operation expense attributable to sound reduction is estimated to be (dollars/year):

	Regulatory Level (dB(A), J-331a)				
	86	83	80	78	75
Street: Nominal Case		0	0.40	1.50	2.7
Worst Case		0	0.75	2.25	3.0
Off-road: Nominal Case	0	0.03	0.25	0.45	—
Worst Case	0	0.05	0.30	0.50	—

7.5 Maintenance Costs

Estimates were made in Section 6.3 on the additional number of labor hours per year required to maintain motorcycles as a result of sound reduction. There has been no indication that at lower sound levels exhaust systems or other parts are any less durable than current systems so no increase in maintenance parts is expected. The nominal and worst case increased labor estimates are listed below (all size categories combined; hours/year):

	Regulatory Level (dB(A), J-331a)				
	86	83	80	78	75
Street: Nominal Case		0	1/4	1/2	3/4
Worst Case		0	3/8	3/4	3/4
Off-road: Nominal Case	0	1/16	1/4	3/8	—
Worst Case	0	1/8	3/8	1/2	—

Although many motorcyclists do their own maintenance, for costing purposes maintenance at a moderate cost repair facility with a labor rate of $16/hour is assumed. The resulting increased annual maintenance costs are listed below (dollars/year):

	Regulatory Level (dB(A), J-331a)				
	86	83	80	78	75
Street: Nominal Case		0	4	8	12
Worst Case		0	6	12	12
Off-road: Nominal Case	0	1	4	6	—
Worst Case	0	2	6	8	—

7.6 Costs of EPA Air Emission Requirements

The assessed costs and impacts of this proposed regulation will be in addition to those costs and impacts attributable to EPA's motorcycle air emission regulations (40 FR 1122, January 5, 1977). EPA studies using information supplied by various manufacturers indicated that the cost of compliance with the air emission standards for 1978 would result in an average increase in retail cost of 47 dollars per motorcycle. This cost would be partially offset by an average discounted lifetime fuel savings of 33 dollars and an undetermined savings in maintenance and improved reliability of the product. The average incremental cost increase for the 1980 standards was estimated to be $9, which included a small additional improvement in fuel economy. The manufacturers estimated that fuel economy improvements associated with the 1978 emission standards would range as high as 65 percent with an average increase of 20 percent. No significant decrease in sales or shift in market shares (between manufacturers) was expected to result from the implementation of that regulation.

SECTION 8

ECONOMIC IMPACT ANALYSIS

Section 8

ECONOMIC IMPACT ANALYSIS

8.1 New Motorcycle Sales Forecast

8.1.1 Historical New Motorcycle Sales and Trends

Demand for new motorcycles increased at an average rate of 27 percent each year between 1967 and 1973, but declined 22 percent in 1974 and 25 percent in 1975, according to estimates of new motorcycle sales shown in Table 8-1. The registration data shown in Table 8-1 and in Figure 8-2 are relatively precise, but do not represent total sales, since off-road and competition models are not required to be registered in most states. Total motorcycle sales data for the 1973 to 1975 period was derived from the Motorcycle Industry Council's Manufacturing Shipment Reporting System, which represents shipment data of the six largest manufacturers to their dealers. This is the closest approximation of actual retail level sales that is available at this time. Based on motorcycle registrations (Table 2-4), the six largest manufacturers combined have accounted for approximately 94 percent of the total market over the duration of the reporting period (1973-1975). This was accounted for in establishing the data base for analysis by factoring all data with the 94 percent factor.

Definitions used in the Manufacturers Shipment Reporting System are contained in Table 8-2. The reporting system was specially formatted for this study to provide sales data for the product categories shown in Table 8-3.

Complete monthly sales data from January 1973 through December 1975 for total motorcycle unit sales, retail and wholesale, and regional sales data has been provided by the Motorcycle Industry Council to the EPA.

Sales by Product Category

The breakdown of 1975 sales by product category shown in Figure 8-3 indicates that on-road motorcycles accounted for 48 percent of the total, combination motorcycles 25.5 percent, and off-road 26.5 percent. Street legal motorcycles therefore made up 73.5 percent of the sales total. Over one-third of the motorcycles (36.3 percent) are on-road motorcycles 250cc and above, the majority of the motorcycles in this category having 4-stroke engines. Almost all of the off-road motorcycles from 100 to 349cc have 2-stroke engines.

Table 8-1 NEW MOTORCYCLE UNIT SALES DATA (1) (1967-1975)

Year	NEW MOTORCYCLE REGISTRATIONS(1)	NEW MOTORCYCLE SOLD (EST)	CHANGE FROM PREVIOUS YEAR
1975	746,778	883,820 (2)	-25%
1974	1,024,084	1,180,138 (2)	-22%
1973	1,189,789	1,520,741 (2)	+16%
1972	1,006,143	1,314,315 (2)	+ 8%
1971	928,185	1,238,000 (E)	+24%
1970	751,291	1,002,000 (E)	+37%
1969	549,933	733,000 (E)	+26%
1968	437,498	583,000 (E)	+52%
1967	287,058	383,000 (E)	-

Sources: (1) R. L. Polk Registration Data

(2) Motorcycle Industry Council, "Manufacturer's Shipment Reporting System" (data representing approximately 94% of estimated retail level sales was factored to obtain total estimate).

(E) New motorcycle registration in these years estimated to be 75% of new motorcycles sold (based on 1972, 1973 data).

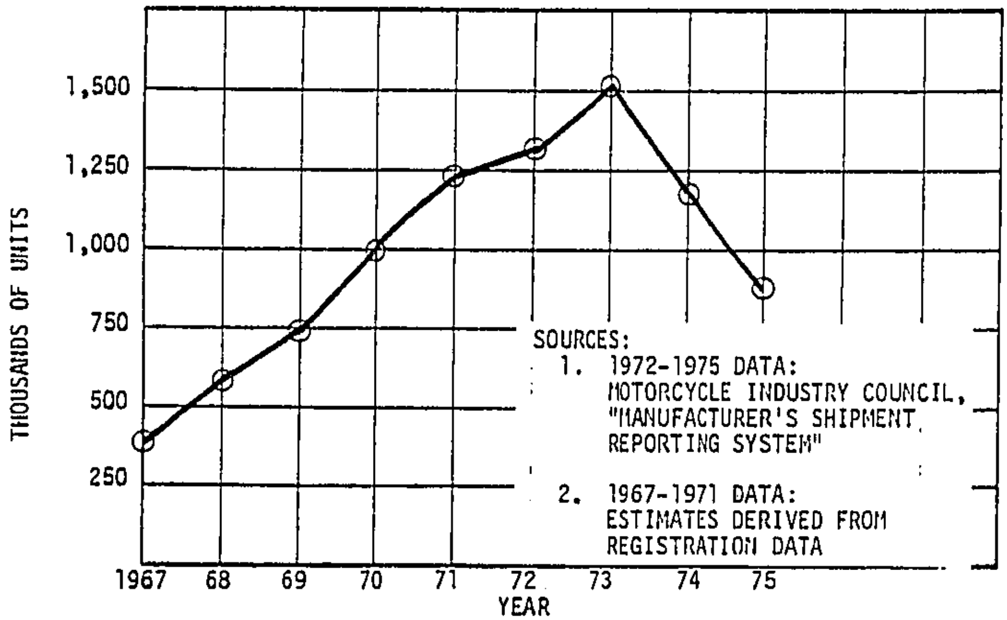


FIGURE 8-1 NEW MOTORCYCLE SALES, 1967 - 1975

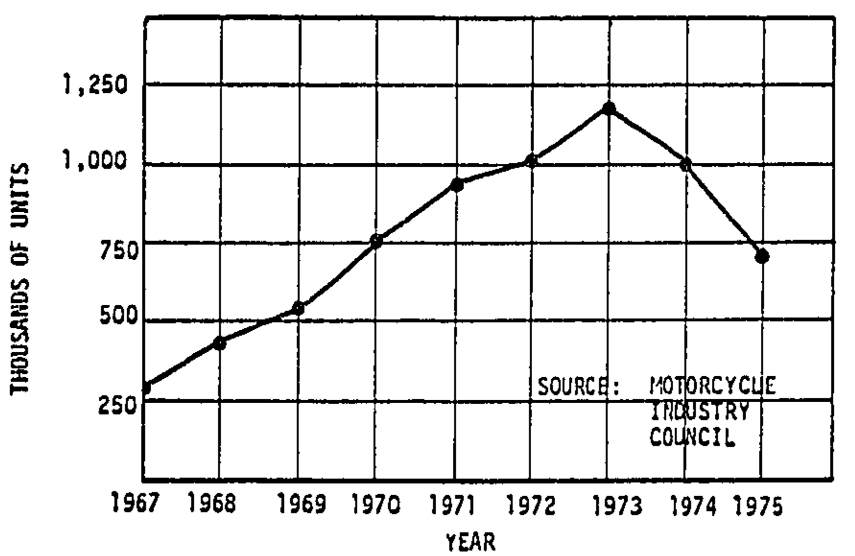


FIGURE 8-2 U.S. NEW MOTORCYCLE REGISTRATIONS, 1967 - 1975

TABLE 8-2

MOTORCYCLE INDUSTRY COUNCIL
MANUFACTURER'S SHIPMENT REPORT
DEFINITIONS

MOTORCYCLE

A vehicle which is fully or partially propelled by a power source other than muscular power and designed to travel with not more than three wheels in contact with the ground.

INCLUDED IN THIS REPORT ARE:

- Two wheel motorcycles
- Motorcycles with side cars
- Three wheel motorcycles
- Mini-cycles
- Mini-bikes
- All-terrain two and three wheels
- Motorized bicycles
- Motor scooters
- Mopeds

SPECIFICALLY EXCLUDED FROM THIS REPORT ARE:

- Golf carts
- Tractors
- Equipment designed specifically for in factory industrial uses
- Three wheel vehicles with a full passenger enclosure

SHIPMENTS

Net wholesale shipments of motorcycles from manufacturers or distributors to retail dealers. Returns and adjustments from original shipments should be deducted in the month they occur, not applied to the original month shipped.

PARTICIPATING MANUFACTURER

The motorcycle manufacturers or wholesale distributors who submit regular shipment reports. The initial participating manufacturers are American Honda, Yamaha International, U.S. Suzuki, Kawasaki Motors, Harley-Davidson, and Norton Triumph. Additional participation by other manufacturers will be approved individually by the M.I.C. Board of Directors.

ENGINE TYPES

Two stroke cycle engine

An engine which requires two strokes of the piston to complete one combustion sequence composed of intake, compression, combustion, and exhaust. The fuel/air mixture is ignited once for every crankshaft rotation.

Four stroke cycle engine

An engine which requires four strokes of the piston to complete one combustion sequence composed of intake, compression, combustion, and exhaust. The fuel/air mixture is ignited once for every two crankshaft rotations.

Other

All engines which do not fall into either of the above categories.

WHOLESALE PRICE

The lowest price at which the motorcycle model is normally sold to dealers f.o.b. point of manufacture or point of entry. This wholesale price would not consider such extraordinary items as discounts, special promotional allowances, rebates or other incentives.

RETAIL PRICE

The estimated retail value of a motorcycle model as published on manufacturer "suggested retail prices". If more than one regional price is published, this should be the lowest of the alternative retail prices and should not include items such as transportation charges, set-up charges, dealer preparation charges, taxes. etc.

MODEL TYPE

On-road motorcycle

A motorcycle which is certified by its manufacturer as being in compliance with the Federal Motor Vehicle Safety Standards, and is designed primarily for use of public roads.

Off-road motorcycle

A motorcycle which is not certified by its manufacturer as being in compliance with the Federal Motor Vehicle Safety Standards.

Combination motorcycle

A motorcycle which is certified by its manufacturer as being in compliance with Federal Motor Vehicle Safety Standards, designed with the capability for use on public roads as well as off-road recreational use.

Table 8-3 MOTORCYCLE INDUSTRY COUNCIL MANUFACTURER'S SHIPMENT REPORTING SYSTEM CATEGORIES*

Function	Size (Engine Displacement)	Engine Type
On-Road	Under 50cc	2-stroke
Combination	50 - 99cc	4-stroke
Off-Road	100 - 169cc	
	170 - 349cc	
	350 - 449cc	
	450 - 749cc	
	750 - 899cc	
	900cc and above	

*Special categories devised for purposes of this study, only. Normal reporting system has different size categories.

The on-road and combination categories correspond to the street-legal category used in the cost analysis. Size categories were selected to provide flexibility in the event product categorizations were required for regulatory purposes, and because it was desirable to evaluate economic impacts in each category.

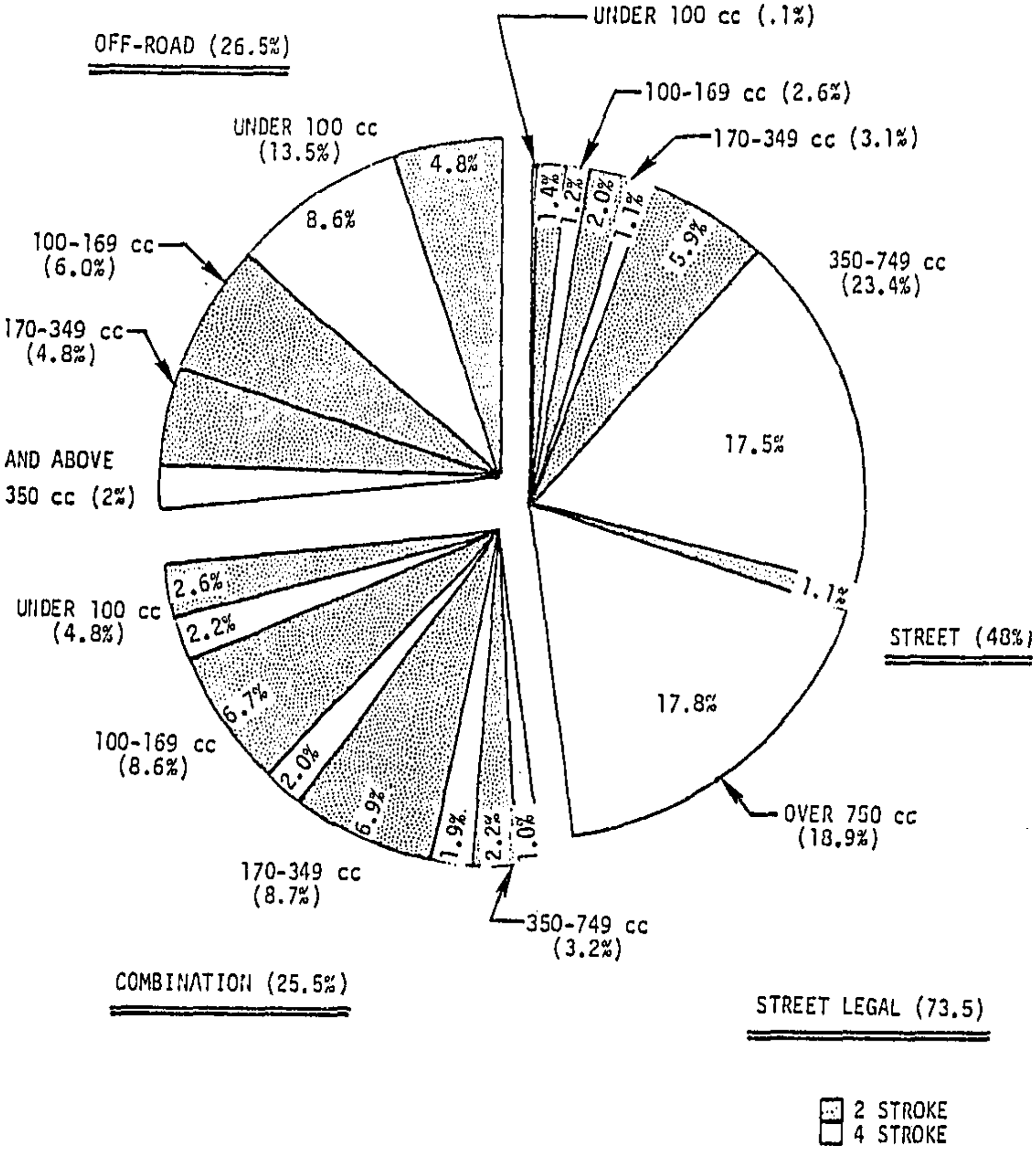


FIGURE 8-3 BREAKDOWN OF NEW MOTORCYCLE SALES BY PRODUCT CATEGORY: 1975

In the actual data base, there were no motorcycles in the following categories: any motorcycle under 50cc; combination motorcycles - 750cc and above; and off-road motorcycles 750cc and above. In fact there were very few off-road or combination motorcycles 450cc and above.

Total On-Road, Combination, and Off-Road Sales

Total motorcycle unit sales, including on-road and combination-type models of all cc classes, reached a level of 1,522,354 units in 1973, generating revenues of $1.175 billion dollars for the motorcycle industry. The succeeding years, however, saw a decline in unit sales to 1,190,046 units in 1974, a drop of 21.8 percent, and to 885,117 units in 1975, a decrease of 25.6 percent over 1974. While the unit volume of motorcycle sales declined by almost 42 percent over the three year period, total sales revenue declined by only 9.1 percent. This is accounted for by the large increases in the average price of motorcycles during this period, from an average price of $814 in 1973 to $1,095 in 1974, an increase of 34.6 percent, and to $1,278 in 1975, an increase of 16.7 percent.

Of the three functional forms of motorcycles (on-road, off-road, and combination), unit sales of on-road motorcycles declined the most during 1973 to 1974, from a level of 655,241 units to 481,689 units, or 26.5 percent. All three types experienced significant price increases during 1974, with on-road motorcycles registering the largest increase (42.2 percent). During 1974, off-road unit sales declined by 22.3 percent, with combination bike sales falling 15.9 percent. New motorcycle sales data for total on-road, combination, and off-road motorcycles in units and retail level dollars derived from the MIC Manufacturer's Shipment Reporting System are summarized in Table 8-4.

In 1975, the rate of price inflation for motorcycles subsided significantly as did the rate of decline in unit sales (which decreased by 51.7 percent). The relative market shares of the three functional types of motorcycles changed significantly over this period, with the share of combination motorcycles declining from 36.5 percent to 25.5 percent. In contrast, on-road and off-road motorcycles increased their shares, from 43 percent to 48 percent, and from 20.2 percent to 26.5 percent respectively over the 1973 to 1975 period.

Table 8-4 NEW MOTORCYCLE SALES DATA FOR TOTAL, ON-ROAD, COMBINATION AND OFF-ROAD CATEGORIES (1972-1975

TOTAL	1972	1973	1974	1975
New Motorcycle Sales (Thousands of Units)	1,314	1,522	1,190	885
Average Retail Price (1) (Dollars)	$ 756	$ 814	$1,095	$1,278
New Motorcycle Sales (Millions of Dollars)	$ 994	$1,175	$1,188	$1,069
ON-ROAD				
New Motorcycle Sales (Thousands of Units)	546	655	482	425
Average Retail Price (Dollars)	$1,048	$1,087	$1,546	$1,805
New Motorcycle Sales (Millions of Dollars)	$ 572	$ 677	$ 684	$ 725
COMBINATION				
New Motorcycle Sales (Thousands of Units)	542	556	468	226
Average Retail Price (Dollars)	$ 598	$ 639	$ 819	$ 834
New Motorcycle Sales (Millions of Dollars)	$ 324	$ 341	$ 346	$ 179
OFF-ROAD				
New Motorcycle Sales (Thousands of Units)	226	308	239	235
Average Retail Price	$ 434	$ 545	$ 717	$ 758
New Motorcycle Sales (Millions of Dollars)	$ 98	$ 158	$ 158	$ 167

*Discrepancies in 1973-1975 Data due to derivation technique used on monthly data series.

Source: Motorcycle Industry Council, "Manufacturers Shipment Reporting System" (Data representing approximately 94 percent of estimated retail level sales in units and dollars factored to derive data shown in Table).

TABLE 8-5

MOTORCYCLE MARKET SHARE, BY FUNCTION

	1973	1974	1975
On-Road	43.04	40.47	48.0
Off-Road	20.2	20.08	26.5
Combination	36.5	39.32	25.5

On-Road Motorcycle Sales by c.c. Class

While total on-road motorcycle unit sales declined from 655,000 units to 425,339 units over the period 1973 to 1975, there were significant differences in the rates of decline among the various cc classes over this period. Sales of motorcycles of over 900c.c. displacement increased, however, by 240 percent in 1974 and by 65 percent in 1975, from 15,373 units to 86,335 units. Sales of on-road motorcycles in the less than 100c.c. category went from 25,267 units in 1975 to only 659 units in 1975. In general, market shares of on-road motorcycles shifted towards the larger cc classes.

TABLE 8-6

ON-ROAD MOTORCYCLES MARKET SHARE BY CC CLASS

	1973 %	1974 %	1975 %
Less than 100cc	3.9	.8	.15
100 - 169cc	8.6	4.2	5.3
170 - 349cc	12.16	9.2	6.4
350 - 449cc	32.32	32.29	25.7
450 - 749cc	24.74	25.78	23.68
750 - 899cc	18.19	16.79	18.00
Greater than 900cc	2.4	10.88	20.62

Combination Motorcycle Sales, by cc Class

All categories of combination motorcycles registered dramatic declines in unit sales between 1973 and 1975, with corresponding declines in total dollar revenues. The market for combination motorcycles is dominated by motorcycles in the 100 to 349 cc classes (the 100 to 169 cc and 170 to 349 cc groups). Together they accounted for 69% of unit sales in 1973, for 74% in 1974 and for 69% of sales in 1975. These two classes suffered declines in unit sales proportionately greater than all of the other classes.

Table 8-7 COMBINATION MOTORCYCLES MARKET SHARE BY CC CLASS

	1973 %	1974 %	1975 %
Less than 100 cc	19.7	15.59	18.44
100 - 169cc	36.2	34.35	33.86
170 - 349cc	33.2	39.73	34.55
450 - 749cc	.5	.2	.6

Off-Road Motorcycle Sales by cc Class

Historically, total unit sales of off-road motorcycles have declined from a level of 289,224 units in 1973 to 220,757 units in 1975, a decrease of 23.7 percent. Revenues, however, increased by 5.8 percent over this period. This revenue increase is accounted for by the increases in average unit price of off-road motorcycles, from $545 per motorcycle in 1973 to $758 in 1975.

Traditionally, the majority of off-road unit sales have been claimed by the 0 to 99, the 100 to 169, and the 170 to 349 cc classes. In 1973, these three groups accounted for 94.0 percent of sales, in 1974 for 92.4 percent, and in 1975 for 91.8 percent of sales. Over the 1973 to 1975 interval, the distribution of market share by cc class did not change significantly. (See following table.)

TABLE 8-8

OFF-ROAD MOTORCYCLES MARKET SHARE BY CC CLASS-PERCENT

	1973	1974	1975
Less than 100cc	63.7	53.3	50.4
100 - 169cc	18.4	27.3	23.2
170 - 349cc	11.9	11.8	18.2
350 - 449cc	4.3	5.2	6.6
450 - 749cc	1.7	2.4	1.6

8.1.2 Recent Market Developments

Over the period 1973 to 1975 total unit motorcycle sales declined by 42 percent, while the average unit price of motorcycles increased by 57 percent.

This sales decline occurred at a time when the U.S. economy was experiencing its worst recession and inflation of the post-war period. Real GNP (in 1972 dollars) declined in 1974 and again in 1975; real personal disposable income declined by 1.4 percent in 1974 and increased slightly in 1975. The unemployment rate moved from 4.9 percent of the work force in 1973 to 5.6 percent in 1974 and increased to the record high rate of 8.5 percent in 1975. Additionally, the inflationary situation became severe. As measured by the consumer price index, the rate of inflation reached 11.1 percent in 1974 and 9.2 percent in 1975.

Given this recessionary environment, the consumer drastically cut back on expenditures. In 1974, real personal consumption expenditures for durable commodies declined by 7.0 percent while the decline in 1975 was 2.6 percent. (See following table.)

TABLE 8-9

HISTORICAL ECONOMIC INDICATORS

	1973	1974	1975
REAL GROSS NATIONAL PRODUCT	1,233.4	1,210.7	1,186.1
% CHANGE	5.3	-1.8	-2.0
REAL DISPOSABLE INCOME	855.7	843.7	856.7
% CHANGE	6.8	-1.4	1.5
UNEMPLOYMENT RATE	4.9	5.6	8.5
% CHANGE	-13.4	15.8	51.0
REAL DURABLE CONSUMPTION	120.9	112.5	109.5
% CHANGE	8.7	-7.0	-2.6
CONSUMER PRICE INDEX	1.330	1.477	1.613
% CHANGE	6.2	11.1	9.2
IMPLICIT PRICE DEFLATOR	1.0590	1.1625	1.2633
% CHANGE	5.9	9.8	8.7

While real personal consumption expenditures on durable comodities declined from $120.09 billion to $109.5 billion, or by 9.5 percent from 1973 to 1975, unit sales of motorcycles declined by 57 percent. This dramatic drop in slaes can be attributed to three major factors:

(a) Demographic trends in the motorcycle buying group,

(b) the impact of the recession on the real purchasing power of potential motorcycle buyers, and

(c) the impact of increased motorcycle prices.

Demographic Developments

Evidence indicates that the relevant consuming group for motorcycles were males in the age cohort 20 through 34 years. The relevant demographic group for analysis of buyer behavior is the number of males with income in this age group.

Over the period 1973 to 1975, the growth rate for the number of males with income declined. Thus the effective demographic market for motorcycle sales was impaired over this period. The following table gives the percentage changes in the number of males with income in the age cohorts 20 to 24 and 25 to 34 years. The large age cohort, males 25 to 34 years, suffered declining rates of growth in 1974 and 1975. The age group 20 to 24 years increased its growth rate in 1974 but showed virtually no growth in 1975. The long-term growth potential for motorcycle sales will be constrained by the growth rates in these effective population age groups, unless there is a structural shift in the buying patterns of older age groups.

TABLE 8-10

PERCENT CHANGE IN THE NUMBER OF MALES WITH INCOME

	1973	1974	1975
Males, 20 - 24	2.46	3.17	.6
Males, 25 - 34	4.6	3.83	1.36

TABLE 8-11

MOTORCYCLE BUYER'S DEMOGRAPHIC PROFILE

Sex	All Owners	Marital Status	All Owners (%)
Male	91%		
Female	9%		
Age			
Under 16 years	13%	Married	49%
16 - 17 years	10%	Single	48%
18 - 20 years	13%	Widowed/Divorced	2%
21 - 24 years	15%	Undesignated	1%
25 - 29 years	15%	Total	100%
30 - 39 years	19%		
40 - 49 years	10%	**Education**	
50 and over	4%		
Undesignated	1%	8th grade or less	10%
Total	100%	High school incomplete	24%
		High school graduate	33%
		College incomplete	20%
		College graduate	11%
Median age	24 yrs.	Undesignated	2%
		Total	100%

Source: Gallup Organization, "Survey of Motorcycle Ownership, Usage, and Maintenance".

Real Income Trends

While the real disposable income (in 1972 dollars) for the U.S. as a whole declined by 1.4 percent in 1974, the real mean income (in 1974 dollars) of the effective market for motorcycles declined by more than three times that amount, by 4.6 percent. This age group traditionally is more seriously affected by downturns in the economy than older age groups. The age group, males 20 to 34 years, which comprises between 36 and 37 percent of the age group 20 to 34 years, suffered a decline in real mean income of 6.6 percent. Nor did the real earning power of the age group 20 to 34 years recover in 1975 when the total U.S. real income increased by 1.5 percent. Instead, the real incomes of potential motorcycle buyers actually declined by 3.4 perent. (See Table.)

Thus with a declining rate of growth in the number of potential buyers and an absolute decline in the real incomes of this group, the market environment for motorcycle sales in 1974 and 1975 was severely impaired.

TABLE 8-12

PERCENT CHANGES IN REAL INCOME OF MOTORCYCLE BUYERS

	1974	1975
Disposable Income for the U.S. (1972 $)	-1.4	+1.5
Mean Income (1974 $) Males, 20 to 34 years	-4.6	-3.4
Mean Income (1974 $) Males, 20 to 24 years	-6.6	-6.3
Mean Income (1974 $) Males, 25 to 34 years	-4.1	-2.8

Price Trends

The average unit price of motorcycles increased from $814 in 1973 to $1,095 in 1974, or by 34.6 percent. During the same period, the price of all other goods competing for the consumer budget, as measured by the Consumer Price Index, increased by 11.1 percent. Thus the relative price of motorcycles vis-a-vis all other commodities increased three-fold in one year. Nor did this competitive disadvantage of motorcycles correct itself in 1975, although the situation was ameliorated somewhat; the average price of motorcycles increased by 16.7 percent in 1975 as opposed to a 9.2 percent increase in the Consumer Price Index.

Table 8-13 PERCENT CHANGES IN THE AVERAGE UNIT PRICE OF MOTORCYCLES AND THE CONSUMER PRICE INDEX

	1974	1975
Average Unit Price of Motorcycles	+34.6	+16.7
Consumer Price Index	+11.1	+9.2

With a deteriorating effective purchasing power base for motorcycle sales and a growing uncompetitiveness of motorcycles vis-a-vis other commodities, the severe decline in unit motorcycle sales over the period 1973 to 1975 is understandable.

8.1.3 Baseline Forecast of New Motorcycle Sales

The analysis of the market environment for motorcycles and the price of motorcycles (and other prices) over the period 1973 to 1975 indicated the approach to model statistically the determinants of demand for unit motorcycle sales. Statistical equations were estimated econometrically by relating unit motorcycle sales (by type and function) to demographic, income, prices, and motorcycle characteristics (i.e., price) over the period 1973 to 1975. Given these estimated equations, and the forecasts of the explanatory variables from Data Resources, forecasts of unit sales and revenues (given prices) for each class of motorcycle were generated.

The forecasting model used to predict future sales in the absence of noise regulations is described in appendix F. Total motorcycle unit sales are forecasted to register a sharp upturn in 1976 and 1977 (14.9 percent and 14.0 percent increases, respectively), consistent with the strong growth in the real income of males aged 20 to 34 expected to result from an upturn in the business cycle. The growth rate in sales will level off in 1978 and 1979 when a mild correction in the economy is expected. This correction will occur because of the monetary policy expected as a result of an overheating of the economy in 1977. The upturn in motorcycle sales in 1976 and 1977 will also be facilitiated by an increase in the growth rate of the demographic base for motorcycle sales. Total male population (with income) is forecast to increase by 3.1 percent respectively in 1976 and 1977. This growth rate is expected to decline somewhat in 1978 and 1979.

1980 and 1981 will see a resumption of growth in the economy with real incomes of the potential market increasing by 6.4 percent and 4.8 percent respectively. The population growth rate will also increase to 3.0 percent and 3.1 percent respectively. A mild correction in the economy is forecast for 1982 and 1983, with a cyclical upturn in 1984 and 1985. Thereon to 1990, the economy and the real incomes of the purchasing age group will remain relatively flat. From 1982 through 1990, the number of males aged 20 to 34 is forecast to remain virtually flat. Sales of motorcycles will basically follow this cyclical pattern. A plateau for sales growth will be reached around 1985, given the current market structure for motorcycles. Figure 8-4 shows the history and forecast for total unit motorcycle sales and real mean income in the age group 20 to 34 years.

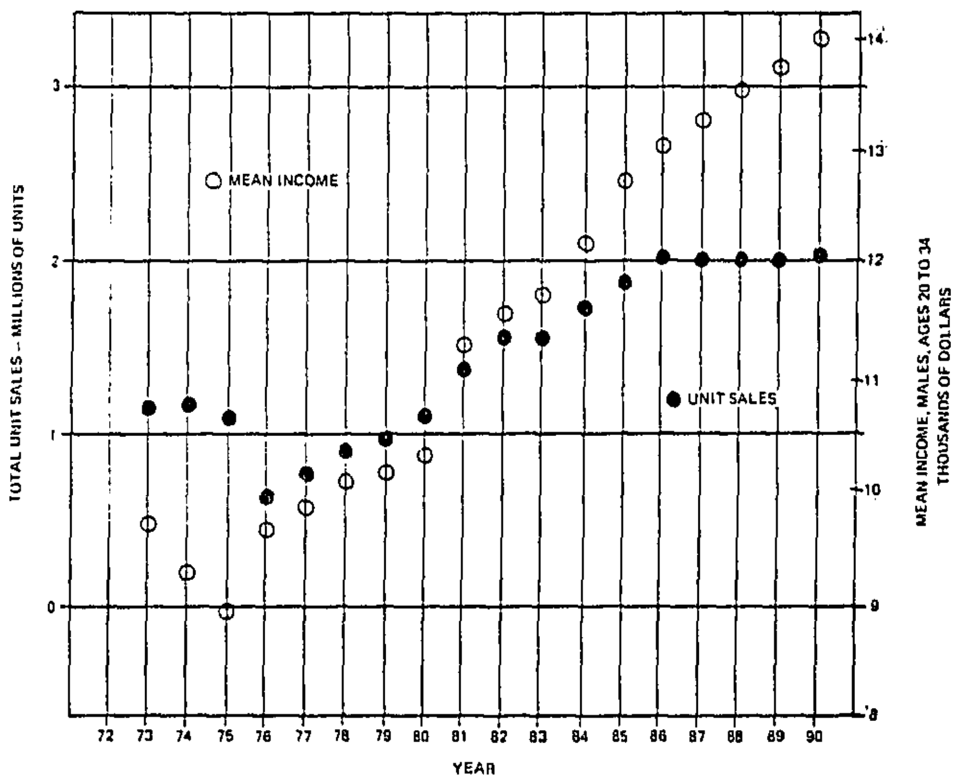
It is interesting to note that by 1990, total unit motorcycle sales will only be 31.5 percent greater than in 1973. Furthermore, despite the impressive gains for motorcycle sales forecast for 1976 and 1977, the 1973 level of 1,522,354 units will not be reached until 1981.

With the assumption of average unit motorcycle prices increasing by 7 percent per year, total motorcycle revenues will reach the 1973 level by 1976. By 1990, the total motorcycle market is forecast to be one of $7.0 billion. This is shown in Figure 8-5.

Forecasts for on-road, off-road and combination motorcycle sales are expected to follow approximately the same growth pattern as total unit sales from 1978 through 1990. In 1976 and 1977, however, the relative growth rates diverge significantly, with combination motorcycles showing the strongest comeback in 1976. Combination motorcycle sales are forecast to increase almost 61 percent in 1976, rebounding from its low level of 226,093 units in 1975. This is shown in Figure 8-6.

FIGURE 8-4

PROJECTED TOTAL UNIT SALES VS. MEAN INCOME, MALES, AGES 20 TO 34



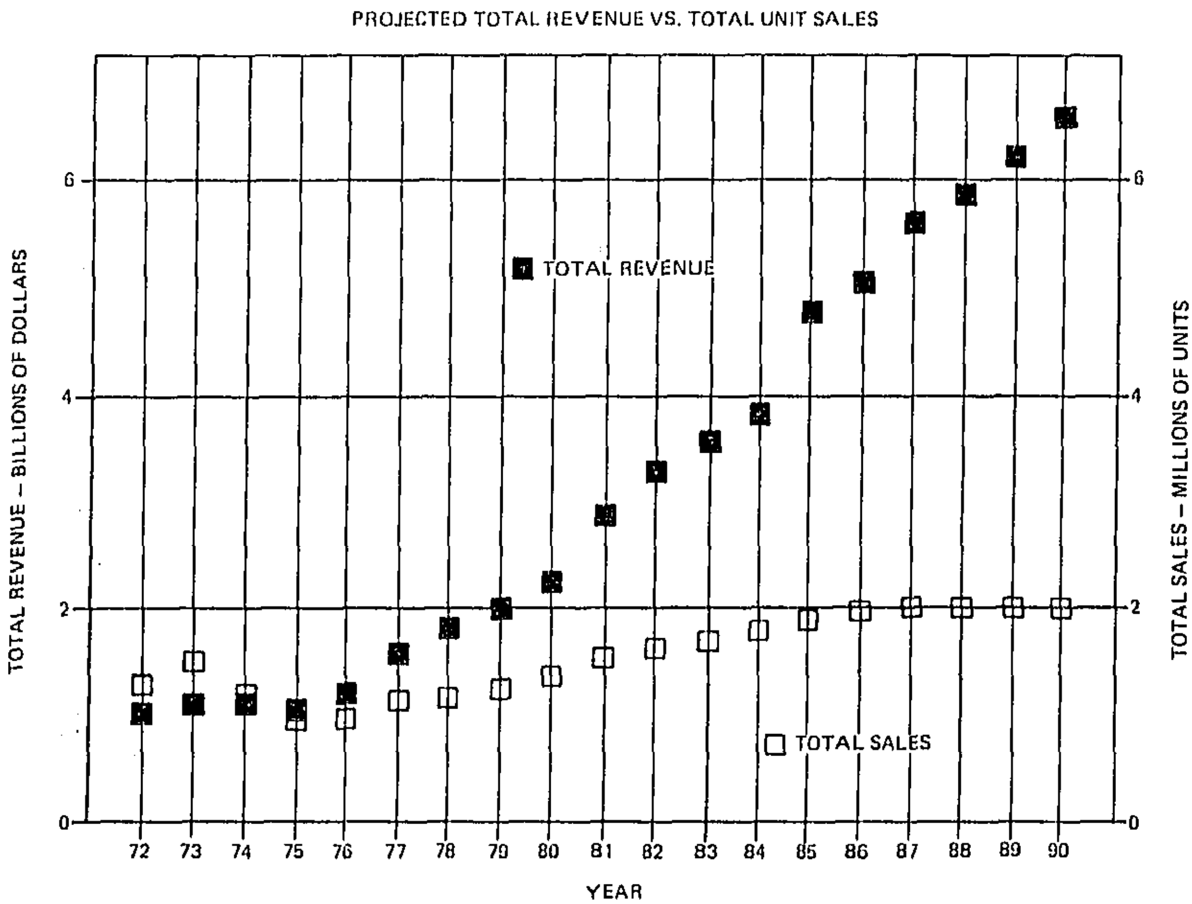

PROJECTED TOTAL REVENUE VS. TOTAL UNIT SALES
TOTAL REVENUE – BILLIONS OF DOLLARS
TOTAL SALES – MILLIONS OF UNITS
TOTAL REVENUE
TOTAL SALES
0
2
4
6
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
YEAR

FIGURE 8-5

PROJECTED STREET, OFF-ROAD, AND COMBINATION UNIT SALES

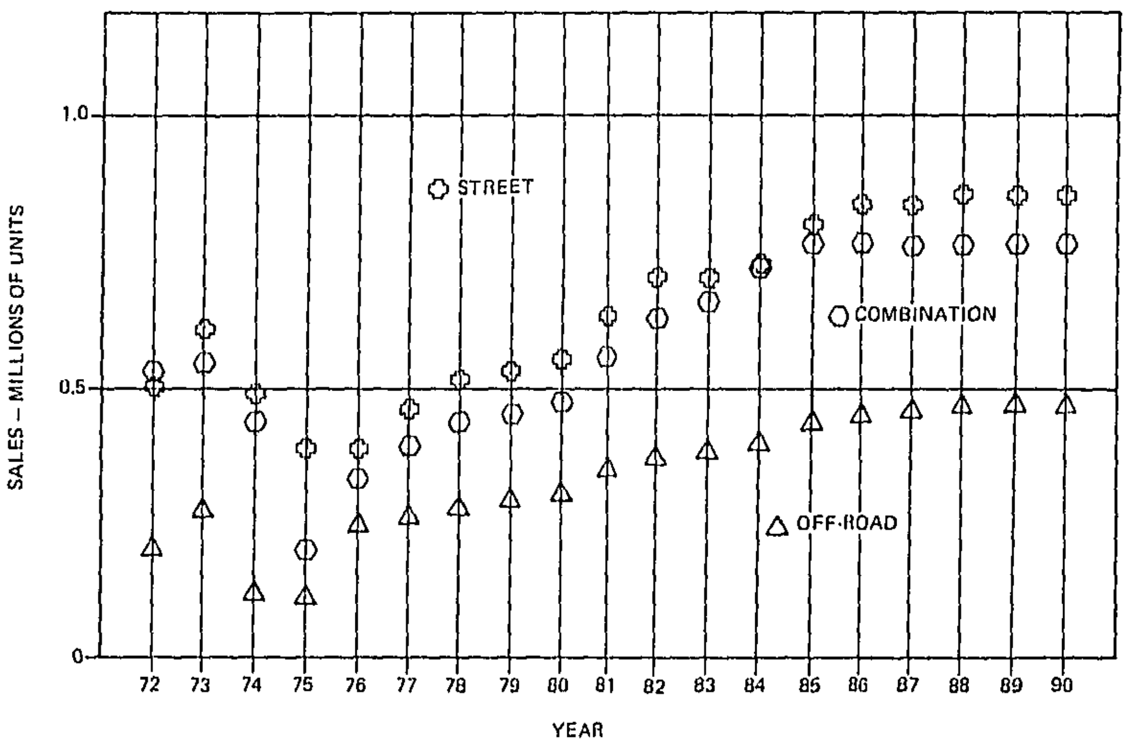


FIGURE 8-6

8-20

PROJECTED STREET UNIT SALES VS. TOTAL UNIT SALES

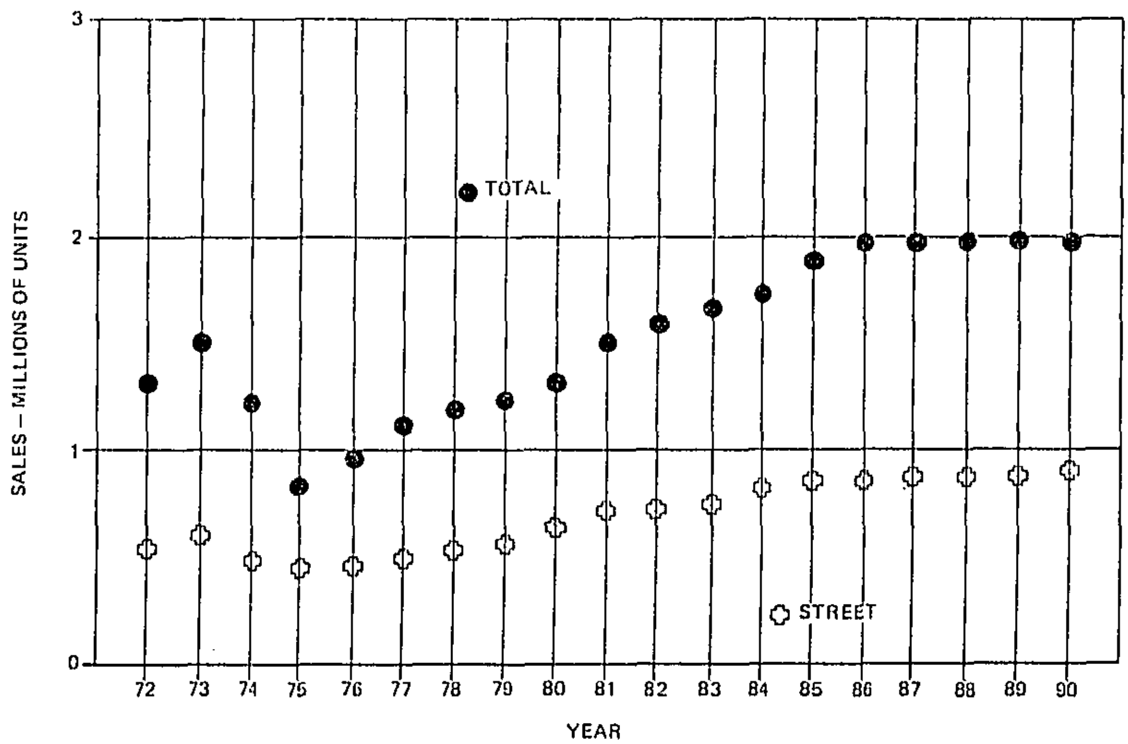


FIGURE 8-7

PROJECTED OFF-ROAD UNIT SALES VS. TOTAL UNIT SALES

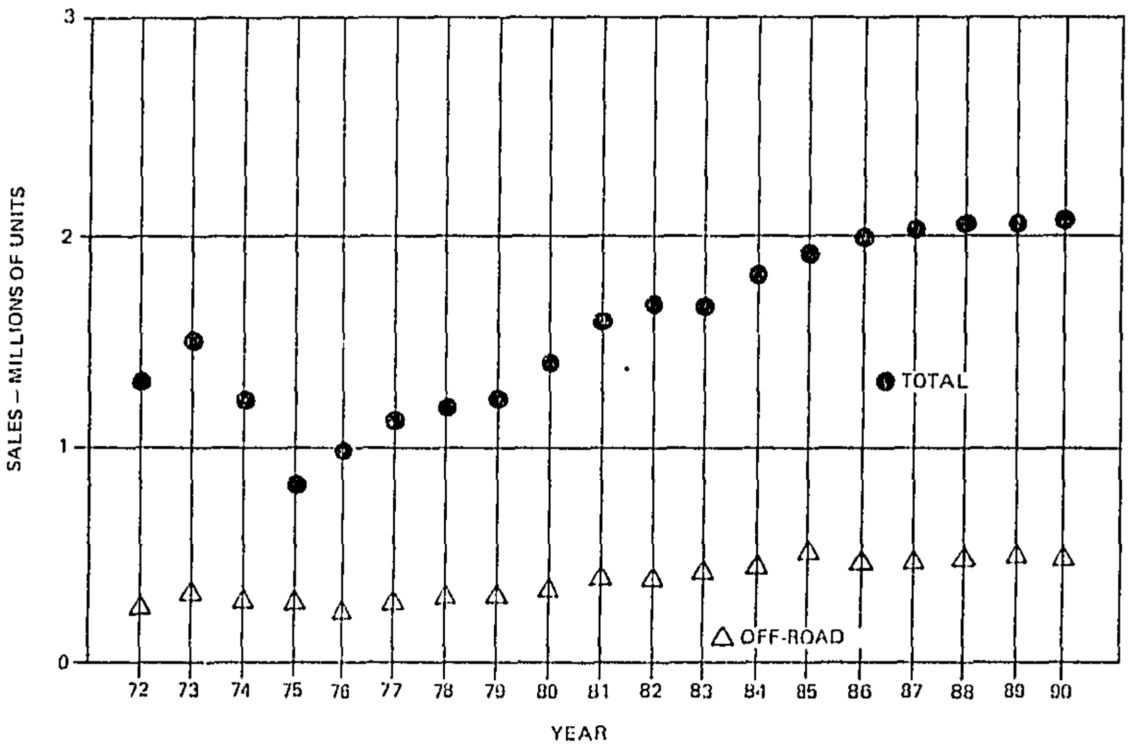


FIGURE 8-8

PROJECTED COMBINATION UNIT SALES VS. TOTAL UNIT SALES

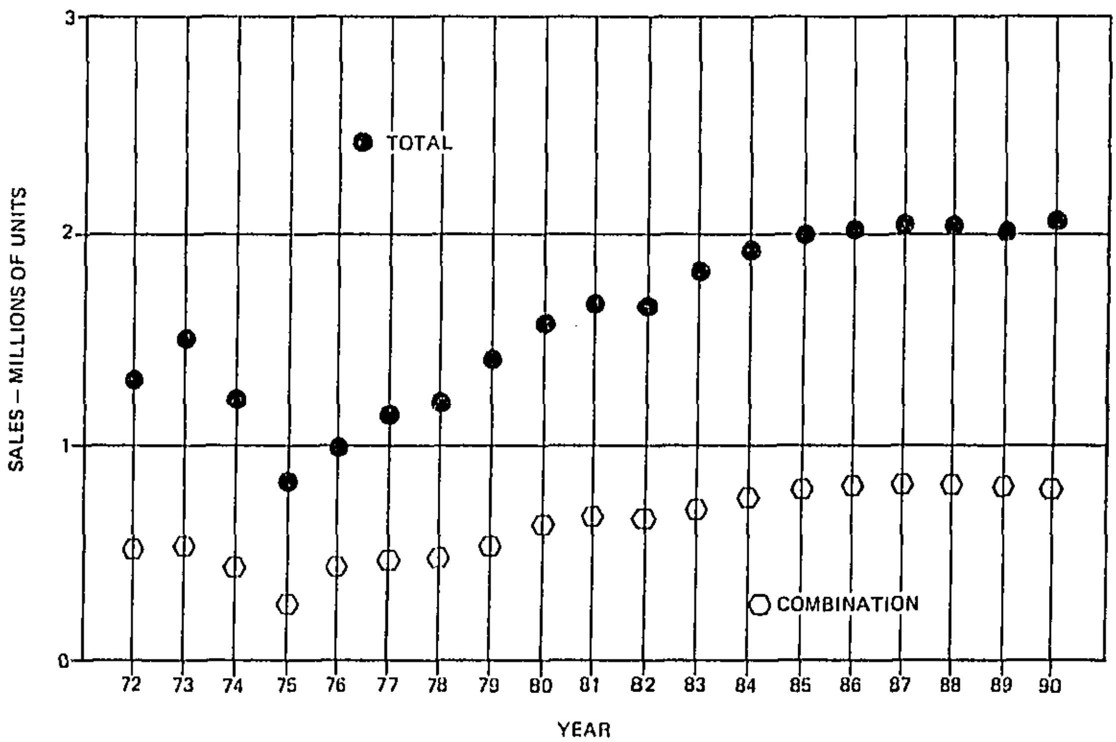


FIGURE 8-9

8.2 Impacts on New Motorcycle Demand

8.2.1 Price Increase Impacts

The primary impact on demand for alternative regulatory standards is expected to be the relationship between demand and unit price increases that are attributable to the alternative regulatory standards. The DRI New Motorcycle Demand Model described previously was used to relate demand impacts to the unit price increases shown in Section 6.

Price elasticities are shown in Table 8-14. The elasticities were calculated at the mean of the independent variable of the historical data base (see Appendix F). Four possible regulatory levels were studied with the lead times listed below.

Table 8-14 MOTORCYCLE PRICE ELASTICITY

Displacement Category	Street	Motorcycle Type Street/Off-Road	Off-Road
Below 100cc	-.928	-.867	-.953
100 - 169cc	-.935	-.997	
170 - 349cc	-.967	-.74	-1.148
350 - 749cc	-.836	-.912	
750 and above	-.768	-.45	

Table 8-15 MOTORCYCLE NOISE EMISSION STUDY LEVELS AND POSSIBLE EFFECTIVE DATES

Date	Regulatory Level (SAE J331a)
January 1978	Promulgation
January 1979	83 dBA
January 1981	80 dBA
January 1984	78 dBA
January 1988	75 dBA

The alternative noise standards used in this analysis are expressed in not-to-exceed regulatory levels. It is assumed, based on available data, that for each regulatory level manufacturers must design for a level 3 dB(A) less than the regulatory level, in order to account for production and test variabilities. In the remainder of this analysis, this level will be referred to as the design level.

Estimates of reductions in demand are summarized in Table 8-16, for both nominal and worst cases. Relative reductions in unit demand from a baseline forecast are shown in order to express the reduction in real terms. A decrease in motorcycle demand is projected because of the negative price elasticities for motorcycles that were determined in this study, and the increase in retail price levels attributable to the implementation of noise control measures. The projected reductions for each study level analyzed are shown in Figure 8-16. The data indicate that significant reductions in demand are expected for sound level standards below 80 dB(A) (J331a).

The impact of each standard is discussed in more detail below.

83 dBA Regulatory Level, 1979

The baseline demand forecast for all new motorcycles in 1979 is 1,346,000 units, broken down as follows: 1,036,000 street motorcycles, and 310,000 off-road motorcycles. An 83 dBA regulatory level in 1979 (J331a) is expected to reduce demand by 1.5 percent in the nominal case and 2.0 percent in the worst case in the first year of the standard.

80 dBA Regulatory Level, 1981

This regulatory standard is expected to reduce demand anywhere from 4.5 percent in the nominal case, to 11.1 percent in the worst case. The product category with the largest potential impact is street motorcycles between 170 to 349cc. Reduction in demand is expected to be 8.8 percent in the nominal case and 20.6 percent in the worst case for this product category.

TABLE 8-16

ESTIMATED RELATIVE REDUCTION IN DEMAND FOR NEW MOTORCYCLES
DUE TO NOISE CONTROL REGULATIONS
FIRST YEAR OF EACH STANDARD

CATEGORY / YEAR	RELATIVE REDUCTION IN DEMAND (%)			
	1979	1981	1984	1988
REGULATORY LEVEL*	83 dBA	80 dBA	78 dBA	75 dBA
Nominal (Expected) Case				
Street-Legal	1.8%	5.0%	16.2%	31.4%
99cc and Below	0.7%	0.7%	6.6%	17.5%
100-169cc	1.8%	5.2%	22.0%	44.5%
170-349cc	2.6%	8.8%	22.5%	41.2%
350-749cc	2.0%	5.8%	15.7%	29.8%
750cc and Above	0.5%	1.5%	3.6%	6.6%
Off-Road	1.5%	1.8%	7.2%	15.6%
99cc and Below	0.6%	0.6%	6.0%	15.3%
100-169cc	0.4%	1.2%	4.4%	8.9%
170-349cc	2.3%	6.5%	15.7%	28.5%
350-749cc**	-	-	-	-
All Motorcycles	1.5%	4.5%	14.2%	27.9%
Worst Case				
Street-Legal	2.2%	13.3%	31.4%	44.0%
99cc and Below	1.0%	1.0%	8.5%	22.1%
100-169cc	2.2%	14.9%	55.2%	76.0%
170-349cc	3.4%	20.6%	39.2%	53.7%
350-749cc	2.5%	14.5%	27.2%	37.6%
750cc and Above	0.6%	3.3%	6.3%	8.5%
Off-Road	1.1%	3.7%	12.7%	20.6%
99cc and Below	0.9%	0.9%	7.5%	19.2%
100-169cc	0.5%	2.5%	11.0%	15.1%
170-349cc	3.0%	14.8%	27.3%	37.1%
350-749cc	-	-	-	-
All Motorcycles	2.0%	11.1%	26.9%	46.3%

* Not to Exceed Regulatory Level (SAE J331a).

** Data Analysis Inconclusive for this Product Category.

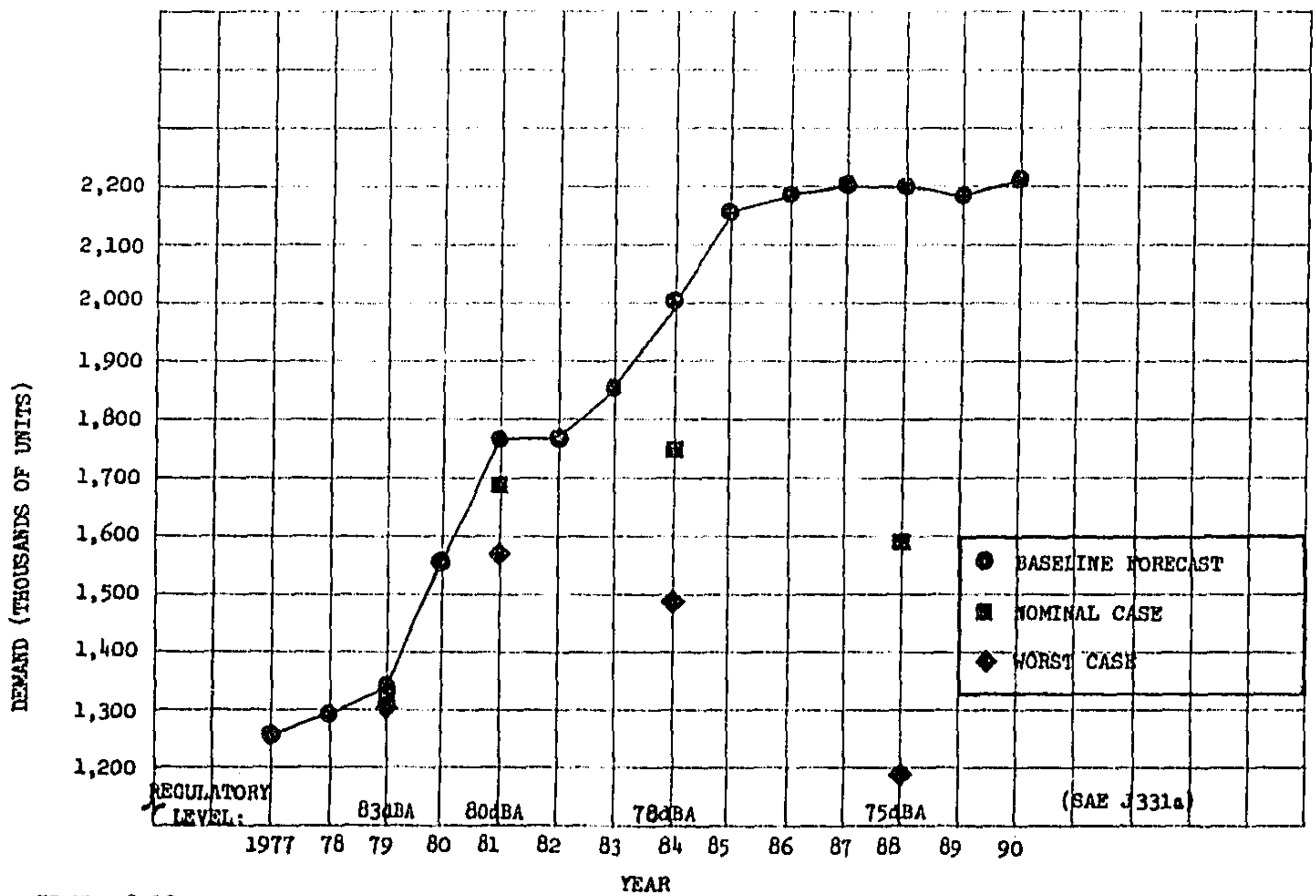


FIGURE 8-10 ESTIMATED REDUCTION IN DEMAND FOR NEW MOTORCYCLES DUE TO NOISE REGULATIONS

78 dBA Regulatory Level, 1984

A 78 dBA standard in 1984 could reduce the baseline forecasted demand by 14.2 percent in the nominal case, and by 26.9 percent in the worst case. The product categories that would be affected the most would be street-legal motorcycles between 100 to 169cc and 170 to 349cc. These categories experience reductions up to 55.2 percent in the worst case. Apparent reasons are that motorcycles in these categories experience the greatest relative price increase, and are the most sensitive to price changes (they have greater price elasticities). The street motorcycles, 750cc and above are expected to have the least severe impact: 3.6 percent reduction in the nominal case and 6.3 percent in the worst case. These are the least sensitive to price increases.

75 dBA Regulatory Level, 1988

A 75 dBA regulatory level in 1988 could reduce baseline forecasted demand by 28 percent in the nominal case and 46 percent in the worst case. Again, street-legal motorcycles between 100-349cc would be affected most, and street motorcycles in the largest displacement class would be affected least. This is a reasonable result, because it is expected that most motorcycles will require a major model change to comply with 75 dBA regulatory levels. Major model changes would tend to impact smaller models more adversely.

8.3 Impacts on Demand for Products and Service

8.3.1 Historical Aftermarket Sales and Trends

The motorcycle aftermarket represents sales of motorcycle replacement parts, accessories, apparel and services. A broader definition of the aftermarket would include motorcycle insurance, and miscellaneous items such as consumer publications, advertising and so forth. The aftermarket has experienced extremely rapid gorwth. For the broader definition, aftermarket sales in 1975 were estimated[1] to be $1.8 billion, an increase of approximately 20 percent over 1974. For the two years prior to 1974, sales increased an average of 40 percent per year, the market more than doubling in the past four years[2]. Table 8-17 provides estimated aftermarket sales for the period 1972 to 1975.

[1]Data for aftermarket sales and growth trends are approximations because motorcycle aftermarket industry is relatively new and no organized data collection effort has been made. Most of the detailed data available is for calendar year 1974.

[2]Frost and Sullivan "Motorcycle Original Equipment and Aftermarket Study Announcement", April 1975.

Table 8-17 AFTERMARKET SALES GROWTH

Year	Aftermarket Sales (Millions of $)	Percentage Increase Over Previous Year	Total Number of Motorcycles (Millions of Units)
1972	764	-	5.4
1973	1,070	40%	6.2
1974	1,500	40%	7.0
1975	1,810	20% (E)	

Sources: 1. The 1974 data point obtained from Ziff-Davis Publishing Company, "Motorcycle Aftermarket Study".

2. Growth rate estimates from Frost and Sullivan "Motorcycle Original Equipment and Aftermarket Study Announcement".

(E) Estimate provided by Motorcycle Dealer News.

The total aftermarket is being stimulated by the growing base of motorcycle owners, improved advertising and merchandizing, new products, more affluent and sophisticated riders, and the trend toward using motorcycles for basic transportation. The growing base of motorcycles is particularly important: Figure 8-11 shows the correlation between sales and number of motorcycles in use.

A Ziff-Davis Motorcycle Aftermarket survey taken early in 1975 indicated that approximately 85 percent of all motorcycle/minicycle owners bought replacement parts, accessories, or apparel items in the motorcycle aftermarket.[1] Twenty-two percent of these owners spent more than $100 for their purchases. On the average, each owner spent $86 for these items, broken down as follows: $54 for replacement parts and accessories, $32 for clothing.[2]

[1] Ziff-Davis Publications, "Motorcycle Aftermarket Study".

[2] Ibid.

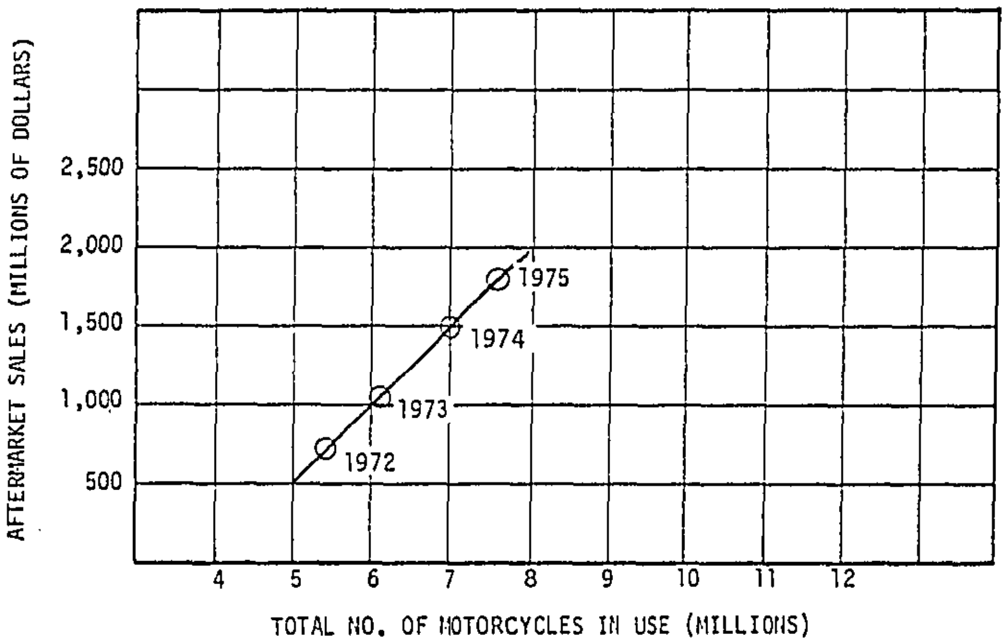


FIGURE 8-11 AFTERMARKET SALES VERSUS TOTAL NUMBER OF FULL-SIZED MOTORCYCLES IN USE

REFERENCE: TABLE 8-17

A detailed breakdown of 1974 motorcycle aftermarket sales determined in the Ziff-Davis Study is shown in Table 8-18. The market for exhaust system products, which was $30.6 million in 1974, will be particularly impacted by the establishment of motorcycle noise control standards. Detailed data for exhaust system purchases by motorcycle owners is shown in Table 8-19. This data indicates that 616,000 buyers (8.8 percent of all motorcycle owners) purchased 1.4 exhaust system products (mufflers, expansion chambers, etc.), and spent an average of $50 for each purchase, or $35 per unit. Most of the exhaust system products (63 percent) were bought from dealers.

Table 8-18 MOTORCYCLE INDUSTRY AFTERMARKET SALES, 1974

Item		1974 Annual Sales* (Millions of Dollars)
Replacement Parts and Accessory Items		400
Air Filters	5.9	
Brake/Clutch Levers	9.7	
Cables	12.1	
Cafe Racing Kits	4.1	
Carburetors	8.7	
Chain Lubricants	7.9	
Cleaners and Waxes	3.8	
Custom Seat	12.9	
Drive Chain	18.1	
Exhaust System Products	30.6	
Fairings	29.2	
Fenders	6.6	
Gas Tank	9.0	
Hop-Up Kit	11.2	
Lubricants (other than chain)	14.1	
Luggage Rack	13.5	
Mirrors	5.8	
Replacement Tires	55.6	
Saddle Bags and Tote Boxes	12.0	
Shock Absorbers	6.8	
Side Cars	14.7	
Sissy Bars	16.4	
Spark Plugs	24.6	
Specialty Wheels	13.4	
Sprockets	16.7	
Tools	31.4	
Windshields	5.2	
Apparel		223
Service Receipts/Repair		450
Insurance		385
Miscellaneous (Consumer Publications, etc.)**		50
	Total	1,508

Source: Ziff-Davis Publications Motorcycle Aftermarket Survey

**Energy and Environmental Analysis, Inc., "Economic Assessment of Motorcycle Exhuast Emission Regulations".

Table 8-19 EXHAUST SYSTEM SALES

	Exhaust System Products
Purchased New in Past 12 Months	8.8%
Total Number of Buyers	616,000
Average Number Purchased	1.4
Total Units Purchased	862,000
Average Amount Spent (Total)	$49.73
Total Dollar Volume	$30,633,000
Where Purchased	
Dealer where cycle bought	22.2%
Other motorcycle dealer	41.3
Motorcycle accessory shop	25.0
Chain/department store	-
Discount auto center	1.0
Mail order	7.7
Other	1.0
Not stated	4.8
Brand Awareness Among Purchasers	42.3%

Source: Ziff-Davis Publications, "Motorcycle Aftermarket Survey".

*8.8% of 7,000,000 Total Motorcycle Owners.
May add to more than 100.0% due to multiple answers.

Estimated aftermarket sales in 1975 are shown in Table 8-20. The estimates are based on a 20 percent growth projection of 1974 aftermarket[1] sales. Each of the components is discussed in more detail in the following paragraphs.

Table 8-20 MOTORCYCLE INDUSTRY AFTERMARKET SALES, 1975

	1975 (Est.)	Percent of Total
Replacement Parts and Accessories	480	27%
Clothing	268	15%
Service/Repairs	540	30%
Insurance	462	25%
Miscellaneous	60	3%
Total	1,810	100%

Note: This estimate based on 20 percent growth projection of 1974 aftermarket sales indicated in Ziff-Davis Motorcycle Aftermarket Survey.

Replacement Parts and Accessories

The market for parts and accessories in 1975 was estimated at $480 million, which represents approximately 27 percent of aftermarket sales. These aftermarket items are generally purchased for performance, styling, functional or maintenance purposes. Performance and styling are particularly significant--exhaust system products, mechanical parts and hop-up kits are big sellers in this category. Sales of styling/functional items that appeal to riders of large street touring motorcycles, such as fairings, windshields, saddle bags and tote-boxes are increasing significantly as the result of the indicated growth in this type of motorcycle. Any change in the demand for replacement parts and accessories will directly affect aftermarket manufacturers, distributors and retail outlets such as dealers, accessory shops, discount stores and mail order firms.

[1] Motorcycle Dealer News

Apparel

Sales of apparel (including helmets) were estimated to be almost $270 million in 1975. The same manufacturers, distributors and retail outlets that are affected by changes in the market for replacement parts and accessories will be affected by changes in the market for apparel.

Service/Repairs

Service and repair receipts totaled an estimated $540 million in 1975. Service revenues are increasing principally because of the larger base of motorcycles in use. Service receipts primarily affect dealers, since on the average these receipts make up 15 percent of each dealer's revenue.

Insurance

Motorcycle owners paid an estimated 462 million dollars for insurance premiums in 1975. Average premium for motorcycle owners purchasing insurance is in the $90-100 range for liability and comprehensive coverage. Cost generally varies with motorcycle size. Changes in the demand for motorcycle insurance will have very little effect on the motorized vehicle insurance industry, since it is a very small proportion of total underwriting. However, there are a few companies that specialize in motorcycle insurance and these companies will be significantly affected by actions affecting motorcycle insurance revenues.

Miscellaneous

Miscellaneous includes revenues from motorcycle publications, books, schools and consultants.

Aftermarket Demand Considerations

Because of its rapid growth in recent years, future aftermarket sales are particularly difficult to forecast since extrapolation of historical data may lead to unrealistically optimistic projections. However, one of the key determinants of future aftermarket sales will be the annual sales of new motorcycles. New motorcycles contribute to the total number of motorcycles in use, which in turn is closely related to aftermarket sales (refer to Figure 8-11). Figure 8-12 shows the relationship of new motorcycles and total number of full sized motorcycles in use for the period 1967-1974. There is growth potential for aftermarket sales as long as the total number of motorcycles in use increases. The baseline forecast for new motorcycles indicates that this will continue to occur (as long as the relationship between new motorcycle sales and total full sized motorcycles in use shown in Figure 8-12 holds true). The figure shows that in

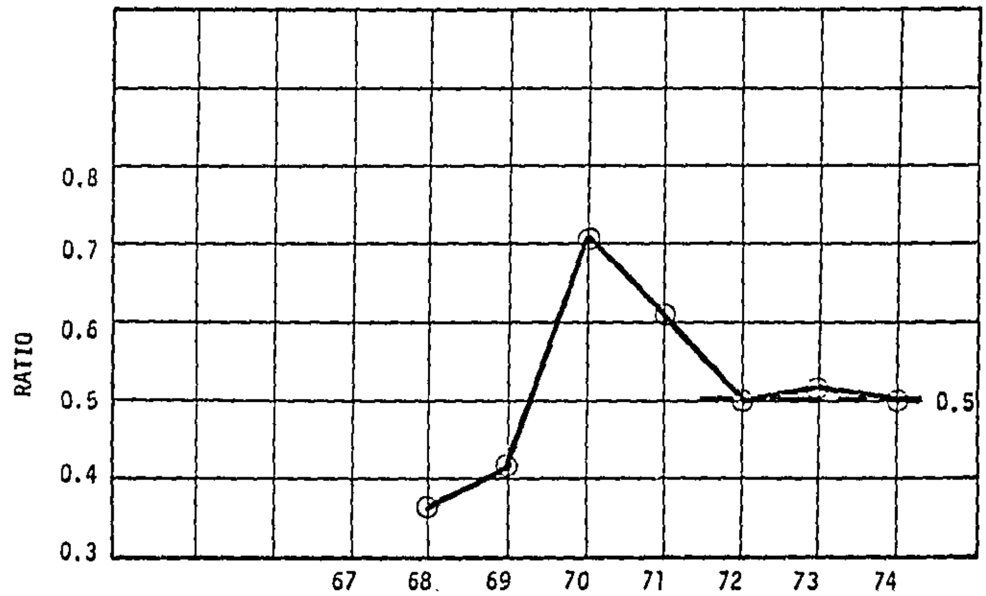


FIGURE 8-12 RATIO OF CHANGE IN TOTAL MOTORCYCLE POPULATION WITH NO. OF NEW MOTORCYCLES SOLD

TABLE 8-21

	YEAR							
	67	68	69	70	71	72	73	74
TOTAL NO. OF MOTORCYCLES IN USE* (THOUSANDS OF UNITS)	2,790	3,001	3,309	4,021	4,779	5,431	6,214	7,099
INCREASE FROM PRIOR YEAR (THOUSANDS OF UNITS)	-	211	308	712	758	652	783	585
NEW MOTORCYCLES (THOUSANDS OF UNITS)	-	583	733	1,002	1,238	1,314	1,520	1,180
CHANGE IN POPULATION / NEW MOTORCYCLES SOLD		0.36	0.42	0.71	0.61	0.50	0.52	0.50

*FULL-SIZED MOTORCYCLES

recent years (1972-1974), for every two new motorcycles added to the total motorcycle population, one older motorcycle is retired from the population for a net increase in the total of one.

The forecast for general aftermarket products and services demand was not quantified, but it is believed that the aftermarket, in general, will not be affected significantly by regulatory actions as long as the number of motorcycles in use is increasing. The effect of regulatory actions is likely to be a slight reduction in the growth rate of demand over a 5 to 10 year period, as opposed to reductions in the demand level. In fact, aftermarket sales may increase in the short run as the result of regulatory actions, since higher prices of new motorcycles resulting from regulations could provide the incentive to repair and maintain older motorcycles for longer periods. Again, this would be exceptionally difficult to quantify.

8.3.2 Price Increase Impacts on Demand for Replacement Exhaust Systems

In 1974, 862,000 exhaust system components were sold at an average price of $35.5 per component. At this time there is no historical data to use as the basis for demand projections. However, the following considerations should be noted.

A survey of exhaust system manufacturers indicated that one of the major product classes in the industry is the complete exhaust system (headers and mufflers) for multi-cylinder 4-stroke street motorcycles. This type of system dominates the product line for many of the exhaust system manufacturers.

Data in Table 7-29 shows expected increases in muffler costs versus regulatory levels, based on an independent cost estimate. This estimate shows that muffler cost increases from 33% at 83 dBA to 289% at 75 dBA can be expected for a large "4 into 1" exhaust system. The revised costs were inserted into the price mark-up structure in Table 7-28, to obtain the revised price increases shown in Table 7-30. The price of the equivalent total exhaust system can increase from 9% (83 dBA) to 89% (75 dBA). A similar procedure was followed for a "2 into 1" system on a street motorcycle assumed to be between 350 and 749cc.

Demand impacts on exhaust system manufacturers may be severe, since relative price increases are greater for exhaust systems than for new motorcycles for equivalent reductions in sound levels. For example, in order to meet 78 dBA regulatory levels (J331a), a street motorcycle in the 170-349cc size category might expect a 13.2 percent price increase in the nominal case, and a 23.1 percent increase in the worst case. By contrast, a "4 into 1" or "2 into 1" exhaust system might have a price increase of 40 to 50 percent, as a result of meeting the same 78 dBA motorcycle regulatory level. Projected price increases for the same exhaust system to meet 75 dBA regulatory levels range from 89 to 114 percent.

In addition, an exhaust system manufacturer's success is very dependent on the styling, performance and tonal quality characteristics of his product. Impact of changes in these factors on demand cannot be quantified, but are believed to be extremely significant, perhaps more significant than price change impacts.

Price elasticities alone, therefore, cannot be used to estimate the impact of noise regulation on demand for replacement mufflers. Estimates of reduced demand based on manufacturer estimates are made below (sec. 8.4.2).

8.4 Total Annualized Costs

Increases in purchase costs and operation and maintenance costs for each of the study levels represent a stream of costs attributable to noise control options. Purchase cost increases are incurred at the time of sale, and operation and maintenance costs are incurred annually for the life of the product. In order to compare regulatory options for a given product and between products it is necessary to use a statistic to characterize this cost stream. The statistic used for all new product noise regulations is "uniform annualized costs", or more simply, annualized costs. A cost stream over a given period is represented by a uniform cost stream (annual costs of equal dollar amount) that has the same present value. That is, the cost stream to be represented is converted to a present value using a specified time value of money. This present value is, in turn, converted to a cash stream of equal units, which, using the same time value of money, has the same present value. In essence, a cost stream over a given period is converted to an annuity over that same period. This statistic, therefore, accounts both for the size and timing of costs incurred. The individual product purchase cost increases developed in the previous sections are used to calculate total purchase cost increases in each year based on particular study levels and assumed effective dates. The numbers of units sold in each year is adjusted by the expected decrease in demand calculated above. Increased purchase costs are all in 1975 dollars. Similarly, the increased operation and maintenance costs developed above are applied to the population of vehicles in any year (adjusted for decreased demand). Again, these costs are expressed in 1975 dollars.

8.4.1 Vehicle Annualized Costs

Table 7-25 displays the nominal and worst case estimates for increases in purchase price expected at the various study levels. The nominal estimates range up to $336 per motorcycle for the above 750c.c. street motorcycle class at 75dB(A). Section 8.2 contains the sales forecast at each of the regulatory levels. Four street motorcycle options are assessed:

	Effective Date			
Option	1979	1981	1984	1988
I-S	83 dB(A)			
II-S	83	80		
III-S	83	80	78	
IV-S	83	80	78	75

Four off-road motorcycle options are assessed:

	Effective Date			
Option	1979	1981	1984	1988
I-OR	86 dB(A)			
II-OR	86	83		
III-OR	86	83	80	
IV-OR	86	83	80	78

The options in each category differ only in the ultimate level considered; all intermediate steps are the same.

The cost stream for each of these options is assessed over a total 20 year period (up to 1996) to fully account for the costs of the ultimate level considered. Ten percent is used for the time value of money.

Operation and maintenance costs are applied to the existing population in any given year. Street motorcycles are assumed to be effectively retired after six years, off-road motorcycles after four.

For each option, nominal and worst case estimates were calculated.

The annualized purchase cost increase, the annualized operation and maintenance cost increases, and the total annualized costs of each option are presented in Table 8-22.

The discount factor tends to de-emphasize the differences in costs between the final two regulatory options, both for street and off-road motorcycles. Whereas in any given year, a 75dB(A) street motorcycle standard would cost about twice as much as a 78dB(A) standard, the uniform annualized cost is only about 50% larger. These differences can be more easily seen from the undiscounted costs that would be incurred once an ultimate level is fully implemented. The fully implemented costs are shown in Table 8-23. The sales and population figures are normalized to 1976 levels.

Table 8-22

TOTAL ANNUALIZED COSTS

(Millions of Dollars)

Street Motorcycles

	Regulatory Level (dB(A), J331a)			
	83	80	78	75
Nominal (Expected) Case				
Annualized Purchase Costs	25	69	132	179
Annualized O/M Costs	0	33	57	67
Total Annualized Costs	25	102	189	246
Worst Case				
Annualized Purchase Costs	31	150	237	286
Annualized O/M Costs	0	52	86	88
Total Annualized Costs	31	202	323	374

Off-Road Motorcycles

	Regulatory Level (dB(A), J331a)			
	86	83	80	78
Nominal (Expected) Case				
Annualized Purchase Costs	0.8	3.0	9.2	15.0
Annualized O/M Costs	0	1.6	2.9	6.0
Total Annualized Costs	0.8	4.6	12.3	21.0
Worst Case				
Annualized Purchase Costs	0.8	4.1	15.3	25.0
Annualized O/M Costs	0	3.2	3.6	7.5
Total Annualized Costs	0.8	7.3	18.9	32.5

1975 Dollars

Table 8-23

FULLY IMPLEMENTED COSTS

1976 Purchase Levels

(Millions of Dollars)

Street Motorcycles

	Regulatory Level (dB(A), J331a)			
Nominal (Expected) Case	83	80	78	75
Annualized Purchase Costs	12	39	104	195
Annualized O/M Costs	0	22	43	80
Total Annualized Costs	12	61	147	275
Worst Case				
Annualized Purchase Costs	14	85	186	312
Annualized O/M Costs	0	36	66	105
Total Annualized Costs	14	121	252	417

Off-Road Motorcycles

	Regulatory Level (dB(A), J331a)			
Nominal (Expected) Case	86	83	80	78
Annualized Purchase Costs	0.5	2.0	7.5	19.0
Annualized O/M Costs	0	0.9	3.8	5.8
Total Annualized Costs	0.5	2.9	11.3	24.8
Worst Case				
Annualized Purchase Costs	0.5	2.7	16.0	32.7
Annualized O/M Costs	0	1.8	5.7	7.7
Total Annualized Costs	0.5	4.5	21.7	40.4

1975 Dollars

8.4.2 Aftermarket Exhaust Annualized Costs

Aftermarket exhaust system prices as a result of noise regulation will rise due to two factors: inexpensive non-complying systems will be eliminated, and currently complying systems will become more expensive as lower levels require greater complexity. Total annualized costs will be calculated for this second effect only. It is reasonable to assume that the fractional increase in prices of currently complying aftermarket systems will parallel the fractional increase of OEM systems at the same level. Based on Table 7-30, the following increases for currently complying (i.e., OEM level) aftermarket systems are assumed:

	Regulatory Level (dB(A)-J-331a)			
	83	80	78	75
Fractional Increase in Price	10%	25%	50%	100%

To establish the current price of complying aftermarket systems, prices for current complying systems were compared to OEM replacement prices. Table 8-24 shows that while some systems for the popular models are less expensive than stock replacements, others are up to $45 more expensive. This comparison is complicated by differing system configurations and presence or absence of header pipes. The OEM replacement price for large motorcycles varies between $100 and $250 with many in area of $175. With replacement systems for smaller motorcycles factored in, $125 is a reasonable average for OEM replacement systems. Table 8-24 indicates that many large systems are being marketed at up to 33% less than OEM systems. Accordingly, $100 will be used as the average current price of complying aftermarket systems.

The other factor necessary to compute annualized cost is the impact of regulation on demand for aftermarket systems. Using price elasticity alone would be unrealistic because it does not account for performance and styling impacts. In addition, such factors are applicable only for price rises in a narrow range, which is not the expected case for aftermarket systems. Based on discussions with aftermarket manufacturers, the following fractional reductions in demand are estimated:

	Regulatory Level (dB(A)-J-331a)			
	83	80	78	75
Reduction in Demand	30%	40%	50%	60%

Table 8-24

PURCHASE PRICE COMPARISON BETWEEN

OEM REPLACEMENT AND AFTERMARKET EXHAUST SYSTEMS

Motorcycle	Exhaust System Mfr.	Sound Level (re stock, J-331a)	Retail Price ($) (re stock)
Honda GL-1000 (muffler only)	A	-2	-31
	B	+1	-31
	C*	-2	-61
Honda CB-750 (4:1)	A	-2	-85 (2 mufflers only)
	B	+1	-30
	C	0	-10
	D	+1	-25
Honda CB-550 (4:1)	A	0	-32 (2 mufflers only)
	B	-1	-42 (2 mufflers only)
	C	+1	+35
	D	0	+43 (4:2)
	E	0	-42 (2 mufflers only)
	F	+2	+28
Kawasaki KZ900 (4:4)	A	-1	-85 (2 mufflers only)
	B	0	-95 (2 mufflers only)
	C	-1	-30 (4:1)
	D	-2	-10 (4:2)
	E	0	-5 (4:2)
H-D XLCH (2:2)	A	+3	-5
	B	+3	+10
Yamaha RD-350 (2:2)	A	+2	+45
	B	+1	+5
Suzuki GT750 (3:3)	A	+1	-53

*Not yet in commerce

The increase in purchase price and reduction in demand are combined to calculate total annualized costs:

	Regulatory Level (dB(A)-J-331a)			
	83	80	78	75
Aftermarket Total Annualized Costs ($M)	8.2	16.2	22.0	32.8

8.5 Expected Impacts on Individual Manufacturers

8.5.1 Street Motorcycles

Honda Honda currently produces several models that would meet an 80dB(A) (F-76a) regulatory level (GL-1000, CB-750F, CB-500T, CB-360T, XL-250). Honda would be expected to have little difficulty bringing its entire model line into compliance with this level with no major model changes. Further reductions to the 78dB(A) regulatory level could be expected to be accomplished on most models with no major model changes. Based on EPA's motorcycle noise data base, the CB-550 would require the most attention. It is expected that, given sufficient lead time, Honda's expertise in motorcycle quieting would allow it to make the major model changes (including use of liquid cooling for some models) necessary to produce a limited number of motorcycle models at the 75dB(A) level. Based on current levels of the larger models, the CB-750F and CB-500T (no longer in production) appear to be candidates for achieving this regulatory level.

Yamaha Based on the current levels of Yamaha motorcycles, it is expected that most models would be controllable to the 80dB(A) (F-76a) regulatory level without major model changes. The recently introduced XS-750 indicates Yamaha's ability to produce large 4-stroke models with low mechanical noise. At the 78dB(A) regulatory level, it is felt that several models may require major model changes including liquid cooling, depending on the mechanical noise contribution to the total vehicle noise. Even with extensive use of liquid cooling, Yamaha might have great difficulty in producing a large number of models at the 75dB(A) level.

Kawasaki Based on the current levels of Kawasaki motorcycles, it is expected that most models would be controllable to the 80dB(A) (F-76a) level without major model changes. The most difficult model would be the KZ-900 series (now KZ-1000). Due to the particular properties of this motorcycle, its F-76a level is louder than average for this size motorcycle in comparison with J-331a. At the 78dB(A) regulatory level it is felt that major model changes, including liquid cooling, may be necessary for the larger street motorcycles. Even with extensive use of liquid cooling, Kawasaki might have great difficulty in producing a large number of models at the 75dB(A) level.

Suzuki Based on current levels of Suzuki motorcycles, it is expected that most models would be controllable to the 80dB(A) (F-76a) regulatory level without major model changes. Suzukis generally tested quieter than average on the F-76 test and the larger motorcycles are already near this level (GT-750, GT-550, RE-5). Suzuki's recently introduced 4-stroke models incorporate many quieting features. At the 78dB(A) level, several models may need major model changes. The GT-750 and RE-5 already feature liquid cooling. Even with extensive use of liquid cooling, Suzuki may have great difficulty in producing a large number of models at the 75dB(A) level.

AMF/Harley-Davidson

(1) Large Models

Harley-Davidson motorcycles equipped with a California exhaust system just meet the California 83dB(A) (J-331a) standard. It is apparent that current Harley-Davidson engine types would need major redesign to meet an 80dB(A) Federal requirement. All known quieting techniques, perhaps including liquid cooling, might be necessary at this level. EPA concludes that there is a reasonable chance that Harley-Davidson models may be able to achieve an 80dB(A) regulatory level with major redesign in conjunction with a performance and tonal charateristics penalty that AMF/Harley-Davidson may feel is damaging from a marketing standpoint. Lead time to accomplish such major redesign would be a primary issue in Harley-Davidson's ability to manufacture large motorcycles at this level.

It is clear, however, that levels below 80dB(A) are probably not achievable with the current engine types. Completely new engine designs would likely be necessary. Again, lead time for such effort would be a significent consideration.

It is clear from other manufacturers of large-bore twins, however, that the 75dB(A) level is essentially unachievable with these designs (see BMW, Moto Guzzi, Ducati). It is also clear that Harley-Davidson's marketing position makes it unfeasible for them to switch engine types to the multi-cylinder designs common to the Japanese manufacturers.

(2) Small Models

Based on current sound levels, the Harley-Davidson 2-stroke models should be able to meet an 80dB(A) requirement without major model changes. Major model changes may be necessary at the 78dB(A) level and the 75dB(A) level may not be achievable.

BMW BMW motorcycles tested much quieter than average on the F-76 test and 80dB(A) is expected to be achievable with little change to current models. BMW felt levels below 80dB(A) (J331a; 77-78dB(A) on F-76a for these motorcycles) were unachievable with their large bore, horizontally opposed twin cylinder engine.

Moto Guzzi, Ducati, Benelli, MV Agusta, Moto Morini These Italian manufacturers of large street motorcycles felt that 80dB(A) (J-331a; also estimated to be 80dB(A) on F-76a) was possibly achievable but that at levels below 80dB(A) the small fraction of their motorcycles produced for the U.S. would force them to consider withdrawing from the U.S. market.

NVT Motorcycles (Triumph) NVT felt that 80dB(A) was possibly achievable on the current Bonneville and Tiger models being produced. Lower levels would require mechanical treatment beyond their resources to quiet. It was felt that the Wankel motorcycle under development could be possibly quieted to 80dB(A). Since mechanical noise is relatively low, lower levels might be achievable at a great performance loss. Use of liquid cooling would rob the motorcycle of its desirable features and would be beyond NVT's severely limited resources.

Can-Am (Bombardier) Can-Am has produced versions of its high performance off-road and MX motorcycles as enduro models intended for limited street operation. Such enduro models would be subject both to EPA air emission and noise regulations applicable to street motorcycles. The combined effect of these regulations could cause Can-Am to drop these models from the U.S. market at or below the 80dB(A) level. Bombardier indicated that the high cost of labor and raw materials in Canada required continued production of high performance motorcycles in order to compete with the Japanese.

Bultaco Like Can-Am, Bultaco produces enduro versions of its high performance off road and MX motorcycles as enduro models intended for limited street operation. Bultaco is currently struggling to meet the California 83dB(A) standard. Since Bultaco enduro motorcycles are based on their off-road versions, major model changes such as liquid cooling are not feasible. The combined effect of air emission regulations and noise regulations could cause Bultaco to drop enduro models from the U.S. market at or below the 80dB(A) level.

Rokon Rokon, the only other U.S. manufacturer with vehicle assembly in the United States besides Harley-Davidson, manufactures an enduro model of its MX motorcycle. It is beyond Rokon's resources to meet air emission standards so these models are likely to be marketed as off-road only when the air emission regulations become effective.

Other Manufacturers Montesa, KTM/Penton, Carabela and other manufacturers also manufacture "enduro" models which have been street legal in some states. Since these manufacturers probably do not intend to meet air emission standards, they will undoubtedly be sold as off-road only motorcycles in the future.

8.5.2 Off-Road Motorcycles

Honda, Yamaha, Kawasaki, Suzuki All of the major Japanese manufacturers could use technology developed for their street and combination motorcycles to meet an 86dB(A) requirement. Given sufficient lead time, all manufacturers are judged capable of 4-stroke conversion and mechanical treatment to achieve an 80dB(A) regulatory level for large off-road motorcycles and a 78dB(A) regulatory level for small off-road motorcycles. At these levels, however, severe performance impacts can be expected.

Other Manufacturers Husqvarna, Can-Am, Bultaco, OSSA, Montesa, KTM, Maico, CZ, Carabela, Hodaka, Rokon and several other manufacturers produce off-road and competition MX motorcycles. Almost all of the manufacturers EPA talked with agreed that the 86dB(A) California standard was achievable at only a limited performance penalty. The manufacturers generally felt that 83dB(A) might be achievable at some time in the future but that consumer shifts to higher performance competition models and user modifications to restore lost performance would make this effort fruitless. Since these manufacturers specialize in high performance, their demand would drop off significantly in comparison to the lower priced Japanese models below 86dB(A). Between 83 and 80dB(A), most of these manufacturers would either drop out of the U.S. market or would market competition models only.

8.5.3 Aftermarket Exhaust Systems

It is estimated that approximately half of the firms currently making replacement motorcycle exhaust systems will either go out of business or be forced to switch to alternate product lines as a result of Federal noise standards. These firms are typically small, low volume enterprises devoted exclusively to manufacturing motorcycle exhaust system production, with little or no capability for product design and development. Other firms currently marketing replacement exhaust systems may likewise be forced to make major readjustments. Catalog suppliers such as J. C. Whitney, and other retailers who offer a wide range of automotive type products may be forced to find new suppliers, or may discontinue selling exhaust systems entirely. Some firms may resort to copying the designs of other manufacturers, a common practice at present.

The ten to twenty leading firms in the industry are expected to be able to produce complying systems, although at similar price and performance penalties associated with OEM systems. Although total demand for aftermarket systems is expected to decline, these firms ought to at least preserve their unit volume as other manufacturers withdraw from the market. The twenty or thirty other firms that are expected to remain in the aftermarket muffler market are expected to experience severe difficulties in remaining competitive, with profits shrinking to the near break even point.

These expected impacts are based upon the assumption that the regulations will be effectively enforced at the state level to prohibit widespread sale and use of systems "designed" for motorcycles manufactured before the effective date of the Federal regulations, or "competition" exhaust systems reconfigured by the operator for use on a regulated motorcycle.

8.6 Impact on U.S. Employment

Vehicle Manufacturers

Harley-Davidson, Rokon, Kawasaki and a few others are the only motorcycle manufacturers with assembly facilities in the U.S. Assuming these manufacturers will stay in the market at any given regulatory level, their decrease in employment ought to follow the total market decrease in demand. Based on elasticities developed from historical price-sales relationships, the following impacts on employment would be expected at each regulatory level studied: 83dB(A)--50 positions; 80dB(A)--150; 78dB(A)--450; 75dB(A)--880. There is reason to believe, however, that actual impact would be considerably less. Harley-Davidson, however, is not expected to be able to produce large motorcycles at the 75dB(A) level. Harley-Davidson's withdrawal from the market at the 75dB(A) or any other level would result in a complete loss of its motorcycle-related positions (approximately 3,300).

Aftermarket Manufacturers

Total employment in the exhaust system manufacturing industry is expected to follow impact on total demand for those systems. As discussed above, some firms are expected to increase production but a large number are expected to be forced out of the replacement exhaust business at any regulatory level. Using the same assumptions as in Section 8.4.2, the decrease in exhaust system manufacture employment would be: 83dB(A)--360 positions; 80dB(A)--480; 78dB(A)--600; 75dB(A)--720. Other aftermarket manufacturers are not expected to suffer any loss of positions at any level.

Distributors/Dealers

Employment amongst dealers and distributors is expected to decline in proportion to the decreased demand for vehicles and exhaust systems as a fraction of their total business. With the same assumptions for decreased demand, the decrease in dealer/distributor employment is expected to be: 83dB(A)--800 positions; 80dB(A)--1800; 78dB(A)--4000; 75dB(A)--6800.

Total U.S. Employment Impact

Table 8-25 sums the total expected employment impact at each regulatory level. Although the levels assessed are for street motorcycles, complementary off-road regulations are expected to contribute to the total shown.

Table 8-25

EXPECTED U.S. EMPLOYMENT IMPACTS

	Regulatory Level (J-331a)			
	83	80	78	75
Vehicle Manufacturer	50	150	450	880
Aftermarket Exhaust System Manufacturer	360	480	600	720
Other Aftermarket Manufacturer	0	0	0	0
Dealer/Distributor	800	1800	4000	6800
Other	0	0	0	0
Total	1210	2430	5050	8300

These are reductions from current employment levels. Expected growth in the industry would more than compensate for these losses, netting a gain in total employment at any regulatory level. Again, these figures are based on historical prices-sales relationships which at felt to overestimate the impact. However, the aftermarket exhaust segment of the total market is expected to suffer a net loss at any regulatory level.

8.7 Regional Impacts

The largest employment impacts are expected to occur at the dealer/distributor level. Except for a certain amount of concentration in California and other regions of high motorcycle interest, this impact is expected to be distributed more or less evenly nationwide. The largest regional impact is expected to be in Southern California, the location of most of the aftermarket exhaust system manufacturers. Other regional impacts could occur in Milwaukee, York (Pennsylvania), or Lincoln (Nebraska) if Harley-Davidson withdrew from the market or Kawasaki closed its U.S. assembly plant. In each of these regions, however, motorcycle-related employment is a very small fraction of total area employment.

8.8 Impact on GNP and Inflation

Total annualized cost for the most restrictive regulatory noise level studied is less than $350 million annually. Since this figure is considerably less than one-tenth of one percent of the over one trillion dollar U.S. economy, there is expected to be no impact on the U.S. Gross National Product or on general inflation as a result of this regulation. Since motorcycles are not commercial goods, price increases are not passed along in higher prices for other commodities, and no inflation multiplier applies.

8.9 Impact on Foreign Trade

The impact of any Federal motorcycle regulation on trade with Canada or Europe is expected to be negligible. Motorcycles do, however, account for a significant portion of total U.S. trade with Japan. In the peak sales year of 1973, the U.S. imported about 1.3 million motorcycles from Japan. At an average purchase price of about $1000 per motorcycle (1973 dollars) this represented about $1.3 billion in imports, almost 14% of the total $9.6 billion in goods imported from Japan that year. Since 1970, the U.S.-Japan annual balance of trade has fluctuated between almost $600 million net U.S. imports (1974) to over $400 million net U.S. exports (1972).

Clearly, any large impact on Japanese motorcycles could affect this balance significantly. The price elasticities developed above have an absolute value of less than one at modest price rises, indicating that a price rise would result in a revenue increase despite falling demand. However, the price elasticity has an absolute value greater than one for larger price rises, indicating that net revenue to Japan would decrease in such a situation. Accordingly, Federal motorcycle noise regulation is likely to marginally increase or decrease the value of U.S. imports from Japan, depending on the regulatory level selected.

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[1] Data Resources, Inc.

[2] Ibid.

SECTION 9

OTHER ENVIRONMENTAL EFFECTS

Section 9

OTHER ENVIRONMENTAL EFFECTS

The primary effect of a motorcycle noise regulation will be to reduce the number of people exposed to motorcycle noise. There will also be several secondary effects.

WATER QUALITY

In recent years there has been a general trend away from two-stroke and toward four-stroke motorcycles for street use; EPA exhaust emission regulations may accelerate this trend somewhat. Currently off-road motorcycles are typically two-stroke configurations. Several manufacturers have indicated, however, that in order to comply with the lower possible study sound level standards for off-road motorcycles, they may switch to four-stroke configurations, although the Agency's analysis shows no significant cost difference.

Two-stroke motorcycle engines generally employ intake oil injection for lubrication. One characteristic of this system can be an oily exhaust. A slight decrease in street surface run off of oil may be realized, and water quality slightly improved if the number of two-stroke motorcycles is reduced.

ENERGY

An increase in fuel economy is expected upon switching from two-stroke to four-stroke configurations. However, such conversions may be negated to some extent by the additional weight of heavier mufflers and other sound control apparatus expected to be required for regulated motorcycles. A five to ten percent reduction in fuel economy is expected to increase fuel consumption by 10 to 20 million gallons per year, as discussed in Section 6.

SOLID WASTE

In general, changes in the amount of raw materials used by motorcycle-related industries are not expected to be significant, although some slight increase in such use is foreseen. No change in the amount of solid waste is expected. The scrapping of old motorcycles should not increase as a result of noise regulation. In fact, increased motorcycle prices and possible performance decrements should have, to a small degree, a reverse effect: users may be encouraged to retain old motorcycles longer.

WILDLIFE

Although there are differing opinions as to the significance of noise impact on animals, it is generally agreed that the impact is somewhat detrimental. Therefore, quieting motorcycles may have some beneficial effect on wildlife and domesticated animals, although the benefit can not be quantified.

AIR POLLUTION

Noise regulations are not expected to significantly increase exhaust emmissions from off-road motorcycles. Noise regulations should not make it more difficult for manufacturers to comply with street motorcycle exhaust emission standards. The relationship between Sound Level Regulations and Exhaust Emission Control is discussed in more detail in Section 6.8.

SECTION 10

REGULATORY ALTERNATIVES

Section 10

REGULATORY ALTERNATIVES

The primary purpose of any proposed sound level regulation would be to reduce the impact of motorcycle noise on human health and welfare. There are a number of alternative methods of achieving this goal, but the options of the EPA are limited to those authorized by the Noise Control Act. Under the provisions of the Act, the EPA may establish sound level limits for newly manufactured motorcycles and replacement exhaust systems. Also, the EPA may require that products be labeled with information on their noise emissions. Any standard established by the EPA would preempt state and local standards, unless such standards are indentical to the EPA standard.

The five options available to EPA are:

(1) Take no action and emphasize state and local regulation and enforcement efforts.

(2) Require manufacturers to label the sound emission level of their product.

(3) Regulate to one or more of the study options evaluated in this document.

(4) Regulate to either lesser or greater levels than those selected for evaluation here.

(5) Alter the timing of the proposed regulations.

Each of these alternatives is discussed below, in addition to alternatives not available to EPA.

EMPHASIZE STATE AND LOCAL REGULATION AND ENFORCEMENT EFFORTS

Even without federal regulation, a slight reduction in nationwide impact from motorcycle sound levels may occur, due to the sound level standards recently enacted in the State of California. Since California comprises a significant portion of the total motorcycle market, motorcycles are generally manufactured to comply with the State's standards, resulting in a small decrease in average motorcycle sound levels nationwide.

An alternative avaliable to EPA, therefore, would be to support the development of state regulations for new motorcycles, rather than promulgate Federal standards. Such a policy, however, would allow manufacturers to market unquieted products in states not having regulations for motorcycles. In the past, for example, several manufacturers have produced special models for sale only in California. A number of individual state regulations would futhermore cause a heavier compliance burden for the motorcycle industry. The need for separate treatment at the state level is also questionable (given the alternative of uniform national standards) in view of the fact that a great part of the motorcycle noise problem is due to exhaust-modified vehicles. Regulations aimed at controlling the use of these modified motorcycles are likely to be more effective in reducing overall noise impact for motorcycles.

The health and welfare analysis in Section 5 of this document shows clearly that regulation of aftermarket exhaust systems is imperative to reducing motorcycle noise impact. EPA considered regulating exhaust systems only, since the analysis does indicate that exhaust modified motorcycles are a primary source of impact. For instance, a fifty percent reduction in owner modifications to street motorcycles would result in the same benefit as a 10 dB reduction in new street motorcycle sound levels. However, most motorcycles are unmodified; without regulations on new street motorcycles, they will stand out as the single loudest traffic noise source when noise emissions of other vehicles are regulated. In addition, State and local government officials have indicated that the stationary test procedure and tampering provisions included in the Federal regulation would be helpful enforcement tools.

Although any Federal regulation would be preemptive, the States will, in any case, reserve the authority to regulate the use of motorcycles. These regulatory alternatives include issuing violations for exceeding a state-established sound level, restrictions on areas where motorcycles can be operated, and license fees which could discourage the use of motorcycles in general or of certain types of motorcycles. These options are not available to the Federal government, except for motorcycles used on Federal land. For example, the U.S. Bureau of Land Management (BLM) could set sound level standards or restrict motorcycle operations on BLM lands. This approach could reduce the impact from off-road noise greatly, since it is estimated that approximately half of all recreational off-road vehicle use takes place on lands administered by the BLM. These lands represent 20% of the nation's land area.

EPA considered several alternative methods of dealing with the off-road motorcycle noise problem. Several labeling schemes were evaluated, as was the option of reserving Federal authority and allowing state and local governments to establish their own new product regulations.

It is generally agreed that the fundamental problem with off-road motorcycles is incompatible land-use, and that reducing the noise from such vehicles will only help, not solve, the problem. In-use regulation are the most effective methods of dealing with these incompatible land-uses. Although progress is being made in some quarters, state and local officials report great difficulty in getting proper in-use and land-use requirements established and in properly enforcing them once established. The fact that off-road vehicles are usually not licensed, that operators are difficult to apprehend once observed in a violation, and that many of the offenders are juveniles contribute to these difficulties. Virtually all state and local officials contacted felt that reduced sound levels would help the problem and either urged EPA to establish regulatory sound levels or were establishing new off-road motorcycle sound level limits themselves.

Since some new off-road motorcycles are extremely loud, any reasonable Federal standard, with its tampering, replacement muffler and stationary labeling provisions, can help to reduce the impact of off-road motorcycle noise considerably. Provided that Federal regulations do not critically impair off-road motorcycle performance, EPA has concluded that reduced sound levels from the majority of unmodified off-road motorcycles are a necessary complement to state and local in-use and land-use regulation. At any level of regulation, however, incompatible land use will continue to exist, and restrictions on the use of off-road motorcycles in certain wilderness areas and in residential areas will still be necessary in many jurisdictions.

The Agency carefully considered the desirability of Federal noise emission standards for competition motorcycles. Acceleration sound levels of competition motorcycles are often one hundred decibels or more. Since several types of competition motorcycles are well suited for off-road operation, the use of such extremely loud vehicles in desert and trail environments is considered to be a serious and widespread problem. One manufacturer suggested that, in conjunction with the vehicle label, engines or other components of competition motorcycles be of a distinctive color to aid enforcement officials in identifying and controlling their use off-road.

In addition to the problem of off-road use of competition motorcycles, noise generated from racetracks where motorcycle competition events are held has in a number of cases become a source of considerable public annoyance in surrounding residential areas. Although Federal noise regulations for competition vehicles are one approach to solving this problem, other solutions such as boundary line noise ordinances or time limit restrictions are available to local authorities. Since racing motorcycles are disassembled between races, vigorous state and local action would still be necessary in any jurisdiction with competition motorcycle noise problem, even if Federal noise standards were established. By reserving Federal authority, state and local governments are free to establish boundary line or vehicle performance standards at their option.

LABELING

Labeling was considered as an alternative to, or in conjunction with, Federal sound level limits for both off-road and competition motorcycles. In either case, it would assist state and local enforcement officials in determining compliance with applicable laws and ordinances.

Different types of labels may be useful for in-use enforcement purposes. Labels which bear a motorcycle's sound level as measured by a simple, stationary procedure can simplify enforcement programs in which actual testing is performed to determine compliance with a standard. The presence of a compliance-type label on a motorcycle or exhaust system could also be used by enforcement authorities as providing evidence that the vehicle is not violating standards tied to a Federal regulation.

Labels which indicate the sound level (as measured by a specified test procedure) of a motorcycle or exhaust system could possibly result in generating an awareness of and a consumer preference for quieter products.

Competition motorcycles would be labeled as not meeting Federal noise emission regulations, and for use only in officially-sanctioned closed-course competition. Labeling of motorcycles and replacement exhaust systems would advise buyers that the product is sold in conformity with applicable regulations, and would also alert the user that the motorcycle possesses noise attenuation devices which should not be tampered with or removed.

Labeling alone at the Federal level would allow state and local governments to establish noise emission regulations for new motorcycles in addition to in-use regulations. However, almost all concerned state and local officials believed that Federal regulation of new off-road motorcycles would help to solve the noise problem in their jurisdictions.

REGULATE TO ONE OF THE STUDY OPTIONS

The analysis in Section 5 presents the reduction in impact on human health and welfare in terms of various levels to which motorcycles might be regulated. Different regulatory study levels have been examined for street motorcycles and off-road motorcycles, since the technology for quieting street motorcycles is not directly applicable to off-road motorcycles. Weight and ground clearance requirements for off-road motorcycles limit the amount of muffling that can be applied. Liquid cooling which will probably be necessary for large displacement motorcycles at regulatory levels below 80 dB(A), is not feasible for off-road motorcycle due to the weight and "crashability" constraints.

The range of off-road motorcycle sound levels is rather wide: small off-road motorcycles of 170 cc or less have a median acceleration sound level of about 80 dB(A), while the sound levels of off-road motorcycles over 170 cc range from 87 to above 90 dB(A). Sound level reduction treatments for small off-road motorcycles are fairly straightforward, with only minor performance decrements. To achieve the same sound levels in larger off-road motorcycles will result in severe performance decrements. An additional problem mentioned by both motorcycle users and some government officials is that there may be an increased tendency for motorcyclists to either modify their off-road motorcycle or switch to an unregulated competition motorcycle to counteract severe performance penalties. For these reasons, EPA has considered establishing two different regulatory limits, according to displacement, for off-road motorcycles. Available technology for such regulation is discussed in more detail in Section 6. Cost of compliance and economic impact are addressed in Sections 7 and 8 respectively.

REGULATE TO LEVELS NOT CONSIDERED HERE

The regulatory levels studied in this document were based on the application of various incremental treatments to the motorcycles. Lesser sound level reductions would not measureably improve public health and welfare, and, as indicated by the analysis of available technology in Section 6 of this document, greater reductions in the sound levels of motorcycles do not appear to be acheivable with "Best available technology" as required by the Noise Control Act.

ALTER THE TIMING OF THE REGULATION

Both "normal" and "accelerated" schedules of regulatory lead times were considered by the Agency. These are indicated in Tables 5-2 and 5-16. The normal lead times were based on a rapid but orderly redesign schedule for a major manufacturer. Smaller manufacturers are expected to need accelerated programs to meet these schedules. Accelerated lead times would require the major manufacturers to redesign many models simultaneously with substantially increased research and development costs: smaller manufacturers may not have the additional research and design capabilities to meet the accelerated schedule. Since there is a maximum difference of three years between the two schedules, the additional environmental benefits are negligible (as discussed in section 5.5.1.

Longer lead times were also considered, since most of the smaller manufacturers would benefit considerably if given an additional year or two to acheive the 78 or 80 dB(A) regulatory levels. As discussed above, the loss of environmental benefits would be small.

ALTERNATIVES NOT WITHIN THE AUTHORITY OF EPA

There are a number of other strategies which could reduce motorcycle noise levels but which are not within the present authority of the Federal government. These strategies include a mandatory reduction in the sale of motorcycles, a special tax on motorcycles, and a limit on the sale of motorcycles by permit. Another strategy would be to establish economic incentives to reduce pollution. For instance, some European countries apply a graduated tax to products according to the sound level they produce, in order to provide an incentive to the manufacturers to produce a quieter product or lose a share of the market.

The proposed Federal sound level regulation is only one of the several strategies to reduce noise. These strategies may be used to complement one another, not at the exclusion of each other.

SECTION 11

ENFORCEMENT

Section 11

ENFORCEMENT

11.1 General. The EPA enforcement strategy applicable to the new motorcycle noise emission standards will place a major share of the responsibility on the manufacturers of the new motorcycles for pre-sale testing to determine the compliance of their products with these standards and regulations. This approach leaves the manufacturers in control of many aspects of the compliance program, and imposes a minimal burden on their business. To be effective, this strategy requires monitoring by EPA personnel of the tests conducted and actions taken by the manufacturers in compliance with these regulations.

The enforcement strategy that will be proposed in the regulations consists primarily of four parts: (1) Production Verification, (2) Label Verification for the labeled stationary value, (3) Selective Enforcement Auditing, and (4) In-use Compliance.

The enforcement strategy for motorcycle replacement exhaust systems will place a major share of the responsibility on replacement exhaust system manufacturers and on original equipment manufacturers for pre-sale testing to determine compliance with the regulations and standards. The effectiveness of this strategy will again necessitate monitoring by EPA personnel of tests conducted and actions taken by manufacturers in complying with the regulations.

In the development of the enforcement procedures for motorcycle replacement exhaust systems several preliminary issues were given careful consideration. The major issues were: (a) What test procedure can be required of aftermarket exhaust system manufacturers; (b) Should the aftermarket be required to meet original equipment production sound levels or, instead, be allowed to assign their own Sound Level Degradation Factor in complying with the Acoustical Assurance Period, and (c) What testing and labeling requirements should be made applicable to "universal" mufflers.

11.2 Test Procedures. Motorcycle manufacturers are required to verify compliance with the new product noise emission standard by conducting the acceleration test proposed by EPA. However, it does not appear at this time to be feasible to require exhaust system manufacturers to perform all required testing using this procedure. Manufacturers of replacement exhaust systems have indicated that requiring the use of the acceleration test procedure for all testing could pose a major problem, due to the difficulty of acquiring new motorcycles for testing purposes (although it is not an EPA requirement that the test motorcycle be a new motorcycle). These manufacturers have indicated, however, that new motorcycles are readily available from dealers for design purposes, as long as mileage is not accumulated on the vehicles. The acceleration test procedure would require some mileage accumulation, hence a stationary test would be desirable.

The Agency has investigated the relationship between test results of the proposed acceleration and stationary test procedures. Test data indicate that if a replacement exhaust system causes a motorcycle to emit sound levels higher than original equipment levels on the stationary short test, then in most cases it would cause the sound levels as measured by the acceleration test to be increased as well.

The regulations prohibit manufacturers from distributing exhaust systems into commerce if such systems cause vehicles for which they are designed and marketed to exceed the applicable Federal standard. In this way both aftermarket and original equipment manufacturers must meet the same standard. However, the strategy proposed herein allows aftermarket manufacturers to demonstrate compliance using the stationary procedure to show that their exhaust system does not cause the test vehicle to exceed its labeled stationary sound level. This labeled value is determined by the original equipment manufacturer using the same stationary test procedure. If the vehicle exceeds the labeled value, the aftermarket manufacturer must conduct the acceleration test and demonstrate that his system does not cause the vehicle to exceed the Federal Standard.

The Agency realizes that there may be instances where an exhaust system passes the stationary test procedure, but is later determined by the Agency to not be in compliance with the standard when tested with the acceleration procedure. In these cases, the Agency will exercise its discretion in formulating a remedial order to be issued to the manufacturer of the replacement system. At a mimimum, however, the Agency would require that the manufacturer cease further marketing of that system for the particular model motorcycle until such time as the non-conformity is remedied.

11.3 Original Equipment Sound Level. The manufacturers of new product motorcycles and motorcycle replacement exhaust systems are required to design their products so that they will meet the noise standard for the period of time specified as the Acoustical Assurance Period. It has been explained to the Agency that the expected degradation in motorcycle noise level, if any, will likely be attributable to muffler system deterioration. For this reason it is resonable to require a replacement muffler manufacturer to assign a sound level degradation factor to his exhaust systems to assure compliance with the AAP. The regulations will not require the aftermarket manufacturer to account also for the vehicle SLDF as determined by the motorcycle manufacturer, on the presumption that the vehicle SLDF is predominately exhaust system related. The SLDF attributable to the remainder of the vehicle is considered to be nearly zero.

The SLDF concept is employed when conducting the acceleration test which defines the standard. It is not employed when conducting stationary sound level test procedures.

11.4 Universal Muffler. A universal muffler is one which is designed to fit many models of motorcycles. If a universal muffler is marketed for Federally regulated motorcycles, the manufacturer must show that it meets the Federal standard for each of these motorcycles. Exhaust system manufacturers have commented that they do not know how the sound level performance of their mufflers varies from one model motorcycle to another. They further maintain that it would not be possible to categorize motorcycles in order to test a worst case to assure that all other motorcycle models in that category would meet the standard with the same replacement exhaust system. The proposed strategy requires testing of all motorcycle/replacement exhaust system combinations that are marketed.

It is not certain what problems may arise from requiring the universal muffler to be labeled for those motorcycles for which it is marketed. In cases where a universal muffler is marketed for only a limited number of models, labeling may not prove to be a burden to the manufacturer. Where they are marketed for several models, labeling may be more difficult. The Agency is considering several alternative methods of dealing with this situation. One would require manufacturers to list on the label all motorcycle models for which the muffler is marketed. Another would allow exhaust system manufacturers to supply the mufflers with different labels. In this way the manufacturer could include a partial list of models on each exhaust system.

11.5 Production verification. Production verification (PV) is the testing by a motorcycle or motorcycle replacement exhaust system manufacturer of early production models of a category or configuration (replacement exhaust systems will be tested by categories only) of the product, and submitting a report of the results to the EPA. This process, using the proposed methodology, gives the EPA some assurance that the manufacturer has the requisite noise control technology in hand and the capability to apply it to the production process. Models selected for testing must have been assembled using the manufacturer's normal assembly process and must be units assembled for sale.

PV does not involve any formal EPA approval or issuance of certificates subsequent to manufacturer testing. The regulations would require that prior to the distribution in commerce of any regulated product, that products must undergo production verification. Responsibility for testing lies with the manufacturer. However, the Administrator reserves the right to be present to monitor any test (including simultaneous testing with his equipment) or to require that a manufacturer ship products for testing to the EPA's Noise Enforcement Facility in Sandusky, Ohio or to any other site the Administrator may find appropriate. The motorcycle manufacturer would be allowed a conditional and temporary waiver of the PV testing requirement under special circumstances such as inclement weather conditions.

The basic production unit selected for testing purposes is a product configuration or category. Motorcycle manufacturers will be required to test configurations of their products. Configurations are sets of vehicles which are grouped together on the basis of parameters which will most likely affect their noise emission characteristics.

The motorcycle manufacturer would be required to verify production products of each configuration. The regulations, however, also allow manufacturers to group configurations into categories based on engine parameters and to verify by category. This is done by selecting and testing the configuration in each category that the manufacturer determines will have the highest level of noise emissions at the end of its Acoustical Assurance Period (AAP) (based on tests or on engineering judgment). If when tested in accordance with the test procedure, that configuration does not exceed a sound level defined by the new product standard minus that configuration's expected noise degradation over the period of its AAP, then all configurations in that same category are considered product verified.

Replacement exhaust system manufacturers will be testing exhaust system categories. A category is a model line of an exhaust system which is marketed for a particular model of motorcycle. The category is described by attenuation parameters of the exhaust system and its intended application. Any exhaust system comprised of different combinations of these parameters constitutes a separate and distinct category. The manufacturer is required to production verify each category.

The Administrator reserves the right to test vehicles or exhaust systems at a manufacturer's test facility using either his own equipment or the manufacturer's equipment. This will provide the Administrator an opportunity to determine that the manufacturer's test facility and test equipment meet the required specifications. If it is determined that the facility or equipment do not meet these specifications, he may disqualify them from further use for testing under this subpart.

The Administrator may require that manufacturers submit to him any product tested or scheduled to be tested pursuant to these regulations or other untested products at such time and place as he may designate.

If a manufacturer proposes to add a new configuration or category to his product line, or to change or deviate from an existing configuration or category with respect to any of the parameters which define a configuration or category, the manufacturer must verify the new configuration or category either by testing a product and submitting data or by filing a report which demonstrates verification on the basis of previously submitted data.

A motorcycle manufacturer may production verify a configuration or category at any time during the model year or in advance of the model year if he so desires. Manufacturers may not, however, distribute into commerce any products within a configuration or category which have not been production verified.

Production verification is an annual requirement. However, the Administrator, upon request by a manufacturer, may permit the use of data from previous production verification reports for specific configurations or categories.

Production verification performed on early production models provides EPA with confidence that production models can conform to applicable noise emission standards and limits the possibility that non-conforming products are distributed in commerce. Because the possibility still exists that subsequently produced vehicles or exhaust systems may not conform, selective enforcement auditing (SEA) testing is also incorporated.

11.6 Selective enforcement auditing. Selective enforcement auditing (SEA) is the testing of a statistical sample of assembly line (production) products from a specified product configuration or category to determine whether the motorcycle and motorcycle replacement exhaust systems comply with the applicable noise emission standards.

SEA testing is initiated when a test request is issued to the manufacturer by the Assistant Administrator for Enforcement or his designated representative. The test request will require the manufacturer to test a sample of products of a specified category or configuration produced at a specified plant. An alternative category or configuration may be designated in the event that products of the first category or configuration are not available for testing.

Motorcycle SEA: Noise Emission Standard

This SEA plan employs a technique known as inspection by attributes. The basic criterion for acceptance or rejection of a batch is the number of sample products in the batch which fail to meet the standard.

A multiple batch sampling inspection plan will be used on motorcycles for SEA testing. Multiple sampling differs from single sampling in that small test samples are drawn from consecutive batches rather than one large sample being drawn from a single batch. It offers the advantage of keeping the number of products tested to a minimum when the majority of such vehicles are meeting the standards.

A batch will be defined as the number of products produced during a time period specified in the test request. This will allow the Administrator to select batch sizes small enough to keep the number of products to be tested at a minimum and still draw statistically valid conclusions about the noise emission levels of all vehicles in that category or configuration.

The sampling plans are arranged according to the size of the batch from which a sample is to be drawn. Each plan specifies the sample size and the acceptance and rejection number for the established acceptance quality level (AQL). This AQL is the maximum percentage of products exceeding the applicable noise emission standard that for purposes of sampling inspection can be considered satisfactory. An AQL of 10% was chosen for new motorcycles to take into account some test variability. The number of failing products in a sample is compared to the acceptance and rejection numbers for the appropriate sampling plan. If the number of failing products is greater than or equal to the rejection number, then there is a high probability that the percentage of non-complying products in the batch is greater than the AQL and the batch fails.

Since the sampling strategy involves a multiple sampling plan, in some instances the number of failures in a test sample may not allow acceptance or rejection of a batch so that continued testing may be required until a decision can be made to either accept or reject a batch.

When a batch sequence is tested and accepted in response to a test request, the testing is terminated. When a batch sequence is tested and rejected, the manufacturer must cease introducing these products into commerce. If the manufacturer desires to continue production and introduction into commerce of the failed configuration (category), he may do so provided he tests all of the vehicles in that category or configuration produced at that plant. He may then distribute the individual products that pass the test.

Regardless of whether a batch is accepted or rejected, failed products would have to be repaired or adjusted and pass a retest before they can be distributed in commerce.

The manufacturer can request a hearing on the issue of non-compliance of the rejected category or configuration.

Since the number of vehicles tested in response to a test order may vary considerably, a fixed time limit cannot be placed on completing all testing. The proposed approach is to establish a limit on test time per product. It is estimated that motorcycle manufacturers can test a minimum of ten (10) products per day.

Replacement Exhaust System SEA

This SEA plan also employs the inspection by attributes technique. The basic criterion for acceptance or rejection of an exhaust system category is the number of failing exhaust systems in the test sample. A single sampling inspection plan will be used on replacement exhaust systems for SEA tesing.

The proposed inspection plan defines a rejection number for each test sample size. The test sample size will be designated by the Administrator in the test request. The rejection number specifies the number of allowable failing exhaust systems in a test sample for the established acceptance quality level (AQL). This AQL is the maximum percentage of failing exhaust systems exceeding the applicable noise emission standard that for purposes of sampling inspection can be considered satisfactory. An AQL of 10% was chosen to take into account some test variability. If the number of failing exhaust systems is greater than or equal to the rejection number, then there is a high probability that the percentage of non-complying exhaust systems of the specified category is greater than the AQL and the exhaust system category is considered in non-compliance.

When an exhaust system category is rejected and therefore considered in non-compliance, the manufacturer must cease introducing these products into commerce. If the manufacturer desires to continue production and introduction into commerce of the failed category, he may do so provided he proceeds with one of the following options: (1) He tests all of the exhaust systems in that category produced at that plant and then he may distribute the individual products that pass the test. (2) If he was required to conduct the original SEA using the stationary test procedure, he may elect to conduct an identical SEA (using the same products) with the acceleration test to show compliance.

The manufacturer can request a hearing on the issue of non-compliance of the rejected category.

One of the advantages to this single sampling plan is that the number of exhaust systems tested in response to a test request will not vary as it does in multiple sampling. Under multiple sampling neither EPA nor the manufacturer will know the number of required tests to be conducted to determine acceptance or rejection. The replacement exhaust system manufacturer, however, knows when he receives the test request the exact number of products he must select and test to determine compliance. In some cases the number of products tested under single sampling could be greater than under multiple sampling. However, since the replacement exhaust system manufacturer will know how many products he will be required to test, he is able to plan his complete testing requirements before he begins testing, and therefore, it is expected that his administrative burden will be less. Also, under this sampling plan, EPA can more easily proportion a manufacturer's testing requirements to his actual production, so as to minimize the burden on his time and business.

A fixed time limit will be placed on completing all testing. It is currently estimated that replacement exhaust system manufacturers can test a minimum of five (5) exhaust systems per day if the acceleration procedure is used or fifteen (15) per day with the stationary test.

One of the problems that replacement exhaust system manufacturers may have in completing the testing under the fixed time limit will be the acquisition of motorcycles on which to conduct the acceleration test. It is expected that no motorcycle acquisition problem will be incurred with the stationary test. In almost all cases the test request will specify a particular model motorcycle that will be tested with a particular model exhaust system. Therefore, the replacement exhaust system manufacturer will, in most cases only have to acquire one particular model motorcycle to conduct his SEA testing.

11.7 <u>Stationary sound level verification</u>. The labeling scheme included in these proposed regulations would require that the manufacturer label each motorcycle at a sound level representative of the 90th percentile sound level of all vehicles of that class. A class is described by engine and exhaust system parameters. These regulations do not specify the amount of testing a manufacturer must conduct to establish that value but rather require the manufacturer to conduct whatever testing is necessary to determine it accurately. The manufacturer must maintain the records and data which were used to determine the class stationary sound level.

Every new motorcycle subject to the standards prescribed in this subpart prior to distribution into commerce shall satisfy the stationary sound level verification requirements. This requires the manufacturer to determine a class stationary sound level for each class of motorcycles and to retain in his files the calculations on which these determinations were based. In addition, each class must pass a stationary sound level audit (described in the next section), and the manufacturer must submit to EPA a label verification report. Once these stationary sound level verification requirements are met, the manufacturer may distribute products of that class into commerce.

11.8 SEA: (Stationary sound level). Selective enforcement auditing for stationary sound levels is the testing of a statistical sample of assembly line (production) products from a specified class to determine whether the products are properly labeled.

One such test must be conducted each year for each class prior to distribution into commerce for stationary sound level verification. Additional required testing, if any, will be initiated by a test request issued to the manufacturer by the Assistant Administrator for Enforcement or his designated representative. The test request will require the manufacturer to test a specific number of products of a class produced at a specific plant. An alternative class may be designated in the event that products of the first are not available for testing.

The testing plan employs a technique known as inspection by attributes. The basic criterion for determination of compliance or noncompliance of a class stationary sound level is the number of sample products in the test group which exceed the labeled value.

The proposed inspection plan defines a maximum and minimum number of vehicles in a sample which may exceed the labeled stationary sound level, consistent with the requirement that 10% of the vehicles must exceed that value.

If the number of vehicles exceeding the labeled value is outside of the acceptable range then there is a significant probability that the labeled value is not representative of the 90th percentile and the class is deemed mislabeled and in noncompliance.

It is estimated that motorcycle manufacturers can test a minimum of thirty (30) products per day during a stationary sound level audit.

The Administrator may require at his discretion that test vehicles be submitted to him for testing at a site and time of his choice. In addition, he reserves the right to be present to monitor any testing by the manufacturer.

11.9 Labeling. These regulations require that motorcycles subject to them be labeled to provide notice that the product complies with the noise emission standard and to display the stationary sound level for that vehicle. The label shall also contain a notice of tampering prohibitions. These regulations also require that motorcycle replacement exhaust systems, marketed for Federally regulated motorcycles, be labeled to provide notice that the product complies with the noise emission standard and that it should only be used on the motorcycle models specified on the label. The label shall also contain the full corporate name and trademark of the manufacturer along with month and year of manufacture.

11.10 Right of Entry and Record Keeping. In this regulatory scheme where a significant part of the regulatory activity is controlled by those being regulated, it is essential that EPA personnel have free access to all aspects of the system in order to determine whether the requirements of the regulations are being followed and if conforming motorcycles and replacement exhaust systems are being introduced into commerce. Such access includes all facets of the testing program required by the regulations, all records, reports, and test results which must be maintained, and all facilities where test products are present or where any product to be distributed into commerce is manufacturered, assembled or stored. The regulations will specify which records and other documents concerning the testing of production units, must be retained, and for how long.

The regulations will also provide for a sanction against any manufacturer who refuses to allow EPA personnel entry to a facility to conduct authorized activities. This sanction is in the form of an order issued by the Administrator to cease distribution into commerce of vehicles or exhaust systems of the specified category or configuration that are being manufactured at that facility. The Administrator will provide a manufacturer the opportunity for a hearing prior to the issuance of such an order.

In instances where a foreign manufacturer markets its products in the U.S. or where a domestic manufacturer maintains a manufacturing facility in a foreign country, the regulations make it clear that all testing and production facilities, wherever located, are subject to the same record keeping and inspection requirements. These requirements are necessary to ensure the integrity of the testing process, and the conformity of production vehicles and exhaust systems to the regulations. Tests which are not subject to such requirements cannot be considered reliable, nor can there be assurance that production facilities not subject to them are producing products that conform to the regulations. In addition, to fail to apply these requirements to facilities located overseas would discriminate unjustly against domestic manufacturers in favor of their foreign competition.

The regulations will apply even to facilities located in jurisdictions where foreign law forbids the kind of summary inspection they allow. Though it is well established that American courts will not order a person to disclose documents or other information located in a foreign jurisdiction that forbids such disclosure, the reason behind that rule is to avoid a conflict of laws, and is not applicable here. EPA will not attempt to make any inspections which it has been informed that local law forbids. However, if foreign law makes it impossible to do what is necessary to ensure the accuracy of data generated at a facility as to the conformity to design requirements of products produced at it, no informed judgment that a product complies with the regulations can properly be made. It is the responsibility of the manufacturer to locate his testing and production facilities in a jurisdiction where this situation will not arise.

11.11 Exemptions. The regulations will also outline the procedures by which EPA will administer the granting of exemptions from the prohibitions of the Act to various product manufacturers, pursuant to section 10(b). The substantive scope of the exemption provisions of sections 10(b)(1) and (2) are defined and procedures whereby exemptions may be requested are set forth. Exemptions will be granted for testing and national security reasons only. Export exemptions for vehicles and exhaust systems manufactured in the United States will be automatically effective, without request, upon the proper labeling of the products involved. Testing exemptions must be justified in writing by a sufficient demonstration of appropriateness, necessity, reasonableness, and control. Requests for national security exemptions must be endorsed by an agency of the Federal Government charged with the responsibility of national defense.

11.12 In-Use Compliance. In-use compliance provisions are included to ensure that degradation of emitted noise levels is minimized provided that the vehicles or exhaust systems are properly maintained and used.

These provisions include a requirement that the motorcycle manufacturer provide a noise emission warranty to purchasers (required by section 6(d) of the Noise Control Act), provide information to the Administrator which will assist in fully defining those acts which constitute tampering (under section 10(a)(2)(A) of the Act), and provide retail purchasers with instructions specifying the maintenance, use, and repair required to reasonably assure elimination or minimization of noise level degradation (authorized by section 6(c)(1) of the Act).

Under the warranty provisions, intended to implement 6(d)(1) of the Act, it is required that the motorcycle manufacturer warrant to the ultimate and subsequent purchasers that new motorcycles subject to these regulations are designed, built, and equipped so as to conform at the time of sale with the Federal noise control regulations. The manufacturer must furnish this time-of-sale warranty to the ultimate purchaser in a prescribed written form, which will be reviewed by EPA in order that the Agency can determine whether the manufacturer's warranty policy is consistent with the intent of the Act.

The tampering provisions require the manufacturer of the motorcycles to furnish a list of acts which may be done to motorcycles in use and which, if done, are likely to have a detrimental impact on noise emissions. The Administrator will then use this information to develop a final list of those acts which are presumed by EPA to constitute tampering. A statement of the Federal law on tampering, which will include the final list of acts which constitute tampering as determined by EPA, must be provided in written form to the ultimate purchaser.

The sections dealing with instruction for proper maintenance, use, and repair of the motorcycle are intended to ensure that purchasers know exactly what is required to minimize or eliminate degradation of the noise level of the motorcycle during its life. A record or log book also must be provided to the ultimate purchaser in order that the purchaser may record maintenance performed during the life of the product. The instructions may not contain language which tends to give the manufacturer or his dealers an unfair competitive advantage over the aftermarket. Finally, the regulations will provide for Agency review of instructions and related language.

The in-use provisions for motorcycle replacement exhaust system manufacturers are similar to the requirements for motorcycle manufacturers and require that the manufacturer provide a noise emission warranty to purchasers, a statement on tampering prohibitions and a warning statement on use of the product when it is not meeting the prescribed standard.

Under the warranty provisions, again intended to implement 6(d)(1) of the Act, it is required that the manufacturer warrant to the ultimate and subsequent purchasers that replacement exhaust systems subject to these regulations are designed, built, and equipped so as to conform at the time of sale with the Federal noise control regulations. The manufacturer must furnish this time-of-sale warranty to the ultimate purchaser in a prescribed written form.

The tampering provisions require the manufacturer to include a statement explaining to the ultimate purchaser what tampering is and what acts are likely to constitute tampering.

The warning statement which the manufacturer is required to provide to the ultimate purchaser is intended to warn purchasers that if the system has degraded significantly through use and is no longer meeting the standard, the owner may become subject to penalties under state and local ordinances. The warning statement, the statement on tampering prohibitions and the warranty must be submitted to the ultimate purchaser with the exhaust system inside any packaging in the format specified by EPA. If there is no packaging, the information shall be affixed to the exhaust system such that it will not be accidentally removed in shipping.

11.13 Acoustical Assurance Period (AAP) Compliance. The motorcycle and replacement exhaust system manufacturer must design their products so that the products will meet the noise standard for the period of time specified as the Acoustical Assurance Period beginning at the date of sale to an ultimate purchaser.

EPA does not specify what testing or analysis a manufacturer must conduct to determine that his vehicle or exhaust system will meet the standard during the Acoustical Assurance Period of these regulations. However, the regulations would require the manufacturers to make a determination regarding the expected degradation and maintain records of the test data and/or other information upon which the determination was based. This determination may be based on information such as tests of critical noise producing or abatement components, rates of noise control deterioration, engineering judgements based on previous experience, and physical durability characteristics of the product or product subcomponents.

The mechanism used in the regulations to express the amount of expected degradation, if any, is the sound level degradation factor (SLDF). The SLDF is the degradation (noise level increase in A-weighted decibels) which the manufacturer expects will occur on a configuration or category during the period of time specified as the AAP. The motorcycle manufacturer must determine an SLDF for each of his vehicle configurations. The replacement exhaust system manufacturer must determine an SLDF for each of his exhaust system categories (motorcycle/exhaust system combination). As previously explained it will not be necessary for the replacement exhaust system manufacturer to know the SLDF of the motorcycle as determined by the motorcycle manufacturer, in determining his own SLDF. The replacement exhaust system manufacturer is only concerned with the sound level increase that would occur on a particular motorcycle due to his own replacement exhaust system.

To ensure that the vehicles or exhaust systems will meet the noise standard throughout the AAP, they must emit a time of sale sound level less than or equal to the applicable new product noise emission standard minus the SLDF (exhaust system manufacturers who use the stationary test will not be required to take into account the SLDF). In no case shall this noise level exceed the Federal standard; i.e., a negative SLDF may not be used. Production verification and selective enforcement audit testing both embody this principle.

If the product's noise level is not expected to deteriorate during the AAP when properly used and maintained, the SLDF is zero. If a manufacturer determines that a vehicle configuration or exhaust system category will become quieter during the acoustical assurance period, the configuration or category must still meet the standard on the time of sale and an SLDF of zero must also be used for that configuation or category.

This strategy for determining whether a product complies for the AAP, should impose little, if any, additional cost on the manufacturers. In fact a basic assumption in our analysis has been that the noise level of a motorcycle which is properly used and maintained will not degrade, at least not any appreciable amount. With the exception of certain glass pack mufflers, it is also expected that the majority of replacement exhaust systems will not degrade significantly during the AAP.

EPA is not dictating that a product's noise level cannot deteriorate during its AAP, but rather merely requiring that it not deteriorate above the standard. It may be that most of the data required to determine an SLDF will already be in the hands of the manufacturer since this information is typically used for general product development work. In any event, EPA is not now proposing to require long term durability tests to be run as a matter of course.

11.14 Administrative orders. Section 11(d)(1) of the Act provides that: "Whenever any person is in violation of section 10 (a) of this Act, the Administrator may issue an order specifying such relief as he determines is necessary to protect the public health and welfare."

This provision grants the Administrator discretionary authority to issue remedial orders to supplement the criminal penalties of Section 11(a). The proposed regulations provide for orders to: (1) recall for failure of products to comply with regulations; (2) cease to distribute products not properly production verified; and (3) cease to distribute products for failure to test.

In addition, the regulations provide for cease to distribute orders for substantial infractions of regulations requiring entry to manufacturers' facilities and reasonable assistance. These provisions would not limit the Administrator's authority to issue orders, but give notice of cases where such orders would in his judgment be appropriate. In all such cases notice and opportunity for a hearing will be given.

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