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EPA 550/9-76-004

UNITED STATES · ENVIRONMENTAL PROTECTION AGENCY

NOISE EMISSION STANDARDS FOR CONSTRUCTION EQUIPMENT

BACKGROUND DOCUMENT FOR PORTABLE AIR COMPRESSORS

December 1975

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA 550/9-76-004	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Noise Emission Standards for Construction Equipment Background Document for Portable Air Compressors		5. REPORT DATE December 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Noise Abatement and Control U.S. Environmental Protection Agency Washington, D.C. 20460		10. PROGRAM ELEMENT NO 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This document contains the technical, economic, health and welfare analyses and other pertinent data and information utilized by the Environmental Protection Agency in the development of the final Portable Air Compressors Regulation.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
compliance costs, construction equipment, enforcement, exposed population, noise levels, portable air compressors, regulations		

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)* 20. SECURITY CLASS *(This page)*	21. NO. OF PAGES 238 22. PRICE

EPA Form 2220-1 (9-73)

EPA 550/9-76-004

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This document has been approved for general availability.
It does not constitute a standard, specification or regulation.

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Section 1

PROLOGUE

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 "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, control of which requires National uniformity of treatment." As part of this essential Federal action, Subsection 5(b)(1) requires that the Administrator of the U. S. Environmental Protection Agency, after consultation with the appropriate Federal agencies, publish a report or series of reports "identifying products (or classes of products) which in his judgment are major sources of noise." Section 6 of the Act requires the Administrator 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 construction equipment is one. Pursuant to Subsection 5(b)(1), the Administrator has published a report identifying portable air compressors as a major source of noise.

PREEMPTION

Section 6(e)(1) of the Noise Control Act states that after the effective date of a Federal regulation "no State or political subdivision thereof may adopt or enforce...any law or regulation which sets a limit on noise emissions from such new product and which is not identical to such regulation of the Administrator." Section 6(e)(2), however, states that "nothing in this section precludes or denies the right of any State or political subdivision thereof to establish and enforce controls on environmental noise (on one or more sources thereof) through the licensing, regulation, or restriction of use, operation or movement of any product or combination of products." The central point to be developed here is the distinction between noise emission standards on products, which may be preempted by Federal regulations, and standards on the use, operation, or movement of products, which are reserved to the states and localities by Section 6(e)(2).

Section 6(e)(1) forbids state and local municipalities from controlling noise from products through laws or regulations that prohibit the sale (or offering for sale) of new products for which different Federal noise emission standards have already been promulgated. States and localities may augment the enforcement duties of the EPA by enacting a regulation identical to the Federal regulation, since such action on the state or local level would assist in accomplishing the purposes of the Act. Further, state and local municipalities may regulate noise emissions for all new products that were manufactured before the effective date of the Federal regulation(s).

Section 6(e)(2) explicitly reserves to the states and their political subdivisions a much broader authority: the right to "establish and enforce controls on environmental noise (on one or more sources thereof) through the licensing, regulation or restriction of the use, operation, or movement of any product or combination of products." Environmental noise is defined as the "intensity, duration, and character of sounds from all sources" (Section 2[11]). Limits may be proposed on the total character and intensity of sounds that may be emitted from all noise sources, "products and combinations of products".

State and local governments may regulate community noise levels more effectively and equitably than the Federal government due to their perspective on and knowledge of state and local situations. The Federal Government may assume the duties involved in regulating products distributed nationwide because it is required and equipped to do so. Congress divided the noise emission regulation power in this manner to allow each level of government to fulfill that function for which it is best suited. Through the coordination of these divided powers, a comprehensive regulatory program can be effectively designed and enforced.

One example of the type of regulation left open to the localities is the property line regulation. This type of regulation would limit the level of environmental noise reaching the boundary of a particular piece of property. Noise emitters would be free, insofar as state regulations are concerned, to use any products whatsoever, as long as they are used or operated in such a fashion so as not to emit noise in excess of the state-specified limits. This type of regulation may be applied to many different types of properties, ranging from residential lots to construction sites.

In such a case, state and local regulation of air compressors may take the form of, but would not be limited to, the following examples:

- Quantitative limits on environmental noise received in specific land use zones, as in a quantitative noise ordinance.

- Nuisance laws amounting to operation or use restrictions.

- Regulations limiting the amount of environmental noise at the boundary of the construction site.

- Other similar regulations within the powers reserved to the states and localities by Section 6(e)(2).

In this manner, local areas may balance the issues involved to arrive at a satisfactory environmental noise regulation(s) that protect the public health and welfare as much as deemed possible.

LABELING

The enforcement strategies outlined in Section 2 of this document will be accompanied by the requirement for labeling products distributed in commerce. The label will provide notice to a buyer that a product is sold in conformity with applicable regulations. A label will also make the buyer and user aware that the air compressor possesses noise attenuation devices and that such items should not be removed or rendered inoperative. The label may also indicate the associated liability for such removal or tampering.

IMPORTS

The determination of whether individual new products comply with the Federal regulation will be made by the U.S. Treasury Department (Customs), based on ground rules established through consultation with the Secretary of the Treasury.

It is anticipated that enforcement of the actual noise standard by the use of a standard test procedure would be too cumbersome for Customs to handle, especially in view of the tremendous bulk of merchandise they must pass on each day. A case in point occurs with imported automobiles, in which Customs inspectors presently assess compliance with requirements of the Clean Air Act solely on the basis of the presence or absence of a label in the engine compartment. A similar mechanism (labeling) appears viable for use to assess compliance of portable air compressors with the proposed regulations.

Section 2

RATIONALE FOR REGULATION OF THE PORTABLE AIR COMPRESSOR

To develop an EPA criterion for identifying products as major sources of noise, first priority was given to those products that contribute most to overall community noise exposure. Community noise exposure is defined as that exposure experienced by the community as a whole as the result of the operation of a product or group of products, as opposed to that exposure experienced by the user(s) of the product(s).

In this section, it is shown that while portable air compressors may not produce the highest sound level at construction sites, they do contribute significantly to community noise exposure, thus justifying their regulation. Air compressors rank with dump trucks and concrete trucks in producing the highest sound energy per day.

In terms of assessment, community noise exposure was evaluated in terms of the day/night equivalent sound level (L_{dn}) [1] that was developed especially as a measure of community noise exposure. Since L_{dn} is an equivalent energy measure, it can be used to describe the noise in areas in which noise sources operate continuously or intermittently but are present enough of the time to emit a great deal of sound energy in a 24-hour period.

Studies have been made of the number of people exposed to various levels of community noise [2, 3]. Table 2-1 summarizes the estimated number of people in residential areas subjected to urban traffic noise, aircraft noise, construction site noise, and freeway traffic noise at or above an outdoor L_{dn} of 60, 65, and 70 dB, respectively.

EPA has identified an outdoor L_{dn} of 55 dB [1] as the day/night equivalent sound level requisite* to protect the public from long-term adverse health and welfare effects in residential areas. Table 2-1 indicates that it will be necessary to quiet the major sources contributing to urban traffic noise, construction site noise, freeway traffic noise, and aircraft noise if this level is to be achieved.

* With an adequate margin of safety and without consideration of the cost and technology involved to achieve an L_{dn} of 55 dB.

Table 2-1

ESTIMATED NUMBER (in Millions) OF PEOPLE IN RESIDENTIAL AREAS SUBJECTED TO DIFFERENT KINDS AND LEVELS OF OUTDOOR NOISE(12)

Outdoor Ldn Level	Urban Traffic Noise	Aircraft Noise	Construction Site Noise	Freeway Noise
70 dB+	4-12	4-7	1-3	1-4
65 dB+	15-33	8-15	3-6	2-5
60 dB+	40-70	16-32	7-15	3-6

IDENTIFICATION OF MAJOR SOURCES

Section 6(a)(1)(C) of the Noise Control Act specifies four possible categories of products that may be regulated by the Administrator:

1. Construction equipment.
2. Transportation equipment (including recreational vehicles and related .quipment).
3. Any motor or engine (including any equipment of which an engine an integral part).
4. Electrical or electronic equipment.

Pursuant to Section 3(3)(A) aircraft are excluded as products under Section 6 of the Act. Aircraft noise regulations will be proposed to the FAA as delineated in Section 7 of the Act. Medium- and heavy-duty trucks contribute the most sound energy to the environment of any highway vehicle and, as such, have been identified for regulation as major noise sources. Consequently, in view of the foregoing and data contained in Table 2-1, attention is focused on construction site noise.

CONSTRUCTION EQUIPMENT

The sound level of a product and the level of background noise determine the intrusiveness of a product's sound emission, which has been shown to determine annoyance in some situations. Table 2-2 indicates that pile drivers and rock drills are perceived as the loudest pieces of construction equipment, but sound energy measurements indicate that these products do not contribute as much sound energy to the environment as other products operating on construction sites. The fact that dump trucks, portable air compressors, and concrete mixers (trucks) produce sound levels equal to or lower than other construction equipment and yet produce higher total sound energy emissions means that these are the most widely used pieces of construction equipment.

Table 2-2

TYPICAL CONSTRUCTION SITE EQUIPMENT SOUND LEVELS (in dBA)
AND ASSOCIATED SOUND ENERGY (in KW-hrs/day)

Construction Equipment	Typical Sound Level at 50 Feet	Estimated Total Sound Energy
1. Dump truck	88	296
2. Portable air compressors	81	147
3. Concrete mixer (Truck)	85	111
4. Paving Breaker	88	84
5. Scraper	88	79
6. Dozer	87	78
7. Paver	89	75
8. Generator	76	65
9. Pile driver	101	62
10. Rock drill	98	53
11. Pump	76	47
12. Pneumatic tools	85	36
13. Backhoe	85	33

A control technology report [14] on dump trucks and concrete mixers indicates that their contribution to construction site noise is largely engine-related noise that will be controlled when these trucks meet the standards proposed for medium- and heavy-duty trucks. This leaves portable air compressors as the major source of sound energy and the most widely-used product among pieces of equipment contributing to construction site noise. This is further confirmed by the data contained in Tables 2-3 and 2-4, which show that portable air compressors contribute significantly to construction site noise.

Table 2-3 shows the contribution to construction site noise by individual pieces of construction equipment, while Table 2-4 shows the ranking of the portable air compressor noise contribution to construction site noise. As shown by the tables, the portable air compressor ranks high on the list of contributors to construction site noise.

Table 2-3

CONTRIBUTION TO CONSTRUCTION SITE NOISE BY INDIVIDUAL PIECES OF CONSTRUCTION EQUIPMENT

Construction Equipment	Percent Contribution* to Construction Site Noise			
	Residential	Public Works	Industrial	Nonresidential
Backhoe	5.6	2.2	7.1	3.5
Dozer	10.0	6.8	8.9	4.8
Grader	2.0	1.9	0.3	0.2
Loader	6.3	3.0	4.4	2.5
Paver	2.5	10.8	1.7	0.8
Roller	0.5	1.7	0.2	-
Scraper	3.1	4.8	1.7	1.5
Shovel	2.2	1.0	2.5	1.2
Truck	6.3	21.5	11.3	7.7
Concrete mixer	28.1	10.0	8.9	6.1
Concrete pump	- **	-	2.1	2.2
Crane, derrick	-	1.9	1.6	3.1
Crane, mobile	5.6	0.7	1.0	1.9
Air compressor	4.6	6.1	10.0	16.9
Generator	1.8	2.5	1.1	2.5
Pump	1.3	2.7	-	3.5
Paving hammer	0.8	8.5	5.1	2.5
Pile driver	-	-	20.6	24.6
Pneumatic tool	11.3	1.4	6.3	3.1
Rock drill	2.2	13.8	5.1	4.8
Concrete vibrator	4.4	-	0.6	0.4
Saw	-	0.2	0.9	3.1

* On an energy bases

** A dash (-) indicates the equipment is not primarily used at the type of site cited or the percent contribution is less than 0.1 percent.

Table 2-4

CONTRIBUTION OF PORTABLE AIR COMPRESSOR NOISE TO CONSTRUCTION SITE NOISE

Site	% Contribution to the Construction Site Noise by the Portable Air Compressor*	Rank at Site**
Residential	4.6	7th
Public Works	6.1	7th
Industrial	10.0	3rd
Nonresidential	16.9	2nd

* On an energy basis.

** On an energy basis relative to 20 typical pieces of equipment employed at construction sites.

Section 3

BACKGROUND INFORMATION

This section summarizes the background information accrued by the Environmental Protection Agency's Office of Noise Abatement and Control relevant to the noise emission regulation for portable air compressors. The requisite regulation is to protect the health and welfare of the American public, taking into account the degree of noise reduction achievable through the application of best available technology and the cost of compliance.

The information has been derived from numerous sources. The EPA contracted with Bolt, Beranek and Newman (BBN), an acoustical consulting firm, and A. T. Kearney, Management Consultants, and has utilized the data gathering and information collecting capabilities of Informatics, Inc. The EPA has also developed an interagency agreement with the National Bureau of Standards (NBS) for technical assistance. BBN provided cost and technology support [5, 6, 7]; A. T. Kearney Management Consultants provided economic analysis support [8]; Informatics, Inc. submitted reports addressing domestic and foreign regulations relating to construction equipment and portable air compressors [9, 10]; and NBS provided technical support in the development of methodology to test and measure portable air compressors [11].

The EPA and contractor personnel made several visits to compressor manufacturers, distributors, and users to obtain the most accurate information available for use in the development of the proposed portable air compressor regulations. NBS personnel held two meetings with industry technical experts to discuss and exchange information on measurement methodology.

The EPA published a Notice of Proposed Rulemaking for Portable Air Compressors on October 29, 1974 (39 FR 38186). The docket, which afforded the public an opportunity to comment on the proposed regulation, closed on December 30, 1974. Additionally, two public hearings were held regarding the proposed rulemaking. Public notice was provided on January 22, 1975 (40 FR 3466) and hearings were held on February 18, 1975, in Arlington, Va., and on February 25, 1975, in San Francisco, Calif. The following is a list of individuals and organizations submitting comments to the various dockets. A summary of the comments received and responses, thereto, is presented in Appendix A.

Portable Air Compressor NPRM Docket

Richard Giner	Compressed Air & Gas Institute
W. S. Price	Worthington Compressor
John Y. Richards	Joy Manufacturing
E. A. Long	Chicago Pneumatic Equipment Division
J. M. Ombrello	LeRoi Division, Dresser Industries
Gerald H. Shaff	Walker Manufacturing Company
J. J. McNally	Caterpillar Tractor Company
D. E. Kipley	Gardner-Denver Company
Bruce J. Smith	Bucyrus-Erie
H. T. Larmore	Construction Industry Manufacturers Assn.
Robert A. Heath	Walker Manufacturing
W. J. Cowan	Barber-Greene Company
C. M. Copeland	P. K. Lindsay Company
Richard Ostwald	Smith Air Compressors
William W. Lang	Institute of Noise Control Engineering
Lawrence H. Hodges	J. I. Case
R. D. Harlow	Schramm, Inc.
Mary Ann Zimmerman	Cummins Engine
Dr. Robert W. Young	Acoustical Society of America
N. J. E. Hartwell	Perkins Engines Company
R. W. Wiedow	Northern Illinois Gas Company
Walter L. Black	Clark Equipment Company
M. E. Rumbaugh, Jr.	Schwitzer Engineered Components
George J. Stradtner	Grimmer-Schmidt Corp.
Hugh I. Myers, Jr.	Citizen
Thomas F. Scanlan	Grossmont College
Robert F. Hand	Clark Equipment
A. J. Cox	Construction Industry Manufacturers Assn.
	American Road Builders' Association
	Caterpillar Tractor Company
Don L. Kerstetter	Penna. Dept. of Environmental Resources
F. A. DelleCave	Ingersoll-Rand
Joseph O'Neill	Quincy Compressor (Colt Industries)
Charles Stewart	Machinery and Allied Products Institute

Portable Air Compressor Hearings – Arlington, Va.

Richard Gimer accompanied by:	Compressed Air & Gas Institute
George Diehl	Ingersoll Rand
Robert Harlow	Schramm, Inc.
Richard Ostwald	Gordon Smith and Company
Bill Heckenkamp	Gardner-Denver Company
William Price	Worthington Compressors, Inc.
Richard Geney	Atlas Copco, Inc.
John Richards	Joy Manufacturing
Lawrence H. Hodges	J. I. Case Company
Max E. Rumbaugh, Jr.	Schwitzer Engineered Components
Andrew Kauders	General Services Administration
David Staples	District of Columbia
Don Gallay	City of Chicago
John A. Hilcken	Arlington County, Virginia
Robert Hand	Clark Equipment Company

Portable Air Compressor Hearings – San Francisco, Calif.

John McNally	Caterpillar Tractor Company
Robert Levy	City of San Francisco
Dr. Donna Dickman	Washington Hearing and Speech Society
H. T. Larmore	Construction Industry Manufacturers Assn.
Alvin Greenwald	Citizen
John W. Ross	City and County of San Francisco
Robert L. Greivell	Koehring Company
Vincent Salmon	Industrial Services, Inc.
J. A. Mills	Industrial Services, Inc.
Richard Anderson	General Acoustics
Paul Laesch	Sullair Corporation

Section 4

THE INDUSTRY AND THE PRODUCT

GENERAL DESCRIPTION

Noise associated with construction has become a major problem in many cities and towns. The trend toward urban renewal and more high-rise structures has created an almost perpetual din in city streets. Equipment associated with construction activities has become more numerous, and the time span for construction at a given site has lengthened. Residents in proximity to a high-rise construction site may well plan on 2 years of elevated noise levels as the structure is built.

The basic unit of construction activity is the construction site, which exists in both space and time. The temporal dimension consists of various sequential phases that change the character of the site's noise output as work progresses. These phases are discussed further subsequently. In the case of building construction, the spatial character of the site is self-evident.

Construction sites are typically classified in the 15 categories in which construction data is reported by the U.S. Bureau of the Census and various state and municipal bodies. The categories are:

- Residential buildings:

  One to four family
  Five family and larger

- Nonresidential buildings:

  Office, bank, professional
  Hotel, motel, etc.
  Hospitals and other institutions
  Schools
  Public works buildings
  Industrial
  Parking garages

Religious
Recreational
Store, mercantile
Service, repair station

- Municipal streets

- Public works (e.g., sewers, water mains)

For purposes of allocating construction effort among the different types of sites, it is possible to group the nonresidential sites into four larger categories differentiated by the cost of the average building in each category, as well as by the distribution of effort among the various construction phases. These four groups, in order of decreasing average cost per building, are [2]:

- Office buildings, hospitals, hotels

- Schools, public works buildings

- Industrial buildings, parking garages

- Stores, service stations, recreational buildings, and religious buildings

Construction is carried out in several reasonably discrete steps, each of which has its own mix of equipment and, consequently, its own noise characteristics. The phases (some of which can be subdivided) are:

- Building construction

1. a. Clearing

   b. Demolition

   c. Site preparation

2. Excavation

3. Placing foundations

4. a. Frame erection

   b. Floors and roof

   c. Skin and windows

5. a. Finishing

   b. Cleanup

- City streets

  1. Clearing

  2. Removing old roadbed

  3. Reconditioning old roadbed

  4. Laying new subbase, paving

  5. Finishing and cleanup

- Public works

  1. Clearing

  2. Excavation

  3. Compacting trench floor

  4. Pipe installation, filling trench

  5. Finishing and cleanup

The most prevalent noise source in construction equipment is the prime mover, e.g., the internal combustion engine (usually of the diesel type) used to provide motive and operating power. Engine powered equipment may be categorized according to its mobility and operating characteristics, as:

- Earthmoving equipment (highly mobile).
- Handling equipment (partly mobile).
- Stationary equipment (The air compressor is in the latter category).

Typical average noise levels [2] at construction site boundaries are shown in Table 4-1 for each phase of construction activity.

It may be generally agreed that construction site noise can be alleviated by reducing the noise levels of individual pieces of equipment employed within the site [2, 3]. Other methods also exist that, by themselves or in combination, may be used to control construction site noise. For example:

- Replacing individual operations and techniques by less noisy ones.
- Selecting the quietest of alternate operations to keep average noise levels low.
- Locating noisy equipment away from site boundaries, particularly near noise sensitive land use areas.
- Providing enclosures for stationary items of equipment and barriers around particularly noisy areas on the site.

Table 4-1

TYPICAL AVERAGE NOISE LEVEL, dBA, AT CONSTRUCTION SITE BOUNDARIES(2)

Phases of Construction	Domestic Housing	Office Building Hotel, Hospital School, Public Work	Industrial Recreation, Store, Service Station	Highways Roads, Sewers, Trenches
Ground clearing	83	84	84	84
Excavation	88	89	89	88
Foundation	81	78	77	88
Erections	81	87	84	79
Finishing	88	89	89	84

There is no doubt that the construction industry can take steps to reduce its noise through equipment selectivity or operational procedure noise control schemes. However, regulations are needed to assure that the basic steps are taken uniformly by all components of the industry.

THE INDUSTRY

The portable air compressor industry is a mature and highly competitive industry. Manufacturers of portable air compressors vary significantly in size, financial strength, manufacturing capability, applied technology, marketing ability, and extent of product diversification. Seventeen manufacturers, currently active in the domestic market, have been identified. Two manufacturers import components and assemble units in the United States, and one imports completely assembled units. Sales in 1974 of $150 million resulted from shipments of more than 16,000 units. Table 4-2 presents a listing of manufacturers and an estimated dollar value of their portable air compressor sales. Eight manufacturers have over 90 percent of the market.

Nine of the 17 manufacturers are divisions or subsidiaries of large corporations with assets in excess of $100 million. These are: Atlas Copco (importer), Chicago Pneumatic, Davey, Gardner-Denver, Ingersoll-Rand, Joy, Le Roi, Quincy and Worthington. Sales of these corporations (parent company) in 1972 ranged from $182 million to $906 million. These corporations are not highly specialized in the construction equipment industry [8], but are extensively diversified, producing a wide variety of products sold in other industries.

Three medium-sized manufacturers have assets ranging from $10 million to $30 million. These are Jaeger, Schramm, and Sullair. Sales of these corporations in 1974 ranged from $10 million to $40 million. Five manufacturers are small companies with assets ranging from $0.5 million to $3.0 million. They are American Jenback (importer), Grimmer-Schmidt, Kent Air Tool, Lindsay, and Gordon Smith [8]. The medium and small-sized manufacturers typically specialize in portable and stationary compressors and a few other products sold primarily outside the construction equipment market.

Portable air compressor manufacturing facilities are concentrated in the northeast and north-central United States. Plants vary considerably in terms of size, efficiency, technology, and employment. Detailed plant location, employment and factory production information is presented in Reference 8. While some firms have efficient plants utilizing the most up-to-date technology, others have old, extremely inefficient plants utilizing technology and

Table 4-2

ESTIMATED SALES OF PORTABLE AIR COMPRESSORS
BY MAJOR MANUFACTURERS, 1974

Manufacturer	Millions of Dollars
American Jenback	0.5 - 2.0
Atlas Copco	1.0 - 3.0
Chicago Pneumatic	6.0 - 8.0
Davey	0.5 - 2.0
Gardner-Denver	16.0 - 18.0
Grimmer-Schmidt	0.5 - 2.0
Ingersoll-Rand	37.0 - 42.0
Jaeger	5.0 - 6.0
Joy	19.0 - 23.0
Kent Air Tool	1.0 - 2.0
Le Roi	10.0 - 12.0
Lindsey	1.8 - 2.0
Quincy	3.0 - 4.0
Schramm	2.5 - 4.5
Gordon Smith	4.0 - 5.5
Sullair	23.0 - 25.0
Worthington	9.0 - 11.0

production methods that are nearly obsolete. Generally, the larger manufacturers have the more efficient plants.

Most manufacturers utilize only one plant for the production of portable air compressors. Generally, these plants are also used for the production of related products, including stationary air compressors. However, each product is typically manufactured on a separate production line or in a separate area.

Approximately 9,000 people are employed in plants that manufacture portable air compressors. The exact employment attributable to the production of portable air compressors is considered confidential. It has been estimated that the total portable air compressor production employment is in the range of 2,000 to 3,000 employees.

The portable air compressor industry generally operates between 65 and 75 percent capacity. However, during 1973 the industry operated in excess of 85 percent of capacity. The industry has been constrained from further expansion by the difficulty in obtaining deliveries of engines and other components.

Manufacturers obtain raw materials and components from interdivisional transfers, component suppliers, and raw material suppliers. The finished product is distributed through construction equipment distributors (dealers) who sell or lease the product to the primary end users (such as the construction and mining industries), other industries, and government agencies. Table 4-3 indicates the estimated distribution of unit shipments by end-use market during the years 1967 through 1974 [8].

Table 4-3

ESTIMATED PERCENTAGE OF
TOTAL PORTABLE AIR COMPRESSOR UNIT
SHIPMENTS BY END USE MARKET, 1967-1974

End Use Market	Percentage of Units Shipped
Construction industry	
Public works and other non-building construction	50
Commercial, institutional and industrial building construction	20
Mining industry	8
Industrial users	7
Government agencies	12
Other users.	3
Total	100

The single largest user of portable air compressors is the construction industry, which currently accounts for an estimated 70 percent of total units shipped. Government agencies account for about 15 percent of the units, followed by mining and industrial users, sharing another 15 percent of total shipments.

Channels of distribution traditionally are through independent, authorized distributors and factory-owned distributors or branches. In excess of 50 percent of manufacturer shipments of new portable compressors reach the end user via rental/purchase agreements. Intermittent use requirements result in a large rental market. The trend to increased rental of compressors is expected to continue. Used equipment is also an important factor in the portable air compressor market.

From 6 to 13 percent of total annual shipments are exported each year, imports have been a minor factor in the market (less than 7 percent of the 1972 unit volume).

Most manufacturers currently offer quieted portable air compressors due to customer demand resulting from OSHA and local noise regulations. Domestic shipments of quieted units vary by compressor capacity and power source type, as shown in Table 4-4.

Table 4-4

ESTIMATED SHIPMENTS OF QUIETED PORTABLE AIR COMPRESSORS AS A PERCENT OF TOTAL UNIT SHIPMENTS BY MARKET SEGMENT

Power Source Type	Air Flow Capacity Range (CFM)	Estimated Percent of Total Shipments
Gasoline engine	75-124	20
	124-250	20
Diesel engine	124-249	20
	249-599	20
	600-899	10
	900 and over	10

THE PRODUCT

Portable air compressors are designed mainly to power pneumatic tools and equipment at a construction job site. Primary applications include the generation of air power for:

- Operating hand tools
- Tunneling operations
- Mixing and atomizing to shoot fine particle material into place

- Pneumatic conveying of small particle material
- Air-operated centrifugal pumps
- Air-powered hoist drums or brakes
- Snow production.

Compressors generally are rated according to maximum flow rate at a pressure of 100 pounds per square inch (psi) (although some firms have units rated up to 150 psi). Portable air compressors used at construction sites generally range in flow capacity from a low of 75 cfm to a high well in excess of 2000 cfm.

Almost all large units are diesel-engine driven, screw-type compressors. The intermediate sized units are diesel and gasoline-engine driven, screw and rotary type compressors, while the smaller types are primarily gasoline-engine driven, screw, rotary, and reciprocating type compressors.

The portable compressors of interest are designed to be towed as trailers on two or four rubber-tired wheels. They have weights ranging from 1 to 14 tons, lengths ranging from 5 to 19 feet, and heights ranging from a little less than 6 feet to almost 10 feet. Mounted on the trailer are the compressor, an air receiver, the driving engine, cooling system, fuel tanks, tool boxes, and an enclosure. The enclosure itself, when designed for noise insulation, can comprise as much as 10 percent of the total weight.

The most widely manufactured compressor in the United States today is the rotary screw-type unit. The screw type compressor is a single-stage unit that provides a high flow-rate-to-size ratio and offers high reliability due to its few moving parts. An engine occupying 5 to 15 times the volume occupied by the basic compressor is needed along with the accompanying cooling and exhaust system to drive the compressor. In most cases, the engine is directly coupled to the male screw element, which then drives the female element.

The basic screw-type compressor unit accounts for only a small fraction of the weight and size of an operating portable compressor. Typically, rotary screw units used in portable compressors are smaller in size than an automobile automatic transmission. Likewise, the compressor mechanism itself produces little of the noise generated during operations.

Most U.S. manufacturers are phasing out their line of sliding-vane rotary compressors, probably because they are reputed to require more maintenance and are less economical to operate than other types. Nevertheless, there are still several portable compressor sets of this type on the market. As in the case of the screw-type compressors, the compressor itself is relatively small, but the necessary concomitant equipment is substantial. Sometimes the compressor is mounted in the receiving tank to save space.

The traditional reciprocating compressor is used today almost exclusively in portable compressors delivering less than 250 cfm. Unlike the screw and rotary-vane types, it usually requires several stages to achieve the required pressure. Consequently, the basic unit is a larger fraction of the total weight and size of the complete compressor assembly.

Rotary-screw manufacturers tend to compete by specializing in one or two types of portable air compressors in each market segment. Table 4-5 summarizes the types of compressors offered by each portable air compressor manufacturer.

Table 4-5

TYPE OF COMPRESSOR OFFERED BY MANUFACTURER

Manufacturer	Rotary Screw	Reciprocating	Rotary Vane
American Jenback	x	x	
Atlas Copco	x	x	
Chicago Pneumatic	x		x
Davey Compressor			x
Gardner Denver	x		
Grimmer Schmidt		x	
Ingersoll-Rand	x		x
Jaeger	x		x
Joy Manufacturing	x		x
Kent Air Tool			x
Le Roi	x		x
Lindsay		x	
Quincy	x		
Schramm		x	
Gordon Smith		x	
Sullair	x		
Worthington	x		x

The basic units used to gauge productive capacity and performance of portable compressors are the engine type (diesel or gasoline) and air flow rating in cfm at 100 psi.

Thirteen manufacturers, shown in Table 4-6, offer a complete line of portable air compressor capacity while the remaining four offer only the smaller capacity units.

Table 4-6

PORTABLE AIR COMPRESSOR CAPACITIES IN cfm
OFFERED BY MANUFACTURERS

Manufacturer	Gasoline Engine		Diesel Engine			
	75-124	125-250	125-249	250-599	600-899	900 & over
American Jenback			X			
Atlas Copco	X		X	X	X	X
Chicago Pneumatic	X	X	X	X	X	X
Davey Compressor	X	X	X	X	X	
Gardner-Denver	X	X	X	X	X	X
Grimmer-Schmidt	X	X	X	X	X	
Ingersoll-Rand	X	X	X	X	X	X
Jaeger	X	X	X	X	X	X
Joy Manufacturing	X	X	X	X	X	X
Kent Air Tool	X	X	X			
Le Roi	X	X	X	X	X	X
Lindsay	X	X	X			
Quincy		X	X	X	X	X
Schramm	X		X	X	X	
Gordon Smith	X					
Sullair	X	X	X	X	X	X
Worthington	X	X	X	X	X	X

Section 5

EXISTING LOCAL, STATE, AND FOREIGN NOISE REGULATIONS

According to Section 6 of the Noise Control Act of 1972, the proposed Federal regulations for new portable air compressors will preempt new product standards for compressors at the local and state level* unless those standards are identical to the Federal standard. Further, according to Section 9 of the Act, regulations will be issued to carry out the provisions of the Act with respect to new products imported or offered for importation.

EPA reviewed available literature and conducted a survey to determine the number of existing regulations that are applicable to construction equipment and portable air compressors and that may be affected by proposed Federal regulations. In the following subsections, the findings of the review are summarized.

LOCAL AND STATE REGULATIONS

Information on state and local construction noise regulations was obtained from 123 cities with populations in excess of 100,000 and from 226 cities with populations of less than 100,000. In addition, information was received from 46 of the 50 states surveyed [9].

As indicated by Table 5-1, 27 of the 123 cities with a population in excess of 100,000 and 21 of the 226 cities with a population less than 100,000 have some form of a construction regulation at this time. Of the 43 cities with some form of construction equipment regulation, 36 have operational limits and 7 have new product standards as shown by Table 5-2.

Of the 46 states that replied to the survey, 4 had specific regulations for the noise of construction equipment. Colorado, Indiana, New York, and Alaska have performance standards, while Indiana has new product standards currently in force.

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*Local and state governments are not prohibited from "establishing or enforcing controls on environmental noise through licensing, regulation or restriction of the use, operation or movement of any product" or from establishing or enforcing new product noise standards for types of construction equipment not regulated by the Federal Government.

Table 5-1

TYPE OF LOCAL NOISE ORDINANCES FOR CONSTRUCTION FOR SELECTED POPULATIONS

Population	No Specific Law	Nuisance Law	Ordinance Under Development	Performance Standards	Total
Over 100,000	54	37	5	27	123
Under 100,000	157	48	0	21	226
TOTAL	211	85	5	48	349

Table 5-2

TYPE OF LOCAL NOISE PERFORMANCE STANDARDS FOR CONSTRUCTION

Population	Operational Limits	New Product Standards
Over 100,000	18	5
Under 100,000	18	2
TOTAL	36	7

Since the Federal portable air compressor regulation will preempt existing or contemplated local and state portable air compressor regulations, cities and states that will be affected have been identified. Figure 5-1 shows that seven cities (and no states) have new construction equipment noise standards. Also shown is that Grand Rapids, Mich., and New York City, N.Y., have the most stringent standard along with the shortest time period for compliance.

These seven regulations then, in part, will be preempted by the new Federal law on portable air compressors. The new Federal law will preempt these jurisdictions only from promulgating or enforcing a new product standard for portable air compressors. It will not prohibit them from enforcing laws against other types of construction equipment and will not prohibit them from establishing or licensing operational limits for portable air compressors.

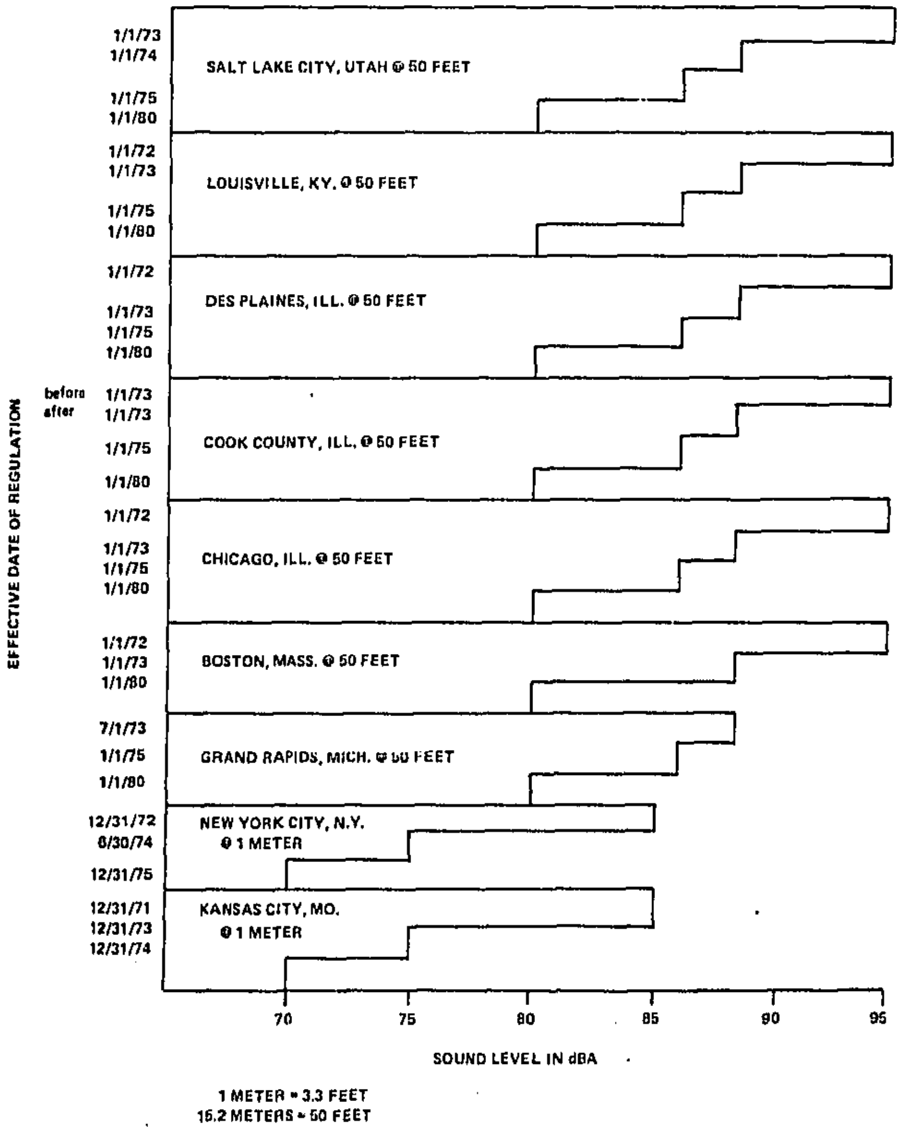


Figure 5-1. New Product Noise Standards for Construction Equipment

FOREIGN REGULATIONS

Over 300 inquiries were sent to foreign manufacturers of portable air compressors and representatives of foreign nations who were knowledgeable in the field of environmental noise [10]. These inquiries solicited information and comments in the following five areas.

1. The technology available to reduce the noise of portable air compressors and noise level data for existing models of air compressors.

2. Legislation setting limits on the noise level of construction equipment, especially portable air compressors.

3. The effects of government regulations on the cost of producing or marketing portable air compressors that must be quieted.

4. Specifications for the noise levels produced by portable air compressors used in government contracts.

5. Standards for measuring the noise level of air compressors.

Although information in areas other than regulations was requested, in most instances the individuals and countries responding did not address anything but the applicable regulations on construction equipment.

Generally, it was found that foreign countries have regulations that deal specifically with construction noise in the following ways:

- Standards of recommended practice such as the Guidelines for Noise issued by the National Federation of Building Trades Employers and the Ministry of Public Works in the United Kingdom.

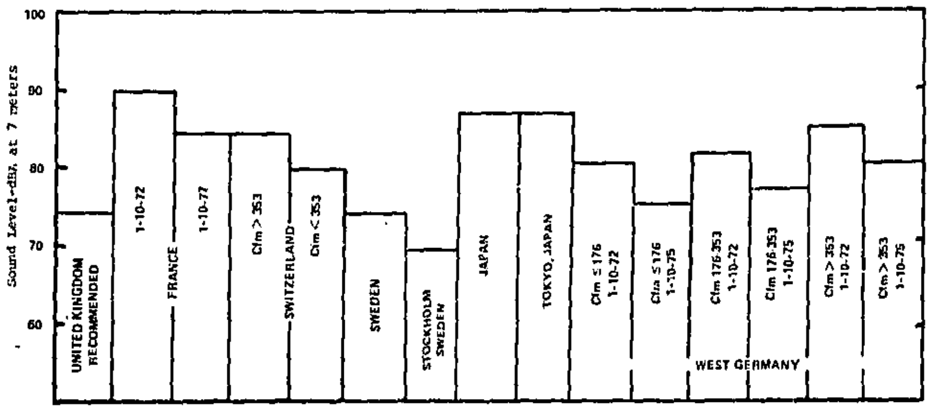
- Contract specifications between buyer and builder such as those in Norway or New South Wales, Australia.

- General nuisance laws such as those in the various municipalities in Canada and Paris, France.

- Regulation of the noise level in various land use areas. These laws frequently differentiate between daytime and nighttime levels. Examples include Oslo, Norway; Zurich, Switzerland; Sweden; and Vienna, Austria.

- Regulation of the noise emission level of specific types of equipment, such as portable air compressors.

The levels specified by the cities and nations regulating portable air compressor noise are summarized in Figure 5-2.



NOTES: (1) Some data corrected to 7 meters
(2) Some data corrected for sound level
(3) Levels are for any air flow currently available unless otherwise stated

Figure 5-2. Foreign Compressor Noise Regulations

Section 6

MEASUREMENT METHODOLOGY

MEASUREMENT STANDARDS

Numerous recommended practices, standards, and regulations for noise measurement have been proposed by national and international organizations [13] to standardize the measurement methodology used by industry, consumers, and government regulatory bodies. The Society of Automotive Engineers (SAE) has published recommended practices and standards or draft documents that standardize the noise measurement methods for construction equipment and construction sites [14, 15]. The American National Standards Institute (ANSI) for the United States and the International Standards Organization (ISO) have developed, through their member groups, numerous noise measurement standards. Of particular interest to the portable air compressor manufacturers is the Compressed Air and Gas Institute (CAGI) test code for measurement of sound from pneumatic equipment [16]. This standard has been accepted for promulgation by ISO as ISO2151-1972 and by ANSI as ANSI S5.1-1971. One section is specifically devoted to portable air compressors and is widely used by portable air compressor manufacturers to describe the sound pressure level of their products.

With consideration given to the possible use of sound power or sound power level to describe portable air compressor noise, methods suitable for this type of description have been investigated. Two methods investigated were:

1. The 10 point hemispherical method of Reference 17.

2. The National Bureau of Standards far and near field method of Reference 11.

In both methods, sound pressure levels are measured and sound power or sound power level is computed. Further description of the sound pressure level and the sound power/sound power level methods follows.

CAGI METHOD – SOUND PRESSURE LEVEL

Octave-band sound pressure levels from 63 to 8000 Hz and A-weighted sound levels are obtained during idle and fullpower conditions at 10 locations around the compressor. The locations are shown in Figure 6-1.

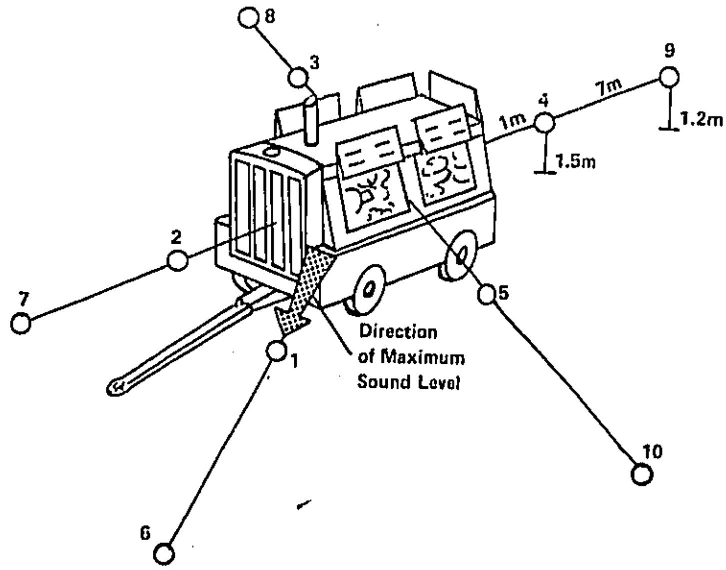


Figure 6-1. CAGI/PNEUROP Method Microphone Locations

Octave-band data are used to show the characteristics of portable air compressor noise at the microphone location at which the highest sound level was recorded.

A-weighted sound levels are used to calculate the average sound level at the 1- and 7-meter microphone locations. The average level is calculated by one of the following three methods:

1. *Maximum Variation of 5 dB or Less.* If the maximum variation in corrected sound pressure levels is 5 dB or less, average the sound pressure levels arithmetically.

2. *Maximum Variation of 5 to 10 dB.* If the maximum variation in corrected sound pressure levels is between 5 and 10 dB, average the sound pressure level values arithmetically and add 1 dB.

3. *Maximum Variation over 10 dB.* If the maximum variation exceeds 10 dB, average according to the equation (6-1) below:

$$\bar{L} = 10 \operatorname{Log}_{10} \left(\frac{1}{n} \sum_{i=1}^{n} 10^{(L_i/10)} \right) \qquad \ldots (6\text{-}1)$$

where

$\bar{L}$ = Average sound level (dB A) (or band average pressure level in decibels),

L_i = Sound level (dB A) (or band sound pressure level in decibels) at the ith position, and

n = Number of measuring stations.

10-POINT HEMISPHERE METHOD – SOUND POWER LEVEL

Theoretically, sound pressure levels measured over the entire surface of an imaginary sphere surrounding the source should be used when calculating sound power levels. The practical procedure for approximating the entire sphere is to select a number of points located at the center of elements of equal area that are situated on the surface of an imaginary hemisphere about the source. Figure 6-2 is a schematic of the microphone points used for the 10-point hemisphere method, while Figure 6-3 shows the coordinates (relative to the radius of the hemisphere) for the microphone positions. Sound power level is calculated using Equation 6-2.

$$PWL = \bar{SPL} + 20 \log_{10} r + 0.5 \text{ dB} \quad \ldots (6\text{-}2)$$

where

PWL = sound power level in dB re 10^{-12} watts,

$\bar{SPL}$ = spatial average sound pressure level dB, and

r = radius of the hemisphere.

NATIONAL BUREAU OF STANDARDS METHODOLOGY

The National Bureau of Standards (NBS) investigated a measurement methodology that would provide for the determination of A-weighted sound power level or the equivalent A-weighted sound pressure level at a reference distance. The methodology makes use of A-weighted sound level data acquired at a minimum of eight measurement positions disposed on a curved surface surrounding the portable air compressor at a distance of 1 meter from the surface of the machine. A-weighted sound data acquired at the eight measurement positions are used to first calculate the average sound level of the test specimen and are then

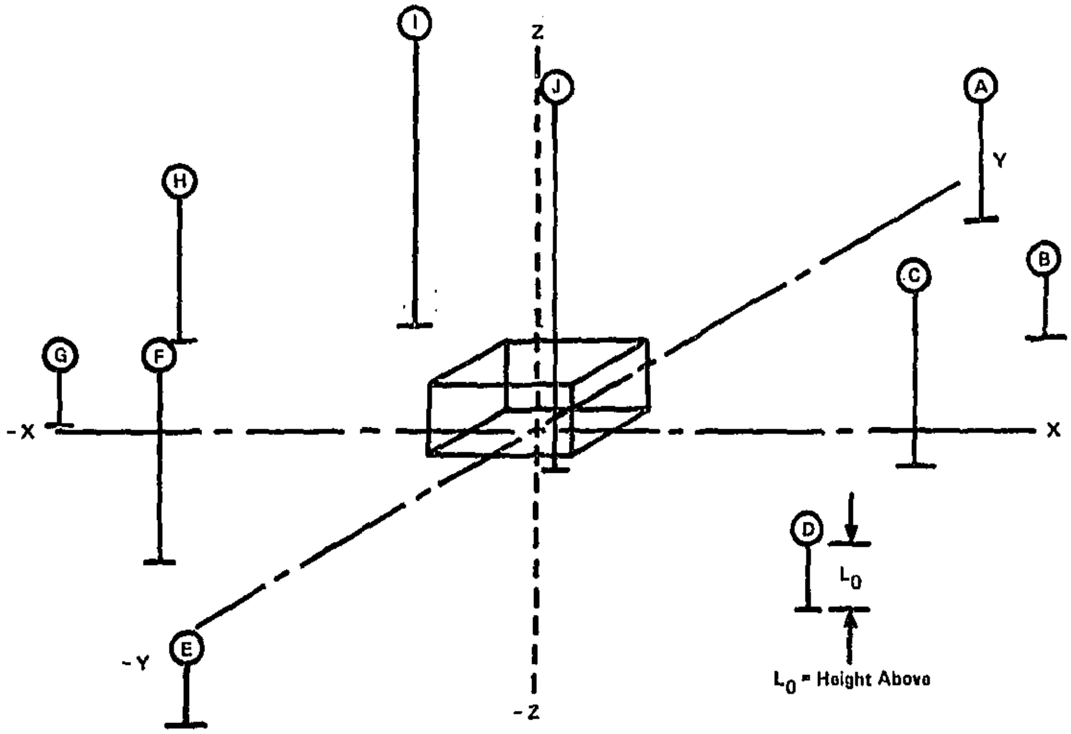
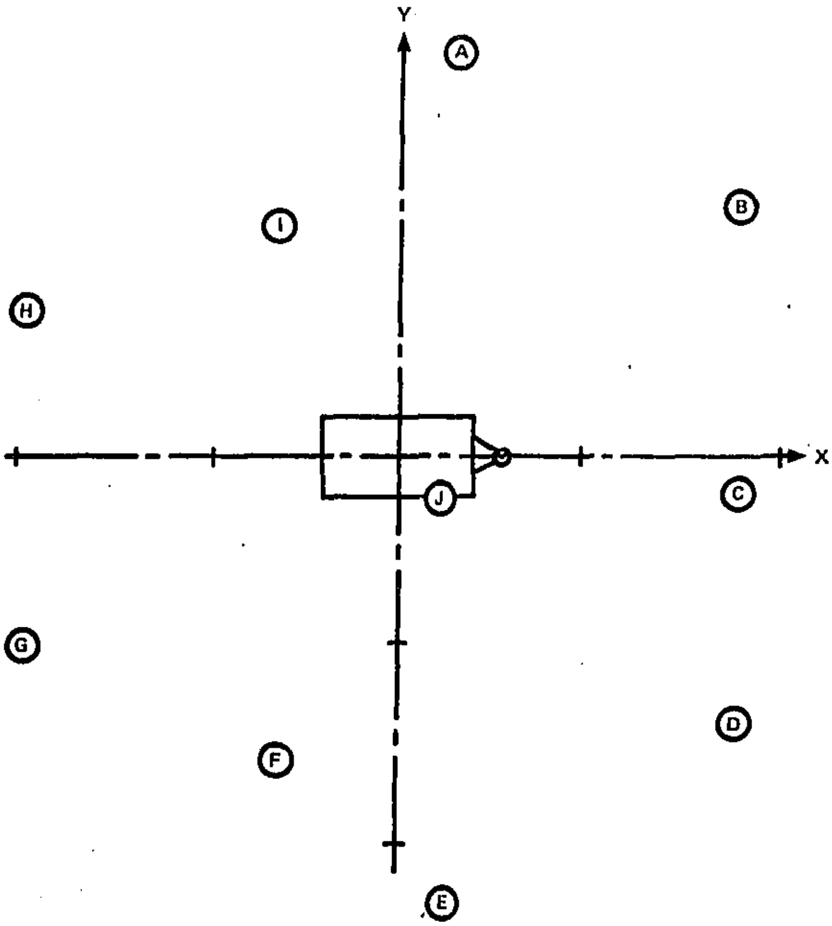


Figure 6-2. Schematic Diagram of 10 Microphone Locations at the Center of Elements of Equal Area on the Surface of a Hemisphere about a Sound Source



POSITION	X/R	Y/R	Z/R
A	0.158	0.898	0.410
B	0.775	0.550	0.313
C	0.738	- 0.067	0.671
D	0.775	- 0.603	0.193
E	0.158	- 0.961	0.224
F	- 0.257	- 0.652	0.713
G	- 0.834	- 0.399	0.381
H	- 0.834	0.315	0.452
I	- 0.257	0.498	0.828
J	0.100	- 0.099	0.990

Figure 6-3. Relative Coordinates for 10 Points of Hemisphere of Radius R

combined with the area of the measurement surface to arrive at the A-weighted sound power level of the machine. Reference 11 provides an in-depth discussion of the steps and requisite calculation employed to determine A-weighted sound power level using the NBS methodology.

As stated above, a minimum of eight measurement positions are employed in the methodology, with provisions for measurements at eight additional positions should the range of the first eight sound level values exceed 8 dB. For conditions under which data at the eight microphone positions suffice, one microphone is located near the center of each of the four sides of the source, and four microphones are located above the top of the source near the corners of the measurement surface. Figure 6-4 shows the microphone array for the minimum (eight) measurement requirements. Table 6-1 lists the microphone position coordinates for the eight measurement points of Figure 6-4. For situations requiring additional measurements, Table 6-2 prescribes the coordinates of eight additional measurement positions.

EPA PORTABLE AIR COMPRESSOR NOISE TEST PROCEDURE

In arriving at a compressor test procedure, EPA recognized the need for a common, well known descriptor of portable air compressor noise to avoid possible confusion over units of measurement by industry, state/local governments, and the public. Also recognized was the need for a relatively simple method to accurately determine portable air compressor noise that could be used both for product verification and enforcement.

Candidates for the proposed description of portable air compressor noise were:

- A-weighted sound pressure in dBA
- Sound power level in dB
- Sound power in milliwatts.

A-weighted sound pressure level in dBA was selected for several reasons, including its utility and ease of acquisition. A-weighted sound pressure level can be measured directly using common, readily available equipment. Thus, it is common to and widely used by industry, the scientific community, state and local governments, and the general public to assess human response to noise. This is in contrast to sound power level and sound power, which cannot be measured but have to be calculated, typically from sound pressure level data.

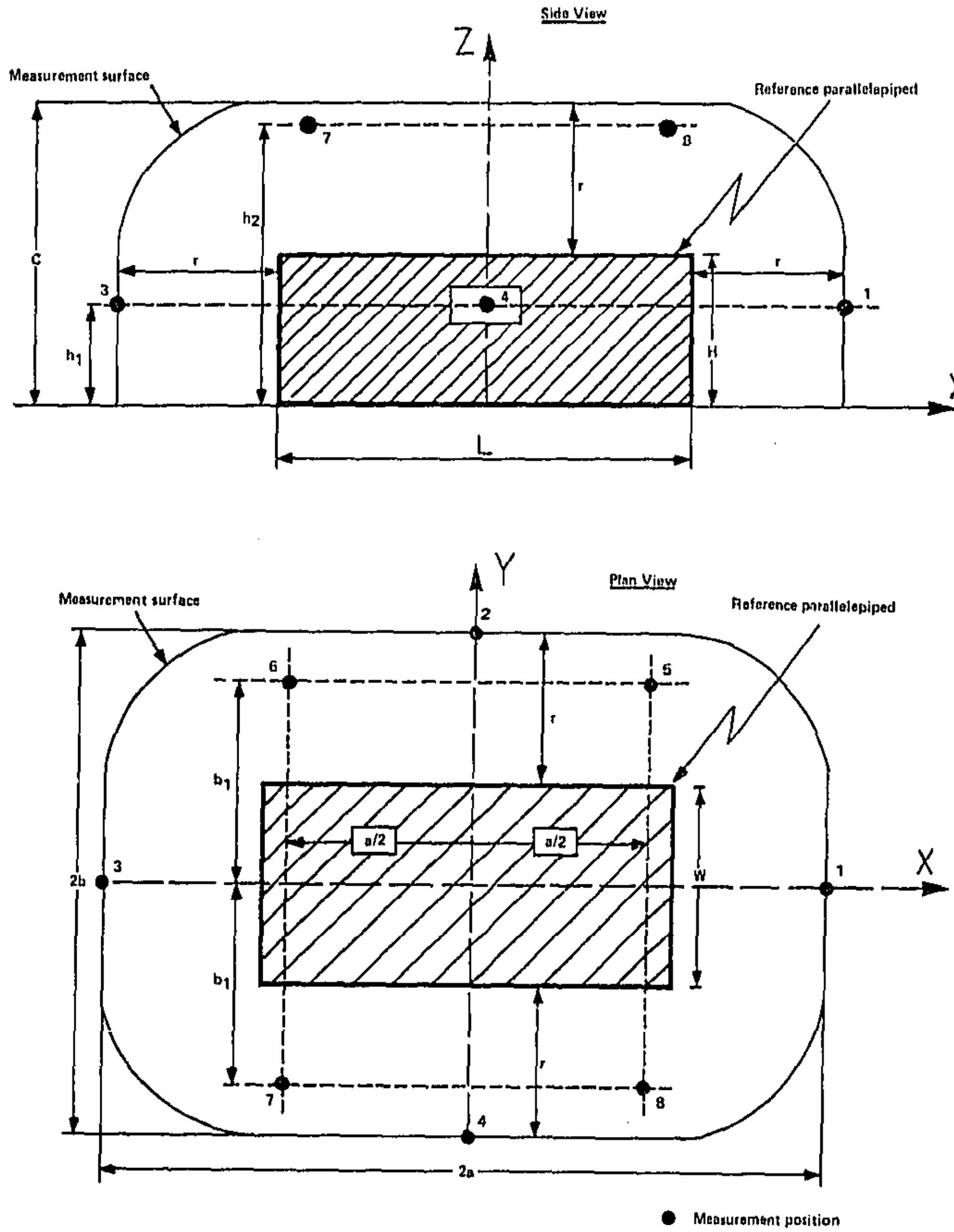


Figure 6-4. Microphone Placement - NBS Methodology

Table 6-1

MICROPHONE POSITION COORDINATES - NBS METHODOLOGY*

Position Number	X	Y	Z	Distance From Reference Surface
1	a	0	h_1	r
2	0	b	h_1	r
3	-a	0	h_1	r
4	0	-b	h_1	r
5	a_1	b_1	greater than h	r
6	$-a_1$	b_1	greater than h	r
7	$-a_1$	$-b_1$	greater than h	r
8	a_1	$-b_1$	greater than h	r

*See Figure 6-4.

Source overall dimensions are L.W.H. corresponding to length, width and height

$a = \frac{L}{2} + r, \ b = \frac{W}{.2} + r, \ c = H + r$

$h_1 = \frac{1}{2} (a + b - \frac{r}{2}) \leq H$

$a_1 = \frac{1}{2} (a + \frac{r}{2}) \leq \frac{L}{2}$

$b_1 = \frac{1}{2} (b + \frac{c}{2}) \leq b$

Origin for the coordinate system is the point on the ground plane under the geometric center of the source.

Table 6-2

COORDINATES OF ADDITIONAL POSITIONS - NBS METHODOLOGY*

Position number	X	Y	Z	Distance from Reference Surface
9	a_2	0		r
10	0	b_1		r
11	$-a_2$	0		r
12	0	$-b_1$		r
13	a_1	b	h_1	r
14	$-a_1$	b	h_1	r
15	$-a_1$	-b	h_1	r
16	a_1	-b	h_1	r

$a_2 = \frac{1}{2}\left(a + \frac{c}{2}\right) \leq a$

*See Figure 6-4.

By selection of the A-weighted sound level descriptor, the 10-point hemisphere and far-field/near-field measurement methods for the acquisition of data to calculate sound power level and sound power, respectively, were eliminated as candidates for the desired test procedure. Their elimination resulted because the rigor involved in the methods is not needed for the simple, direct measurement of A-weighted sound pressure level.

The remaining candidate for the desired test procedure was the CAGI/PNEUROP measurement method. In reviewing this method, consideration was given to whether data were needed at both the 1- and 7-meter microphone locations. EPA concluded that only one set of data was needed, that at 7 meters. This conclusion was based on the fact that the 1-meter measurement locations lie in the near field (see Section 7 of this document). Although the near field data may be appropriate for regulatory use, they would not be satisfactory for far-field extrapolation, as is often the case when it is desired to estimate noise levels at residential positions some distance from the construction site (Section 7 discusses the problem in more detail). In other words, the 1-meter data are not as utilitarian as are the 7-meter data.

Consequently, EPA selected the 7-meter microphone locations because:

- The microphone locations are in the far field.
- The data satisfactorily describe compressor noise.
- The data could be used for extrapolation with some degree of confidence.

The Agency also added an overhead microphone location to guard against compressor design that would direct major sound energy upwards (this would be of significance to persons residing in high-rise buildings adjacent to construction sites). Further, the need to search for and report the maximum A-weighted sound pressure of the compressor was eliminated, since data indicate that the maximum occurs at or near the four horizontal points selected for measurement.

By selection of a modified but more simple CAGI/PNEUROP test method, little education, if any, would be required on the part of industry, since the members of CAGI are familiar with and currently use the CAGI/PNEUROP procedure.

The conditions and the measurement procedures requisite to measure the noise of portable air compressors for the purpose of compliance with a noise standard are presented in the following discussion.

Test Site Description

Locations for measuring noise during noise compliance testing must consist of an open site above a hard reflecting plane. The reflecting plane must consist of a surface of sealed concrete or sealed asphalt and must extend 1 meter beyond each microphone location. No reflecting surface such as a building, sign board, or hillside shall be located within 10 meters of a microphone location.

Measurement Equipment

The following measurement equipment or its equivalent must be used during noise standard compliance testing.

- A sound level meter and microphone system that conform to the requirements of American National Standard Institute ANSI S1.4-1971, "Specification for Sound Level Meters," as shown in the section concerning Type 1 sound level meter, and the International Electrotechnical Commission (IEC) Publication No. 179. "Precision" Sound Level Meters" regarding the sections concerned with microphone and amplifier characteristics.

- A windscreen must be employed with the microphone during all measurements of portable air compressor noise when the wind speed exceeds 11 km/hr. The windscreen shall not affect sound levels from the portable air compressor in excess of ± 0.5 dB.

- The entire acoustical instrumentation system, including the microphone and cable, shall be calibrated before and after each test series. A sound level calibrator accurate within ± 0.5 dB shall be used. A complete frequency response calibration of the instrumentation over the entire range of 25 Hz to 11.2 kHz shall be performed at least annually using methodology of sufficient precision and accuracy to determine compliance with ANSI S1.4-1971 and IEC 179. This calibration shall consist, at a minimum, of an overall frequency response calibration and an attenuator (gain control) calibration plus a measurement of dynamic range and instrument electronic noise.

- An anemometer or other device, accurate to within ± 10 percent, shall be used to measure wind velocity.

- An indicator accurate to within ± 2 percent shall be used to measure portable air compressor engine speed.

- A gauge accurate to within ±5 percent shall be used to measure portable compressor air pressure.

- A metering device accurate to within ± 10 percent shall be used to measure the portable air compressor compressed air volumetric flow rate.

Portable Air Compressor Operation

During noise standard compliance testing, the portable air compressor must be operated at a design full speed with the compressor on load, delivering its rated output flow and pressure. The discharged compressed air must be piped clear of the test site or silenced.

Test Conditions

Noise standard compliance testing must be carried out under the following conditions:

- No rain or other precipitation.

- No wind above 19 km/hr.

- No observer located within 1 meter, in any direction, of any microphone location, or between the test unit and any microphone.

- Portable air compressor sound levels, at each microphone location, shall be a minimum of 10 dB greater than the background sound level.

Microphone Locations

Five microphone locations must be employed to acquire portable air compressor sound levels to test for noise standard compliance. A microphone must be located 7 ± 0.1 meters from the right-, left-, front-, back side and top of the test unit. The microphone position to the right-, left-, front- and back side of the test unit must be located 1.5 ±0.1 meters above the reflecting plane. Figure 6-5 shows the microphone array.

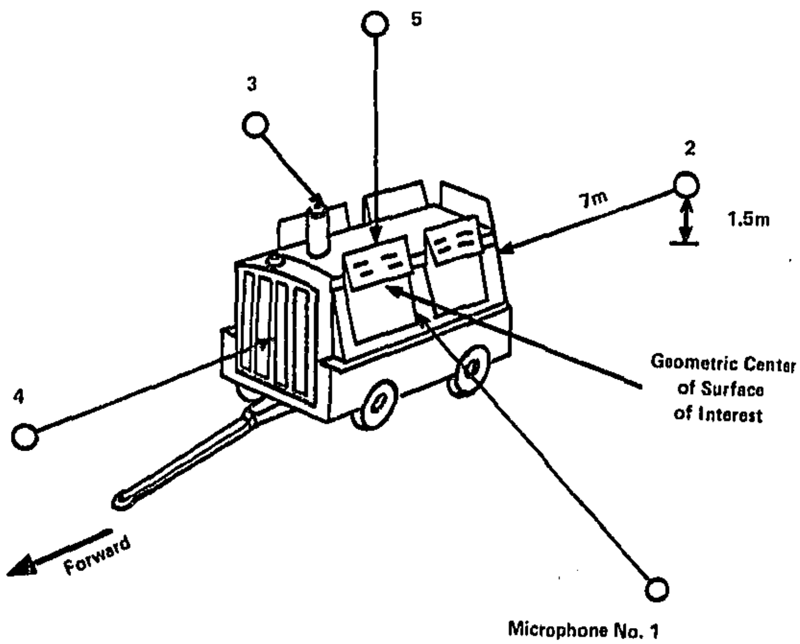


Figure 6-5. Microphone Locations to Measure Portable Air Compressor Noise

Data Required

The following data must be acquired during noise standard compliance testing:

- A-weighted sound levels at one microphone location prior to operation of the test unit and at all microphone locations during test unit operations.
- Portable air compressor engine speed.
- Portable air compressor compressed gas pressure.
- Portable air compressor flow rate.

Calculation of Average Sound Levels

The average A-weighted sound levels from measurements at the specified microphone locations must be calculated by the following method.

$$L = 10 \log_{10} \left(\frac{1}{n} \sum_{i=1}^{n} 10^{(L_i/10)} \right) \qquad \ldots(6\text{-}3)$$

where:

L = average sound level, dBA, in decibels

L_i = sound level, dBA, in decibels at the i th location,

and

n = number of measurement position.

Presentation of Information

The following information must be reported:

- Background ambient sound level in dBA.
- Portable air compressor sound levels in dBA at each microphone location.
- Average portable air compressor sound levels in dBA.
- Portable air compressor compressed gas pressure, in kg/cm^2 or psig.
- Portable air compressor compressed gas flow in m^3/min or cfm.
- Portable air compressor manufacture, model and serial number.
- Acoustic instrumentation manufacturer, and model number.

The recommended data format is shown in Figure 6-6.

Test Report Number ___________

SUBJECT:

Manufacturer: __________ Model: __________ Serial No.: __________
Rated Speed: __________ rpm: __________ Rated Capacity: __________ m^3/min
Configuration Identification: __________ Category Identification: __________
Portable Air Compressor Identification No.: __________ Build Date: __________

TEST CONDITIONS:

Manufacturers Test Site Identification and Location: __________
Reflecting Plane Composition: __________
Operating Speed as Tested: Beginning of Test __________ rpm
End of Test __________ rpm
Air Pressure Supplied: __________ kg/cm^2. Ambient Wind Speed __________
Actual Flow Rate: __________ m^3/min. Barometric Pressure __________
Temperature: __________ °F

INSTRUMENTATION:

Microphone Manufacturer: __________ Model No.: ____ Serial No. ____
Sound Level Meter Manufacturer: ____ Model No.: ____ Serial No. ____
Calibrator Manufacturer: __________ Model No.: ____ Serial No. ____
Other and Manufacturer: __________ Model No.: ____ Serial No. ____

DATA:

Sound Levels, Decibels	Background Sound Level at Location 1 in Decibels	Location					Average Sound Level
		1	2	3	4	5	
A-weighted							

TESTED BY: ______________________________ DATE: __________

REPORTED BY: ______________________________ DATE: __________

SUPERVISORY PERSONNEL: ____________ TITLE: ____________

____________ TITLE: ____________

Figure 6-6. Recommended Portable Air Compressor Noise Data Sheet

Section 7

PORTABLE AIR COMPRESSOR NOISE

The basic elements of all noise problems are the (1) source, (2) path, and (3) receiver. Studies have been conducted on all three of these elements. The first two are discussed in this and the following section, and the third is discussed in Section 10.

Study of the portable air compressor as a source included evaluation of:

- Overhead noise levels of unsilenced and silenced compressors.
- Noise levels of unsilenced and silenced portable air compressors ranging from 85 to 1200 cfm capacity.
- Repeatability of compressor noise measurements.
- Noise directivity of unsilenced and silenced compressors.
- Compressor sound power levels.
- Low frequency compressor noise.
- Identification of major noise sources associated with portable air compressors (see Section 8).
- Degree of quieting with application of present technology (see Section 8).

Study of the propagation path included the following considerations:

- Ground reflections
- Path discontinuities
- Calculation of far field data from near field data.

OVERHEAD NOISE

To increase the data base and to provide data to assess the noise characteristics of portable air compressors, noise measurements were made of 4 gasoline and 19 diesel powered compressors ranging in capacity from 85 to 1200 cfm. Table 7-1 lists information about the units and the test method employed. As indicated in the table, both silenced and standard versions of some compressors were evaluated, and, in some cases, the compressor housing doors were purposely left open.

The most commonly used portable air compressor measurement scheme, the CAGI/PNEUROP method (see Section 6), does not presently include measurement of sound above portable air compressors. Since engine exhaust often is directed upward, noise radiating in this direction could be of significance, particularly to persons in offices and apartments located above operating compressors. Consequently, measurements were made of noise radiating upward and were compared with that radiated to the side of compressors.

Table 7-2 lists the measured CAGI/PNEUROP average and overhead noise levels for the 26 compressor tests. The last column in this table is the difference between these two levels. Figure 7-1 shows a histogram of these differences.

For 4 of 26 compressors, the overhead noise level is greater than the horizontal noise level. All other models show the overhead direction to be quieter than, or equal to, horizontal radiated noise. The mean difference in Figure 7-1 shows the upward-directed noise to be 0.6 dBA less than the CAGI/PNEUROP calculated level not including an overhead measurement point. The spread in the data, however, results in a standard deviation of 2 dBA.

Of the four compressors that are significantly noisier overhead, two are for the same model (doors open and closed) with a relatively inefficient exhaust muffler. The other two are for silenced units similar to companion products with overhead sound levels significantly less than the sideline average. Consequently, if we momentarily ignore these results as atypical or as possible measurement error, the statistics of the remaining 20 are computed. The following values result:

- Mean: −1.5 dBA
- Standard deviation = 1.1 dBA

Thus, for this group of compressors, the overhead noise level is about 1.5 dBA less than in other directions.

Table 7-1

COMPRESSORS TESTED AND TEST METHODOLOGY EMPLOYED

Manufacturer	Model	Silenced or Standard	Type Engine	Type Compressor	Serial No.	Test Condition (cfm, psi)	Test Method: CAGI/PNEUROP	Test Method: Overhead Measurement[2]	Test Method: 10 Point Hemispherical[3]	Test Method: Diagonal[4]
Atlas Copco	ST-48	Standard	Diesel	Reciprocal	51232751	160, 100	x	x		
Atlas Copco	ST-95	Standard	Diesel	Reciprocal	51-274977	330, 105	x	x		
Atlas Copco	VSS-170 Dd	Silenced	Diesel	Reciprocal	51-23507-	170, 850	x	x		
Atlas Copco	VT-85 Dd	Standard	Gas	Reciprocal	ARP203149	85, 100	x	x		
Atlas Copco	VS-85 Dd	Silenced	Gas	Reciprocal	ARP203903	85, 100	x	x		
Atlas Copco	VSS-125 Dd	Silenced	Diesel	Reciprocal	51-345060	125, 100	x	x		
Atlas Copco	STS-35 Dd	Silenced	Diesel	Reciprocal	ARP550924	125, 100	x	x		
Atlas Copco	VSS-170 Dd	Silenced	Diesel	Reciprocal	51-235072	170, 100	x	x	x	x
Gardner-Denver	SPWDA/2	Silenced	Diesel	Rotary-Screw	635851	1200, 000	x	x		
Gardner-Denver	SPQDA/2	Silenced	Diesel	Rotary-Screw	608227	750, 000	x	x	x[5]	
Gardner-Denver	SPHGC	Silenced	Gas	Rotary-Screw	629717	185, 000	x	x		
Ingersoll-Rand	DXL 1200	Standard	Diesel	Rotary-Screw	74430	1200, 125	x	x		
Ingersoll-Rand	DXL 1200 (doors open)	Standard	Diesel	Rotary-Screw	74430	1200, 125	x			
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	73693	900, 125	x	x		
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	74050	900, 125	x	x		
Ingersoll-Rand	DXL CU1050	Standard	Diesel	Rotary-Screw	75613	1050, 125	x	x	x	
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	74051	900, 125	x	x		
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	740471	900, 125	x	x	x	
Ingersoll-Rand	DXL 900	Standard	Diesel	Rotary-Screw	75847	900, 125	x	x		
Ingersoll-Rand	DXL 750	Standard	Diesel	Rotary-Screw	77380	750, 125	x	x		
Jaeger	A	Standard	Gas	Rotary-Screw	RS-32189	175, 100	x	x		
Jaeger	A (doors open)	Standard	Gas	Rotary-Screw	RS-32189	175, 100	x	x		
Jaeger	E	Standard	Gas	Vane	RC-32032	85, 100	x	x		
Jaeger	E (doors open)	Standard	Gas	Vane	RC-32032	85, 100	x	x		
Worthington	160 G/2 QT	Silenced	Gas	Vane	821-478	160, 100	x	x	x	x
Worthington	750-QTEX	Silenced	Diesel	Rotary-Screw	848-019	750, 100	x	x	x	x

1. ISO 2151-1972 Method (See Figure 6.1)
2. ISO 2151-1972 Method plus A 7 meter overhead point
3. See Figure 6.9 and 6.10
4. Measurements were made at diagonal locations at 0 meters
5. Measurements were made for the compressor operating at idle and full power

Table 7-2

COMPARISON OF CAGI/PNEUROP AVERAGE SIDE WITH OVERHEAD NOISE LEVELS

No.	Manufacturer	Model	(A) CAGI/ PNEUROP	(B) Overhead	B-A
1	Atlas Copco	ST-48	84	83	-1
2	Atlas Copco	ST-95	80.5	79.5	-1
3	Atlas Copco	VSS-170 Dd	71	68	-3
4	Atlas Copco	VT-85 Dd	82.5	79	-3.5
5	Atlas Copco	VS-85 Dd	75.5	76	0.5
6	Atlas Copco	VSS-125 Dd	70	72.5	2.5
7	Atlas Copco	STS-35 Dd	73	77	4
8	Atlas Copco	VSS-170 Dd	71	68.5	-2.5
9	Worthington	160 G/2 QT	75	72	-3
10	Worthington	750-QTEX	75	73.5	-1.5
11	Ingersoll-Rand	DXL 1200	94.5		
12	Ingersoll-Rand	DXL 1200*	96.5		
13	Ingersoll-Rand	DXL 900S	77.5	75	-2.5
14	Ingersoll-Rand	DXL 900S	75.5	74.5	-1
15	Ingersoll-Rand	DXL CU1050	91	89	-2
16	Ingersoll-Rand	DXL 900S	76	73.5	-2.5
17	Ingersoll-Rand	DXL 900S	75.5	74	-1.5
18	Ingersoll-Rand	DXL 900	90.5	89	-1.5
19	Ingersoll-Rand	DXL 750	88	88	0
20	Gardner-Denver	SPWDA/2	74	73	-1
21	Gardner-Denver	SPQDA/2	78.5	78	-0.5
22	Gardner-Denver	SPHGC	77.5	75	-2.5
23	Jaeger	A	88.5	88	-0.5
24	Jaeger	A*	89	89.5	0.5
25	Jaeger	E	81.5	84	2.5
26	Jaeger	E*	82	85	3

*Doors open

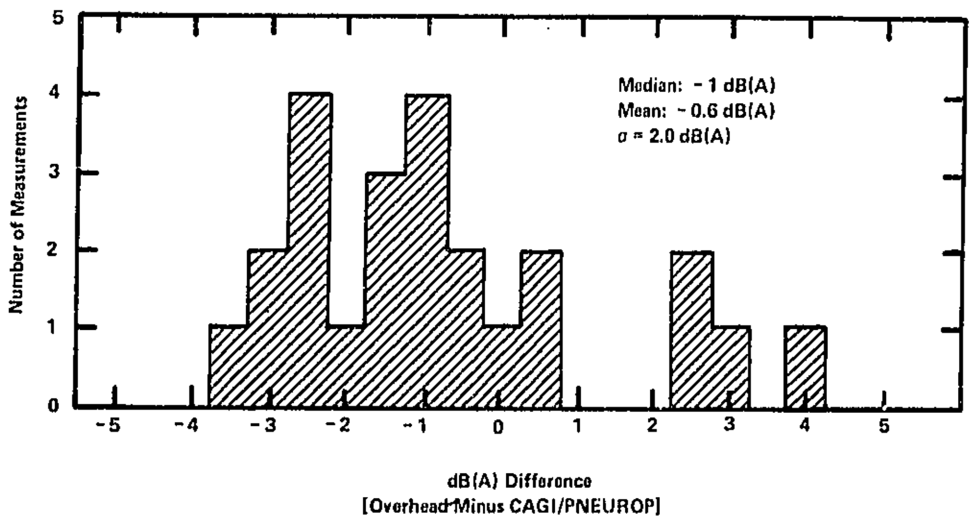


Figure 7-1. Comparison Between Overhead Noise Level and CAGI/PNEUROP Level

PORTABLE AIR COMPRESSOR NOISE LEVELS

New Data

As discussed previously, measurements were made of a total of 23 portable air compressor types. Tables 7-3 and 7-4 list noise levels of the standard and silenced compressors, respectively, while Figure 7-2 shows a plot of noise versus cfm capacity. From review of the data in the tables and figures, the following may be concluded:

- Noise levels of both standard and silenced compressors increase with increasing compressor capacity, with noise of the standard units increasing at a more rapid rate.
- Noise levels of standard compressors range in level from 81.4 to 92.6 dBA at 7 meters.
- Noise levels of silenced compressors range in level from 70.1 to 78.2 dBA at 7 meters.
- Silenced compressors are on the average 10 to 15 dBA quieter than standard units.

Table 7-3

NOISE LEVELS OF STANDARD COMPRESSORS
USING THE CAGI/PNEUROP MEASUREMENT METHOD

Manufacturer	Model	S/N	Cfm	Average Noise Level (dBA)	
				1 meter	7 meter*
Atlas Copco	VT85Dd	ARP203149	85	94.8	81.4
Atlas Copco	ST-48	51-232751	160	96.6	83.3
Atlas Copco	ST-95	51-274977	330	91.9	80.2
Jaeger	E	RC32032	85	92.5	81.5
Jaeger	A	RS32189	175	98.9	88.2
Ingersoll-Rand	DXL750	77380	750	98.6	87.7
Ingersoll-Rand	DXL900	75847	900	97.9	89.9
Ingersoll-Rand	DXLCU1050	75613	1050	100.8	90.2
Ingersoll-Rand	DXL1200	74430	1200	103.0	92.6

*Includes overhead measurement point

Table 7-4

NOISE LEVELS OF SILENCED COMPRESSORS
USING THE CAGI/PNEUROP MEASUREMENT METHOD

Manufacturer	Models	S/N	Cfm	Average Noise Level (dBA)	
				1 meter	7 meter*
Atlas Copco	VS85	ARP203903	85	89.0	75.5
Atlas Copco	STS35Dd	ARP550924	125	85.5	73.5
Atlas Copco	VSS125Dd	51-345060	125	81.0	70.1
Atlas Copco	VSS170Dd	51-235072	170	83.9	70.2
Worthington	160G/2QT	821478	160	84.5	74.2
Gardner-Denver	SPHGC	629717	185	87.0	77.1
Gardner-Denver	SPQDA/2	608227	750	86.1	78.2
Worthington	750QTEX	848-019	750	84.0	74.7
Ingersoll-Rand	DXL 900S	73693	900	82.4	76.0
Ingersoll-Rand	DXL 900S	74050	900	82.0	75.1
Ingersoll-Rand	DXL 900S	74051	900	83.1	75.3
Ingersoll-Rand	DXL 900S	740471	900	82.4	75.0
Gardner-Denver	SPWDA/2	635851	1200	84.1	73.7

*Includes overhead measurement point

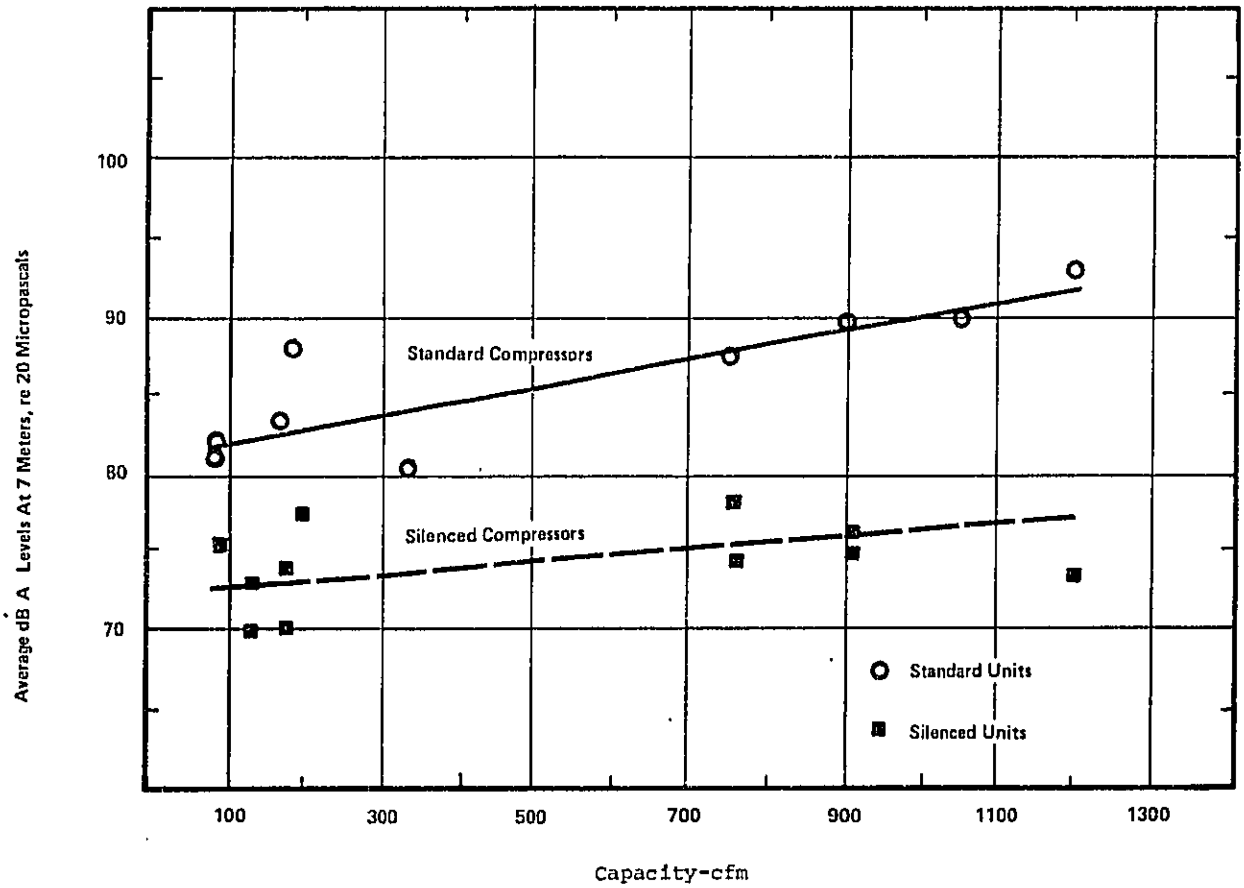


Figure 7-2. Noise of Standard and Silenced Compressors as a Function of Capacity - CFM

Existing Data

Manufacturers supplied EPA (Contractor BBN) with noise data at 7 meters for 194 compressor models. Table 7-5 lists the data in terms of compressor capacity, engine type, and standard/quieted units. Also shown in the table is the number and percent of units below a particular noise level.

In summary, the data shows:

- Standard models of gas engine powered compressors range in noise level from 71.0 to 92.0 dBA with a mean value of 82.8 dBA.
- Silenced models of gas engine powered compressors range in noise level from 72 to 81 dBA with a mean value of 76.1 dBA.
- Standard models of diesel engine powered compressors of less than 251 cfm capacity, range in noise level from 80.0 to 93.0 dBA with a mean value of 84.7 dBA.
- Silenced models of diesel engine powered compressors, of less than 251 cfm capacity, range in noise from 70.0 to 88.0 dBA with a mean value of 75.5 dBA.
- Standard models of diesel engine powered compressors, of greater than 250 cfm capacity, range in noise level from 84.0 to 102.0 dBA with a mean value of 91.7 dBA.
- Silenced models of diesel engine powered compressors of greater than 250 cfm capacity, range in noise level from 74.0 to 88.0 dBA with a mean value of 77.7 dBA.

CORRELATION OF DATA

Data acquired by EPA, using the CAGI/PNEUROP method were compared with available manufacturer's data. Figure 7-3 presents a histogram of the compressor in which good correlation is shown, i.e., both mean and median ratios are approximately zero.

To assess the correlation of noise levels of compressors of a particular model, measurements were made of four units of 900 cfm capacity. Table 7-6 summarizes the tests results and shows that noise levels correlate to within 1.5 dB at individual measurement positions and to within 1.0 dB on the average.

Table 7-5(a)

PERCENT AND NUMBER OF PORTABLE AIR COMPRESSORS
WITH NOISE LEVELS NOT IN EXCESS OF A PARTICULAR VALUE*
(Major Category of Portable Air Compressors by Capacity and Type of Engine)

Gasoline Engine, All Capacities**					
Standard Models			Quieted Models		
dBA Level	Percent of Cumulative Units Below	Number of Units Below	dBA Level	Percent of Cumulative Units Below	Number of Units Below
71.0	0.0	0			
72.0	3.12	1	72.0	0.0	0
73.0	3.12	1	73.0	11.54	3
74.0	9.37	3	74.0	15.38	4
75.0	9.37	3	75.0	26.92	7
76.0	12.50	4	76.0	50.00	13
77.0	12.50	4	77.0	65.38	17
78.0	18.75	6	78.0	69.23	18
79.0	18.75	6	79.0	84.62	22
80.0	21.87	7	80.0	92.31	24
81.0	28.12	9	81.0	100.00	26
82.0	28.12	9			
83.0	34.37	11			
84.0	50.00	16			
85.0	62.50	20			
86.0	75.00	24			
87.0	81.25	26			
88.0	90.26	29			
89.0	90.62	29			
90.0	93.75	30			
91.0	96.87	31			
92.0	100.00	32			

Mean: 82.8 dBA***
Standard Deviation: 4.92 dBA***

Mean: 76.1 dBA***
Standard Deviation: 2.40 dBA***

* Average sound pressure level in dBA at 7m according to the recommended measurement practice of ISO 2151-1972. Manufacturers were sometimes imprecise in defining the noise data submitted to BBN. BBN has treated this data as an average of noise level for a model based on testing a number of units.

** BBN did not document in its report the manufacturers whose model data is included in the 194 data points reported.

*** The mean is a simple average of model noise data. Data is not available to weight by relative model unit volume sold. Partial weighting schemes by capacity and/or manufacturer were not utilized.

Table 7-5(b)

PERCENT AND NUMBER OF PORTABLE AIR COMPRESSORS WITH NOISE LEVELS NOT IN EXCESS OF A PARTICULAR VALUE*
(Major Category of Portable Air Compressors by Capacity and Type of Engine)

Diesel engine, below 251 cfm capacity**					
Standard models			Quieted models		
dBA Level	Percent of Cumulative Units Below	Number of Units Below	dBA Level	Percent of Cumulative Units Below	Number of Units Below
			69	0.00	0
			70	12.12	4
			71	12.12	4
			72	12.12	4
			73	18.18	6
			74	21.21	7
			75	48.48	16
			76	54.54	18
			77	66.67	22
			78	69.70	23
79	0.00	0	79	75.76	25
80	2.86	1	80	78.79	26
81	2.86	1	81	81.82	27
82	20.00	7	82	87.88	29
83	28.57	10	83	93.94	31
84	34.29	12	84	96.97	32
85	54.29	19	85	96.97	32
86	62.86	22	86	96.97	32
87	74.29	26	87	96.97	32
88	77.14	27	88	100.00	33
89	85.7	30			
90	88.57	31			
91	88.57	31			
92	97.17	34			
93	100.0	35			
Mean: 84.7 dBA***			Mean: 75.5 dBA***		
Standard Deviation:	3.0 dBA***		Standard Deviation:		5.14 dBA***

* Average sound pressure level in dBA at 7m according to the recommended measurement practice of ISO 2151-1972. Manufacturers were sometimes imprecise in defining the noise data submitted to BBN. BBN has treated this data as an average noise level for a model based on testing a number of units.

** BBN did not document in its report the manufacturers whose model data is included in the 194 data points reported.

*** The mean is a simple average of model noise data. Data is not available to weight by relative model unit volume sold. Partial weighting schemes by capacity and/or manufacturer were not utilized.

Table 7-5(c)

PERCENT AND NUMBER OF PORTABLE AIR COMPRESSORS WITH NOISE LEVELS NOT IN EXCESS OF A PARTICULAR VALUE*
(Major Category of Portable Air Compressors by Capacity and Type of Engine)

Diesel engine, above 250 cfm capacity**					
Standard models			Quieted models		
dBA Level	Percent of Cumulative Units Below	Number of Units Below	dBA Level	Percent of Cumulative Units Below	Number of Units Below
			73	0.00	0
			74	6.25	2
			75	9.38	3
			76	21.88	7
			77	46.88	15
			78	56.25	18
			79	62.50	20
			80	65.63	21
			81	68.75	22
			82	75.00	24
83	0.00	0	83	78.13	25
84	2.33	1	84	81.25	26
85	9.30	4	85	87.50	28
86	9.30	4	86	90.63	29
87	11.63	5	87	96.88	31
88	21.21	7	88	100.00	32
89	23.26	10			
90	37.21	16			
91	46.51	20			
92	53.49	23			
93	62.79	27			
94	74.42	32			
95	76.74	33			
96	76.74	33			
97	81.40	35			
98	88.37	38			
99	93.02	40			
100	97.67	42			
101	97.67	42			
102	100.00	43			
Mean: 91.7 dBA***			Mean: 77.7 dBA***		
Standard Deviation:	4.02 dBA***		Standard Deviation:	3.87 dBA***	

* Average sound pressure level in dBA at 7m according to the recommended measurement practice of ISO 2151-1972. Manufacturers were sometimes imprecise in defining the noise data submitted to BBN. BBN has treated this data as an average noise level for a model based on testing a number of units.

** BBN did not document in its report the manufacturers whose model data is included in the 194 data points reported.

*** The mean is a simple average of model noise data. Data is not available to weight by relative model unit volume sold. Partial weighting schemes by capacity and/or manufacturer were not utilized.

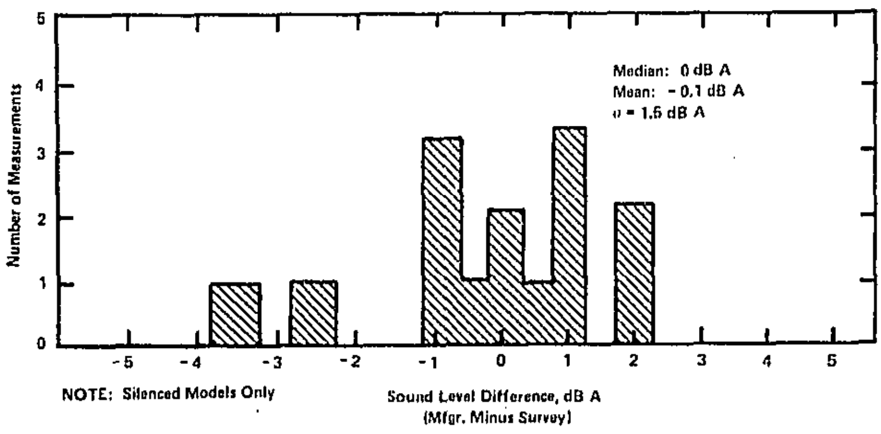


Figure 7-3. Comparison of Manufacturer Supplied Data with Survey Data

NOISE DIRECTIVITY

Noise levels measured during compressor operation at rated power were analyzed to assess noise directivity around portable air compressors. Table 7-7 lists dBA levels, average dBA levels, and the maximum directivity factor associated with the six types of compressors. The data were acquired using the 10-point hemisphere measurement method and show little variance in noise level from position to position, indicating little directivity of noise.

Figure 7-4 shows a polar plot of noise at azimuthal locations every 30 degrees in the horizontal plane around a compressor. Again, little directivity is shown.

PORTABLE AIR COMPRESSOR SOUND POWER LEVEL

Though portable air compressors have been and are currently characterized in terms of sound pressure level at a specified distance, thought was given to the possible characterization in terms of sound power. Of prime consideration was a feasible measurement methodology. Accordingly, portable air compressor sound power levels were calculated

Table 7-6

REPEATABILITY OF NOISE LEVELS OF FOUR MODELS
THE INGERSOLL RAND DXL 900S COMPRESSOR

	Measurement Positions**					Average dBA Level
Serial No.	7	8	9	10	11*	
73693	73	76.5	78.5	77	75	76.0
74050	72.5	75.5	76.5	76.5	74.5	75.1
74041	73	76.5	77	76.5	73.5	75.3
740471	72	76.5	77	75.5	74	75.0

* Overhead Position
** See Figure 6-1

Table 7-7

AIR COMPRESSOR NOISE DIRECTIVITY

Microphone Location*	Worthington 160G/2QT	Atlas Copco YSS-170	Worthington 750QTEX	Ingersoll Rand DXLCU1050	Ingersoll Rand DXL900S	Gardner Denver SPQDA/2
	Sound Level, dBA					
A	77	71	72	92	77.5	81
B	77	75	72	94.5	76.5	80.5
C	77	72	73	93	80	77
D	77	72	73	94.5	75.5	78.5
E	78	72	71	94.5	78	79
F	77	71	71	93	80.5	79.5
G	78	71	72.5	91	81	80.5
H	77	72	72.5	91.5	81	81
I	77	71	72	92	79	80.5
J	76	70	72.5	89	78	77
Average dBA	77.1	71.7	72.2	92.5	78.9	79.5
Maximum Directivity Factor **	1.23	2.14	1.22	1.58	1.62	1.43

* See Figure 6-2 and 6-3

** Maximum directivity factor = $\text{antilog}_{10}\left(\frac{L_{max}-\bar{L}}{10}\right)$

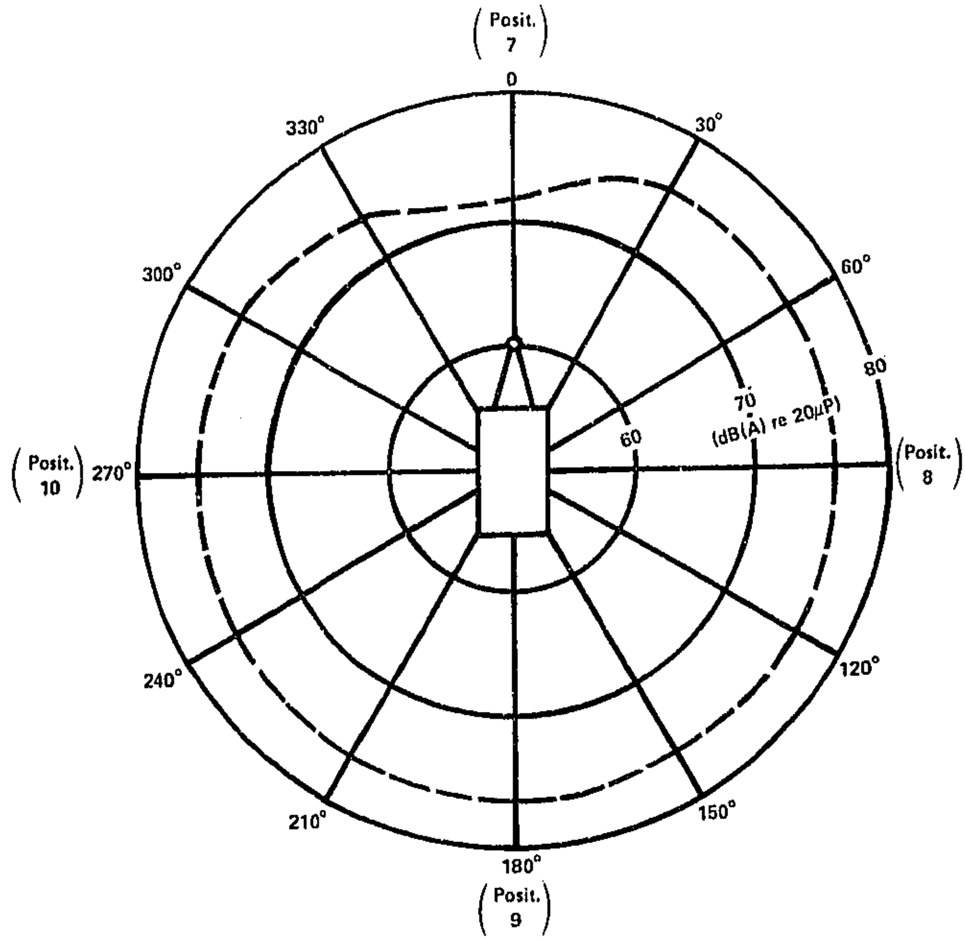


Figure 7-4. Horizontal Directivity of Ingersoll-Rand (DXL 900S) Compressor

using data acquired by the CAGI/PNEUROP method and by a method developed by the National Bureau of Standards. These levels were then compared with levels calculated from data acquired by more conventional means; i.e., by microphones located at the center of surfaces of equal area on the surface of an imaginary hemisphere about the source. The distinct differences between the measurement methodologies evaluated are the microphone placement in the far field (7 meters) for the CAGI/PNEUROP methodology and in the near field (1 meter) for the NBS methodology.

CAGI/PNEUROP Measurement Methodology

The results presented in Table 7-8 show that power levels calculated from the CAGI/PNEUROP 4- and 5-point data compare well to those calculated from data obtained using the more precise 10-point hemispherical measurement method. An average difference of only 0.6 dB was found in each case. These results occurred primarily because the compressors tested were not very directive. In the extreme case of a completely nondirective compressor, all methods would yield exactly the same results. In fact, only one sound level measurement would be required.

NBS Measurement Methodology

NBS performed an experimental study to assess the validity of using "near field" measurements of sound pressure levels to predict the sound power level of portable air compressors. The experimental program consisted of the measurement of the sound pressure levels of 17 portable air compressor models. Measurements were made on two hypothetical surfaces, a large and a small surface, surrounding the test units.

The larger surface yielding the "far field" measurement data was a hemisphere of a fixed 7-meter radius. Sound pressure levels were measured at a total of 84 positions. This was accomplished by rotating an array of seven microphones through 12 different positions. Figure 7-5 shows the basic seven microphone array and lists the coordinates of the 84 microphone positions.

The smaller measurement surface, which yielded the "near field" data, consisted of a hypothetical rectangular box surrounding the source at a distance of 1 meter from the surfaces of each of the 17 portable air compressor models tested. Figure 7-6 shows the typical microphone array employed. Further details regarding the microphone arrays appears in Reference 11.

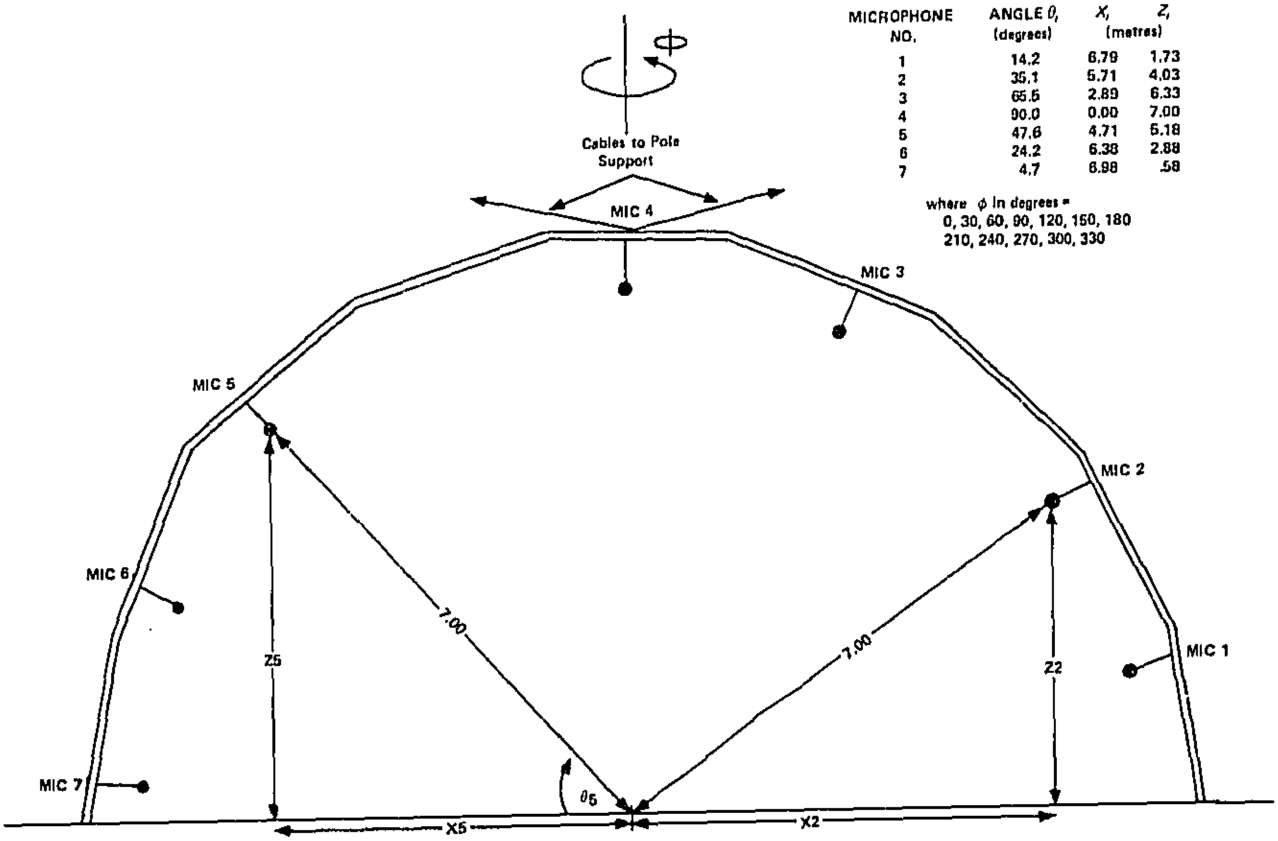
Table 7-9 presents a comparison of portable air compressor sound power levels calculated from near and far field data for 17 models of compressors. Shown is the excellent correlation between the data, with the average difference being 0.44 dB. Accordingly, it is

Table 7-8

SOUND POWER LEVEL COMPARISONS

Compressor	PWL* (4 pt.) (dBA)	PWL* (5 pt.) (dBA)	PWL* (10 pt.) (dBA)	PWL_{10} minus PWL_4	PWL_{10} minus PWL_5
Atlas Copco VSS 170	96.4	96.3	96.7	0.3	0.4
Worthington 160 QT	100.9	100.5	102.1	1.2	1.6
Worthington 750-QTEX	99.9	99.9	100.2	0.3	0.3
Ingersoll-Rand DXLCU 1050	117.4	117.2	117.5	0.1	0.3
Ingersoll-Rand DXL 900S	102.2	102.1	103.9	1.7	1.8
Gardner-Denver SPQDA/2 (Full Power)	105.0	105.1	104.5	-0.5	-0.6
Gardner-Denver SPQDA/2 (Idle)	96.6	97.1	97.5	0.9	0.4

*PWL = Sound power level



MICROPHONE NO.	ANGLE θ_i (degrees)	X_i (metres)	Z_i (metres)
1	14.2	6.79	1.73
2	35.1	5.71	4.03
3	65.6	2.89	6.33
4	90.0	0.00	7.00
5	47.6	4.71	5.18
6	24.2	6.38	2.88
7	4.7	6.98	.58

where ϕ in degrees =
0, 30, 60, 90, 120, 150, 180
210, 240, 270, 300, 330

Figure 7-5. Far-Field Measurement Microphone Array (p: 1.5 cm = 1 m)

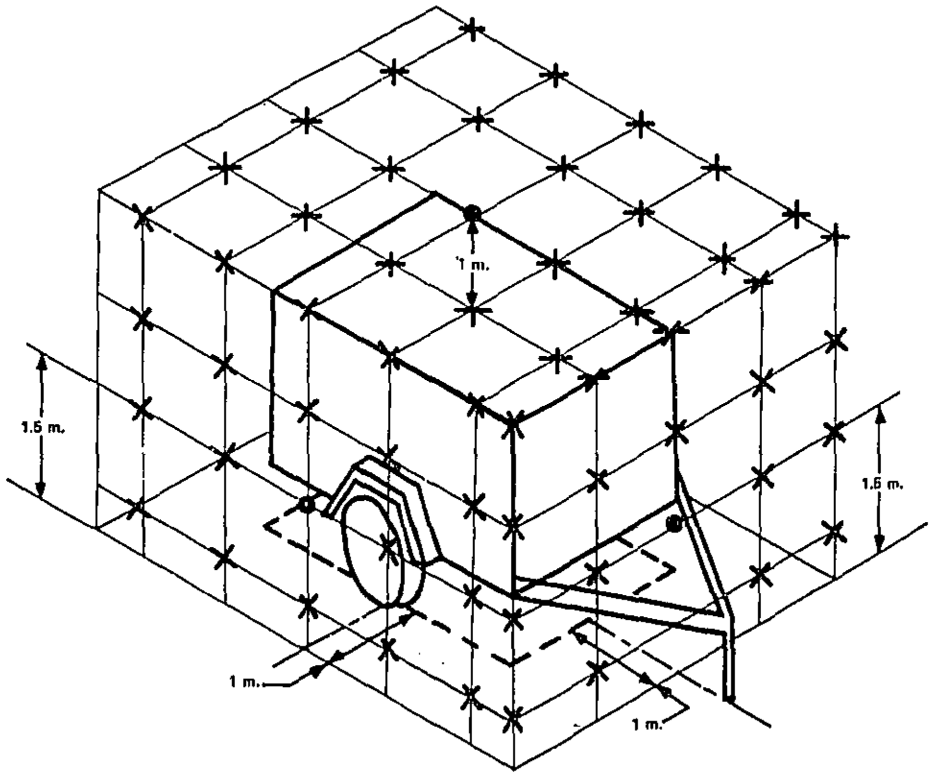


Figure 7-6. Representative Near-Field Measurement Positions

Table 7-9

COMPARISON OF PORTABLE AIR COMPRESSOR SOUND POWER LEVELS CALCULATED FROM NEAR AND FAR FIELD DATA

Compressor cfm	Characteristic Size (Length, Width, Height) Meters	Far Field Sound Power Level, dBA Re 10 Watts	Near Field Sound* Power Level, dBA Re 10 Watts	Difference, dBA Far Field Minus Near Field
185	1.97x1.28x1.40	105.1	103.9	1.2
150	1.73x0.77x1.47	110.8	110.8	0
160	2.07x1.14x1.77	106.8	106.5	0.3
150	1.71x1.24x1.77	113.1	113.8	0.7
200	1.83x0.96x1.50	108.9	107.5	1.4
100	1.52x0.67x1.42	109.0	108.4	0.6
160	2.10x1.28x1.78	106.9	107.0	0.1
125	1.78x1.30x1.85	103.1	103.0	0.1
365	3.66x1.82x2.14	98.7	97.1	1.6
900	4.29x2.19x2.51	104.8	105.8	1.0
100	1.78x1.22x1.37	107.7	108.2	-0.5
175	2.70x1.29x1.43	101.1	100.6	0.5
175	2.70x1.29x1.43	101.4	99.1	2.3
185	2.70x1.29x1.43	99.3	98.7	0.6
175	1.99x1.27x1.45	108.7	110.1	-1.4
85	1.96x1.10x1.34	101.1	101.8	-0.7
150	1.93x1.24x1.36	103.6	103.6	-0.6

* One of eight calculations using near field data (see reference 11 for additional calculations/comparisons). This particular listing uses data at points corresponding (approximately) to the eight point measurement array of ISO draft standard DIS 3744 and DIS 3746.

concluded that portable air compressor sound power levels may be accurately calculated from data measured on a surface 1 meter from the compressor enclosure using the NBS measurement methodology calculation scheme.

LOW FREQUENCY NOISE

The A-weighting network of sound level meters attenuated low-frequency noise; e.g., -39.4 dB, -26.2 dB, -16.1 dB, and -8.6 dB at frequencies of 31.5 Hz, 63 Hz, 125 Hz, and 250 Hz, respectively [18]. As such, great differences can result between A-weighted levels and the unweighted (relatively speaking) C-weighted levels. The significance of this is the possibility that while noise suppression methods may reduce a compressor's A-weighted noise rating, the C-weighted level could conceivably remain the same or could, in fact, increase. Though A-weighted sound level decreases might adequately reduce health and welfare impact, C-weighted noise control may be desirable as well to preclude the escalation of overall unweighted compressor noise.

Tables 7-10 and 7-11 show dBC/dBA differences for standard and silenced portable air compressors, respectively. As shown, dBC/dBA differences up to 28 dB are noted for silenced models. Figures 8-1 and 8-2 give insight into the cause for the greater dBC/dBA difference for the silenced models. In the figures it is shown that a lower dBA level for the silenced unit has been achieved by a shift of peak sound levels to the low-frequency range. Note that while the A-weighted sound level of a compressor has been reduced by 5 dB (standard to silenced) the C-weighted value has been reduced by only 1 dB as a result of the different weighting characteristics of the A and C networks.

Since (1) an A-weighted noise reduction does not necessarily imply an attendant C-weighted reduction and (2) there may arise a need to control the C-weighted level of compressor noise, Figure 7-7 was prepared from the data of Tables 7-10 and 7-11 to give insight into achievable C-weighted levels. The line in Figure 7-7 represents a best-fit curve through the data points and indicates that a dBC minus dBA limit of 20 dB would be a reasonable control limit.

ACOUSTIC VALUE OF PORTABLE AIR COMPRESSOR DOORS

At a construction job site, portable air compressor equipment compartment doors are sometimes left open because of the operators' misguided intent of furnishing more engine and compressor cooling. Actually, portable air compressors are designed to provide adequate cooling with the access doors closed. Since closed access doors eliminate a direct line of sight to the engine (which is the major source of noise), an escalation of portable air compressor noise is expected to occur when the doors are left open.

Table 7-10

COMPARISON OF dBA LEVELS WITH dBC LEVELS OF STANDARD PORTABLE AIR COMPRESSORS

Manufacturer	Model	S/N	cfm	dBC Level Minus dBA Level* dB
Atlas Copco	VT85Dd	ARP203149	85	11
Atlas Copco	ST-48	51-232751	160	8.5
Atlas Copco	ST-95	51-274977	330	9.5
Ingersoll-Rand	DXL750	77380	750	5
Ingersoll-Rand	DXL900	75847	900	3
Ingersoll-Rand	DXLCU1050	75613	1050	7
Ingersoll-Rand	DXL1200	74430	1200	3
Jaeger	E	RC32032	85	12.5
Jaeger	A	RS32189	175	13.5

*Average levels at 7 meters

Table 7-11

COMPARISON OF dBA LEVELS WITH dBC LEVELS
OF SILENCED PORTABLE AIR COMPRESSORS

Manufacturer	Model	S/N	cfm	dBC Level Minus dBA Level* dB
Atlas Copco	VS85	ARP203903	85	16.0
Atlas Copco	STS35Dd	ARP550924	125	23.5
Atlas Copco	VSS125Dd	51-345060	125	28.0
Atlas Copco	VSS170Dd	51-235072	170	21.0
Worthington	160G/2QT	821478	160	15.0
Gardner-Denver	SPHGC	629717	185	12.0
Gardner-Denver	SPQDA/2	608227	750	7.5
Worthington	750QTEX	848-019	750	10.5
Ingersoll-Rand	DXL 900S	73693	900	7.7
Ingersoll-Rand	DXL 900S	74050	900	6.9
Ingersoll-Rand	DXL 900S	74051	900	7.8
Ingersoll-Rand	DXL 900S	740471	900	7.5
Gardner-Denver	SPWDA/2	635851	1200	10.0

*Average levels at 7 meters

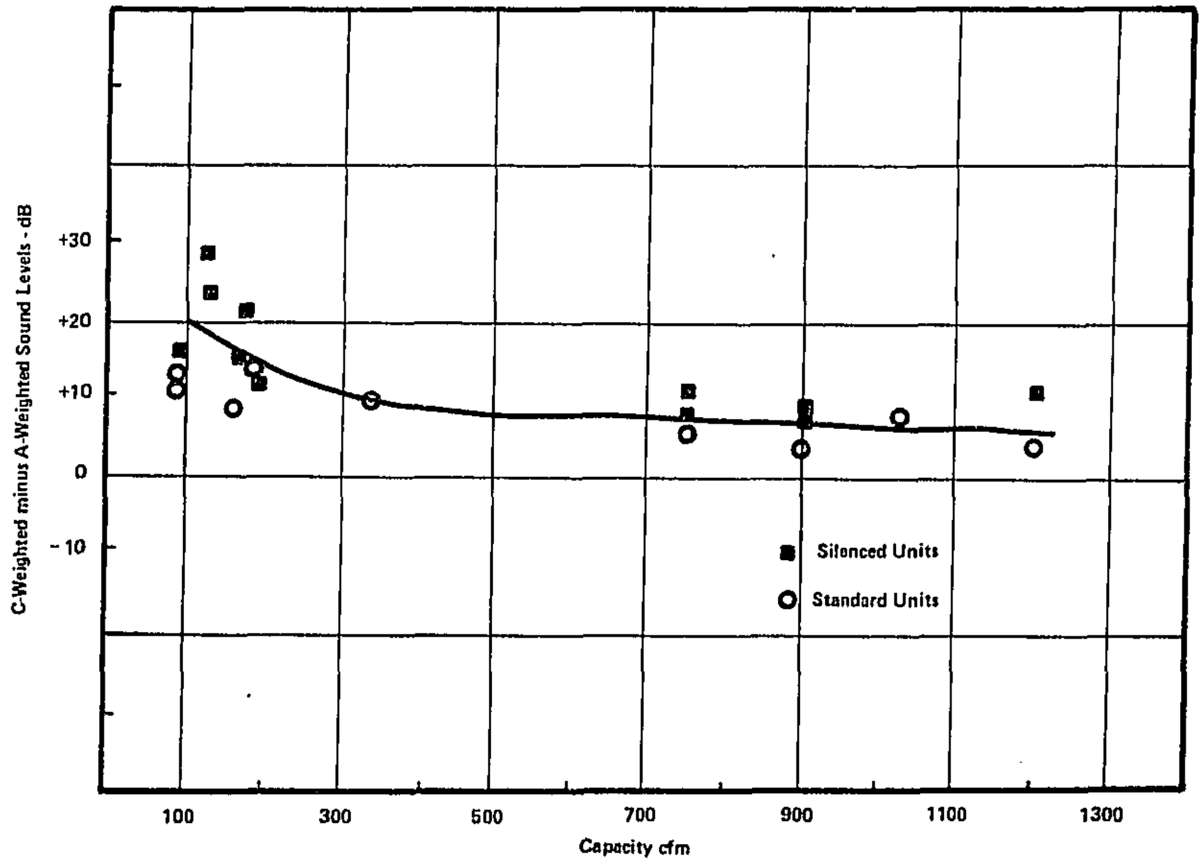


Figure 7-7. Portable Air Compressor C-Weighted minus A-Weighted Levels Versus Capacity - CFM

Six tests were conducted (three of the standard units and three of silenced units) to assess the magnitude of escalation of portable air compressor noise due to opening the access doors. Table 7-12 presents the results of the tests of the standard units. Shown is a noise increase of up to 5 dB.

Table 7-12

EFFECT ON STANDARD PORTABLE AIR COMPRESSOR NOISE OF OPENING THE EQUIPMENT COMPARTMENT ACCESS DOORS

Manufacturer	Model	A-Weighted Increase, dBA*
Ingersoll-Rand	DXL 1200	5.0
Jaeger	A	1.5
Jaeger	E	1.5

* Difference in level at the right side of the unit between door open and closed position.

Table 7-13 lists the results for the silenced units. Shown is an increase up to 12 dBA when the access door of the Worthington 750 QTEX was left open.

Table 7-13

EFFECT ON SILENCED PORTABLE AIR COMPRESSOR NOISE OF OPENING THE EQUIPMENT COMPARTMENT ACCESS DOOR

Manufacturer	Model	A-Weighted Increase, dBA
Worthington	160 QT	5.0
Atlas Copco	VSS170Dd	11.0
Worthington	750 QTEX	12.0

In view of the data of Tables 7-12 and 7-13, portable air compressor equipment compartment access doors must remain closed during compressor operation to preclude acoustic degradation.

PORTABLE AIR COMPRESSOR NOISE PROPAGATION

If the propagation of sound from compressors to points more than several hundred feet distant is of concern, then meteorological factors, i.e., wind, temperature, humidity, and precipitation, may play a significant role. In addition, obstacles and variations in ground cover may also be important. For shorter distances, the propagation may be complicated by interference phenomena between the sound waves radiating directly from a source and those reflected from nearby surfaces, especially the ground [19, 20, 21].

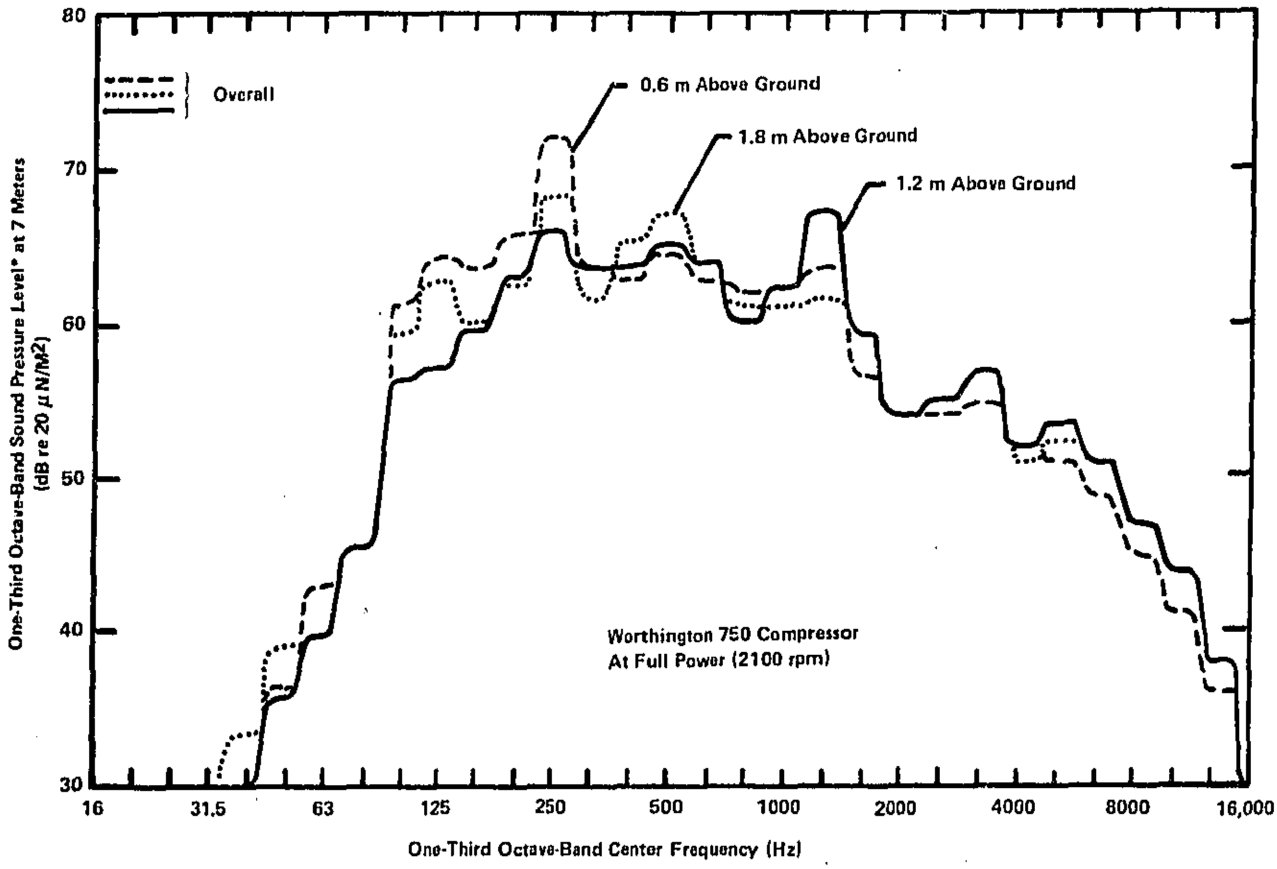
Ground Reflections

Contributions arising from constructive/destructive interference between direct sound waves and sound waves reflected from the ground plane at measurement positions have been evaluated. Figure 7-8 shows A-weighted noise measured 7 meters away from a compressor at various heights above the ground. While sound levels may vary in some 1/3 octave-bands as much as 7 dBA from one height to another, the variation in overall sound level is ± 1 dBA from the central position.

The effect of ground reflections on the measured sound levels at the 7-meter positions appear to be "averaged out" by the spatial distribution of the individual noise-generating components of the compressor. Thus, it is concluded that at 7 meters ground reflections do not modify the overall measured sound levels.

Path Discontinuities

As compressor noise propagates away from the source, propagation path discontinuities can affect the sound waves. The six configurations in Figure 7-9 comprise those typical at construction sites. The half space shown in this figure represents the area surrounding a compressor during testing per ISO-2151-1972 or when used during construction in residential or light-industrial areas. Sound propagating in a half space is subject to the interference effects discussed previously. When a compressor in a residential or light-industrial area is next to a building, the buildings usually are far enough apart to be described by the "L" space in Figure 7-9. Anderson [22] reported that sound propagates in an "L" cross section as it does in free space. The sound level at a point in an "L" space is expected to be on the order of



*Sound was prefiltered by A-weighing network prior to 1/3 octave band analysis.

Figure 7-8. Effect of Microphone Height on A-Weighted Sound at 7 Meters

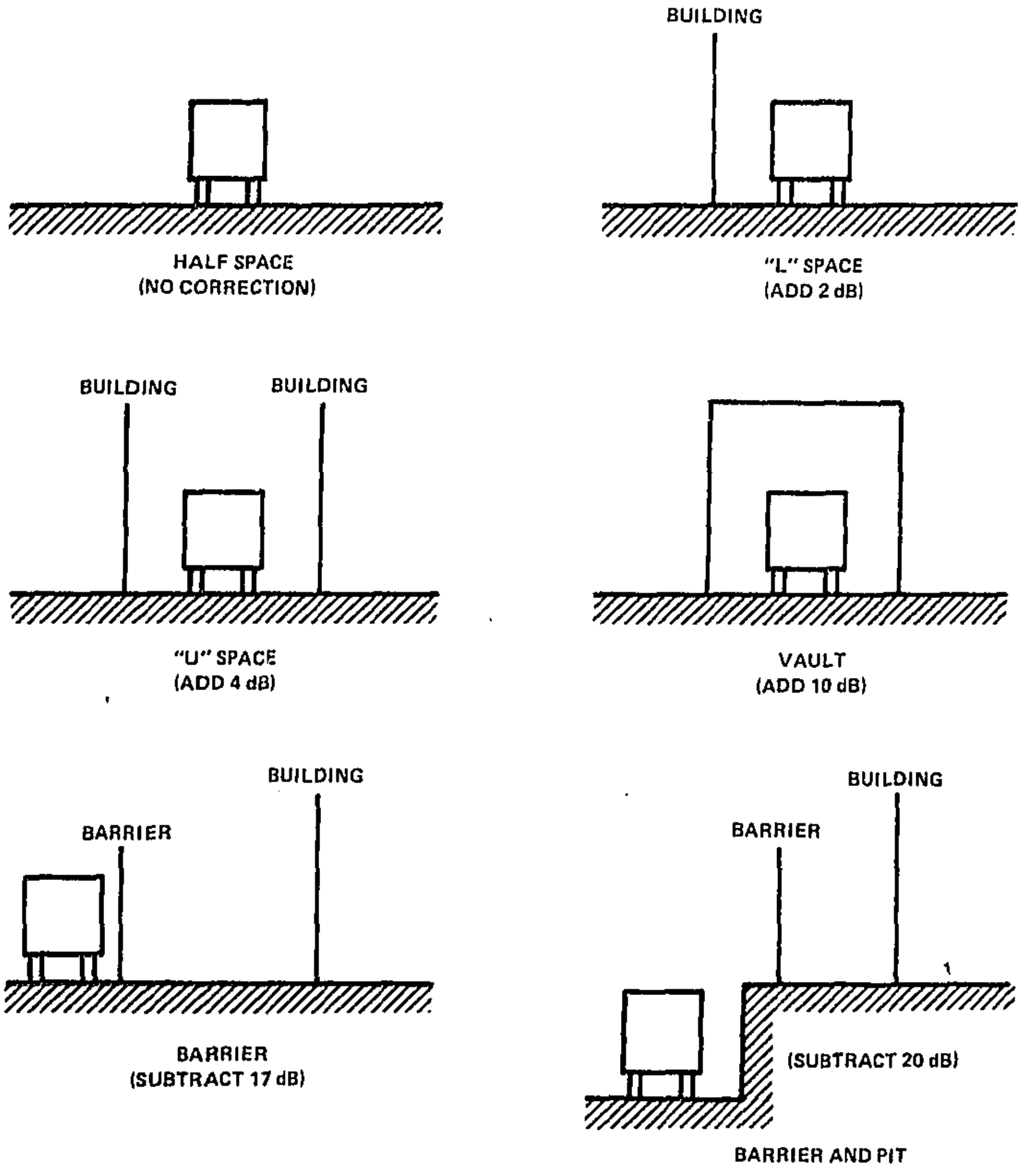


Figure 7-9. Configurations of Locations of Compressors at Construction Sites (Corrections are for half space sound levels measured at 7 meters from the machine surface.)

3 dB higher than the sound level measured at the same point in a free field over a reflecting plane, because the sound energy is concentrated in a smaller volume in an "L" space than in a half space. Francois and Fleury [19] measured a corresponding 2-dB increase in compressor noise in an "L" space.

The "U" space in Figure 7-9 is representative of city "canyons," formed by a street or alley and the vertical walls of nearby buildings. Appendix A of Reference 10 discusses the propagation of sound in city canyons in more detail and also includes the results of calculations carried out using an extension of the theory of Weiner, *et al* [23]. The theory shows that a nondirectional source produces sound levels in a typical city canyon that are 6 dB higher 100 feet from the source than the levels present in a half space. Francois and Fleury [19] measure a corresponding 4 dB increase for a "U" space of different dimensions from the "U" space analyzed in Appendix A of Reference 6.

There is some concern that the sound levels experienced in the upper stories of city buildings might be unusually high if the observers are located above a compressor with pronounced vertical directivity, particularly if the compressor sound is confined within a city canyon. However, Appendix A of Reference 6 shows that an air compressor radiating sound four times as efficiently (in terms of intensity) in the vertical direction than it does in the horizontal direction would expose people in city buildings to less than 4 dB higher sound levels than an air compressor that uniformly radiates an amount of sound energy. Thus, this assertion does not appear to be valid.

A compressor operated under a bridge or overpass can be described in terms of the vault space in Figure 7-9. The sound levels generated in such a space can be more than 10 dB higher than the sound levels generated in a half space.

The barrier and pit configurations depicted in Figure 7-9 are typical of construction sites in cities. Usually the construction of a building in a city center begins with the erection of a tall broad fence. During the initial ground breaking, compressors operate at ground level behind the fence. As excavation proceeds, compressors operate within the pit dug for the basement floors. Calculations presented in Appendix B of Reference 24 show that pits and barriers can reduce the noise levels experienced by outdoor ground level observers by as much as 20 dB below the levels experienced in an unobstructed half space. The benefits to upper story observers in buildings across the street depend on the construction stage, the observer's elevation and on whether there are vertical reflecting surfaces in addition to those shown in the barrier configurations in Figure 7-9.

Section 8

AVAILABLE NOISE CONTROL TECHNOLOGY

UNITED STATES TECHNOLOGY

In 1968, a major manufacturer of portable air compressors demonstrated significant noise reduction by the use of muffling devices and acoustic enclosures [25, 26]. Since then, numerous manufacturers in the United States and abroad have applied various degrees of noise control technology and have reduced portable air compressor noise. Figures 8-1 and 8-2 show two examples of effective noise control. In this section, the current state-of-the-art of compressor noise control is discussed and noise control techniques are summarized.

Most large air compressors are diesel-engine driven, screw-type compressors. The intermediate sizes are diesel and gasoline-engine driven, screw- and rotary- type compressors, while the smaller types are primarily gasoline-engine driven, screw-, rotary-, and reciprocating- type compressors. For all standard types, the major noise sources are the driving engine and the fan associated with the engine and compressor cooling air system. A description of the various types of compressors is contained in References 5 and 6.

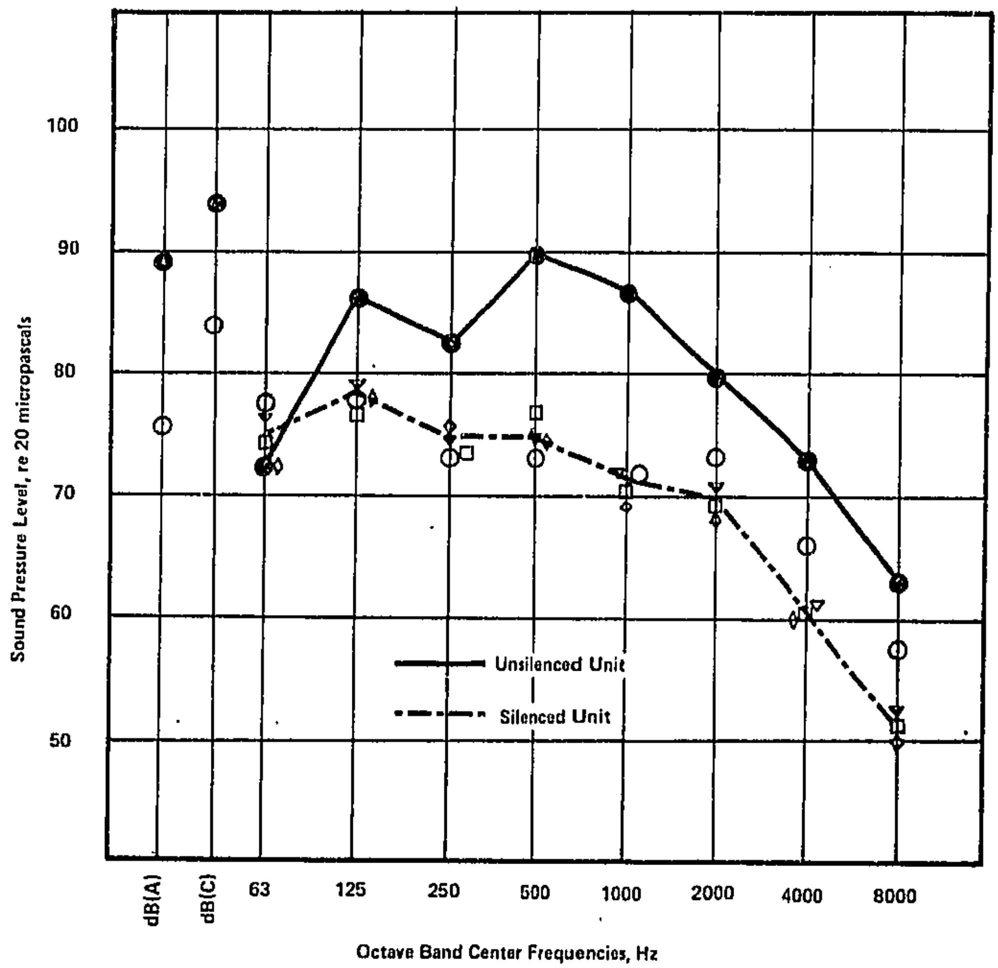
Application of acoustic insulation, effective mufflers, shock mounts, damping material, and some fan, cowling, and duct hardware modifications/improvements generally describe the technology used to quiet compressors. Use of this technology has produced the mean noise reductions listed in Table 8-1.

The values listed in Table 8-1 may be compared with the potential for noise reduction discussed in Reference 3. As indicated in Reference 3, the potential noise reduction was 5 dB and 10 dB by the use of improved intake silencers and engine mufflers, respectively. Note that the 5 dB and 10 dB noise reductions are not additive, because the total noise reduction is dependent upon individually reducing the noise level of all the major sources of noise. To determine more accurate potential noise reduction capabilities for compressors, a study was conducted of the three quieted units:

1. A gas engine powered air compressor.

2. A diesel engine powered air compressor of less than 500 cfm capacity.

3. A diesel engine powered air compressor of greater than 500 cfm capacity.



NOTES: (1) CAGI/PNEUROP Position 10
(2) 900 cfm, 125 psi

Figure 8-1. Noise Control Applied to the Ingersoll-Rand Model DXL 900

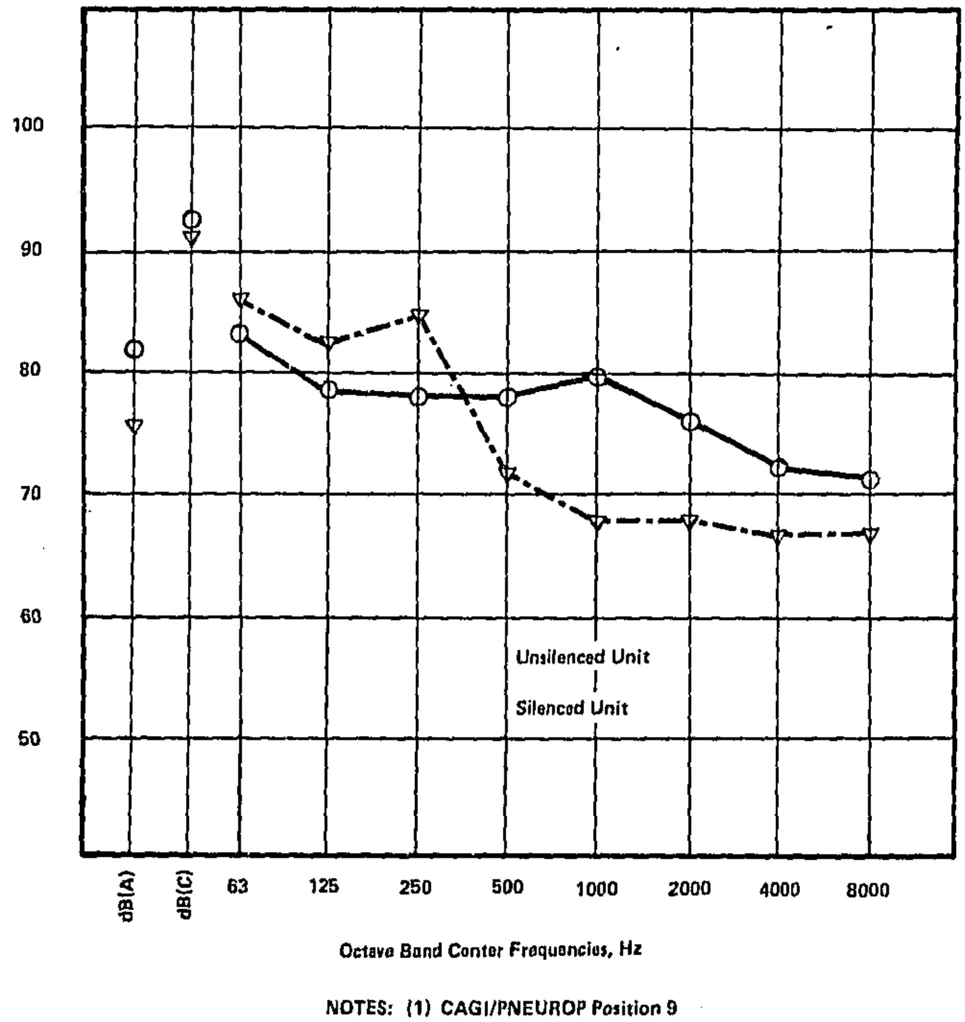


Figure 8-2. Noise Control Applied to the Atlas-Copco Model VT85 Dd

Table 8-1

MEAN NOISE REDUCTION BETWEEN "STANDARD," "QUIETED," AND "QUIETEST" UNITS

	Gasoline	Diesel Below 500 cfm	Diesel Above 500 cfm
Standard to quieted units	6.7 dB	9.7 dB	14.1 dB
Quieted to quietest units	3.8 dB	6.4 dB	5.2 dB

The purposes of the study were to determine the major sources contributing to compressor noise, the effectiveness of the noise control techniques currently used by manufacturers, and the evaluation of additional noise control required to reduce each unit's noise to 65 dBA, measured at 7 meters from the unit.

Gas Powered Engine Compressor

A Worthington 160 QT was selected for analysis. Significant noise sources of this unit are the compressor, the engine and its cooling fan, the exhaust and muffler shells, and the air intake [7].

The engine and compressor assembly radiate noise directly, with the compressor assembly somewhat attenuated by the surrounding air-oil tank. In addition, since they are rigidly attached to the chassis and shell of the machine, both engine and compressor vibrations are transmitted directly to the frame and outer sheetmetal, which also vibrate and radiate noise.

The engine cooling fan can produce considerable broadband noise as the result of fan design practices that would cause excessive turbulance of the air surrounding the fan. In addition to generating noise, such practice would also reduce efficiency of both the fan and the overall cooling system.

The engine exhaust and muffler arrangement radiate noise via an airborne path through the muffler exhaust gas-flow path and via the structure (shell) surrounding the muffler. The air-intake system supplies air for the engine and compressor through a common air filter and silencer. The two air-induction-pressures combine to form a separate noise source.

The noise level at 7 meters to the right side of the "as sold" unit was 76 dBA. The contribution of the principal noise sources to this level are tabulated in Table 8-2.

Table 8-2

WORTHINGTON COMPRESSOR 160 QT COMPONENT NOISE LEVELS

Component	dBA
Engine and compressor casing	74
Engine cooling fan	69
Muffler shell	66
Exhaust,	62
Intake	61

The individual noise sources were carefully studied to determine the methodology to further reduce the unit's noise level to the 65 dBA study level. Table 8-3 lists one combination of noise control techniques and anticipated attendant noise reductions that, when analytically combined with the compressor noise producing component source levels, may result in a portable air compressor with a noise level of 65 dBA at 7 meters.

Diesel Powered Compressor, Less Than 500 cfm

The quieted Atlas Copco Super Silensair VSS170 Dd was selected for analysis [7]. This unit produces approximately 72 dBA at a distance of 7 meters from the unit. The analysis of the units's noise signature indicates that the principal noise sources are the engine casing, engine exhaust, engine air intake, compressor casing, and compressor cooling fan, each of which produce the sound levels at 7 meters listed in Table 8-4.

Midfrequency silencing is achieved by use of an enclosure having sidewalls and end doors lined with a foam-type acoustic absorption material. The enclosure has built-in

Table 8-3

PORTABLE AIR COMPRESSOR NOISE REDUCTION

Source	Noise Control Technique	Noise Reduction
Engine and compressor casing	Vibration isolation plus increased transmission loss through side doors	14 dB
Engine cooling fan	Shroud redesign, blade twist and reduced fan speed	11 dB
Muffler shell	Lagging with acoustic insulation	10 dB
Exhaust	Additional muffling	5 dB
Intake	Improved silencer	4 dB

Table 8-4

ATLAS COPCO COMPRESSOR (VSS170 Dd) COMPONENT NOISE LEVELS

Component	dBA
Engine casing	63
Engine exhaust	60
Engine intake	61
Compressor casing	64
Compressor cooling fan	63

ducting for the engine and compressor air intake and cooling. Cooling air exhausted from the diesel engine, the compressor and intercooler, is ducted through another part of the enclosure prior to discharge. These ducts are primarily effective in blocking direct, line-of-sight, internal noise radiation from the engine and compressor to the ambient. An additional reduction of 5 to 7 dB in radiated sound could probably be obtained by employing the following noise reduction techniques:

- Application of damping material to the enclosure panels; damping will reduce panel vibration levels and improve panel transmission loss due to the added mass.

- Increasing the internal sound absorption by (a) treating a larger amount of the internal surface area and (b) using a thicker absorptive material.

  NOTE: The absorptive material should be treated to prevent degradation due to oil/fuel contamination.

- Use of a more effective vibration isolation mount to decouple the engine and compressor from the chassis.

- Use of a more effective diesel exhaust muffler.

By using the preceding noise control techniques, a 7 dB overall reduction in a compressor noise level of 65 dBA at 7 meters may result.

Diesel Engine Powered Air Compressor Greater Than 500 cfm Capacity

The "Blue Brute" 750-QTEX single stage, portable, rotary screw compressor manufactured by Worthington CEI was selected for study [7]. The 750-QTEX is a unit silenced to produce 75 dBA at 7 meters. Among diesel powered compressors delivering greater than 500 cfm, the 750-QTEX is one of the quietest; it is only 1.5 dB noisier than the mean for the lowest decile.

The technology by which the 750-QTEX has been quieted is also characteristic of the quietest compressors in its category. It has rubber engine mounts, nonrigid hose coupling, sealed doors, damped panels, interior sound absorption, silenced fan louvers for cooling air intake and exhaust, two-stage custom designed muffler, bottom pan, and a special cooling fan. Principal sources of the noise are listed in Table 8-5 along with their individual noise levels.

Table 8-5

WORTHINGTON COMPRESSOR 750 QTEX COMPONENT NOISE LEVELS

Component	dBA
Engine and compressor casing	69
Engine cooling fan	62.5
Muffler shell	70
Exhaust outlet	67

The 750-QTEX enclosure presently provides adequate noise reduction of engine and compressor airborne sound, except at the cooling air intake and exhaust ducts. Additional noise reduction is possible with design improvement of both the ducts and the material used for acoustic absorption [7].

EUROPEAN TECHNOLOGY

Atlas Copco and CompAir compressors use a double-wall enclosure that serves as an air duct and silencer as well as a barrier to engine and compressor radiated noise. All the "Super Silenced" Atlas Copco air compressors are of the reciprocating type. Discussions with Atlas Copco indicate that reciprocating air compressors are more efficient, with less heat rejection. Atlas Copco uses air cooled engines with cooling fans built in, which demonstrate a much better performance than the fans measured on domestic air compressors. CompAir compressors use a sliding vane or rotary screw type compressor with a water cooled Perkins diesel engine. The pusher type fan is well shrouded. Proper air flow through either unit requires door-shut type operation. The noise control technology used in Europe is similar to that used in the United States, but a more systematic approach is applied to quieting air compressors. Noise control design is more from the frame up and uses an integrated approach rather than merely adding on quieting components. Foreign "super silenced" air compressors tend to have a boxy look.

To achieve low noise levels, enclosures should be absolutely sealed under operation in order to avoid noise leaking out through even small openings. It has been reported that large compressors emitting less than 65 dBA under full power are already on the market[27].

Section 9

ECONOMIC STUDY

Section 6 of the Noise Control Act of 1972 provides that the Administrator of the Environmental Protection Agency (EPA) shall establish noise emission standards (when feasible) for products that are found to be major sources of noise and which fall into specific product categories. Construction equipment is one such category and the portable air compressor is a piece of equipment in that category.

Section 6 further states that the regulation:

> shall include a noise emission standard which shall set limits on noise emissions from such product and shall be a standard which . . . is requisite to protect the public health and welfare, taking into account the magnitude and conditions of use of such product . . . the degree of noise reduction achievable through the application of the best available technology, and the cost of compliance . . . Any such noise emission standards shall be a performance standard. In addition, any regulation . . . may contain testing procedures necessary to assure compliance with the emission standard in such regulation, and may contain provisions respecting instructions of the manufacturer for the maintenance, use, or repair of the product.

To address the potential economic impact of noise emission regulations upon the various affected societal units (industry, user, suppliers), EPA acquired data on the pricing characteristics, dollar sales, and unit sales of the portable air compressor manufacturing industry. Additional information was developed on the costs of quieting portable air compressors using the current production technology and on the best available quieting technology. The major conclusions of the economic impact analysis performed with these data are presented in this section.

The objective of the analysis was to assess the economic impact of the adoption of alternate noise emission standards for the portable air compressor industry. This assessment included consideration of the impact on raw material and component suppliers, distributors, manufacturers, and users, and the general public. The impact on key governmental policy concerns such as employment and the balance of trade was also assessed.

INDUSTRY BACKGROUND

Dollar Sales

Sales of portable air compressors are sensitive to government and private construction activity. Sales of large units have historically followed trends in the construction industry, while smaller units have followed the general economy. Dollar value of portable air compressor shipments has fluctuated between $58.7 million and $89.7 million during the years 1967 through 1972.

Table 9-1 presents the value of total portable air compressor shipments during 1967 through 1972. The data of Table 9-2 were derived from information made available by the Compressed Air and Gas Institute and the Department of Commerce. The derivation of these data is discussed in Reference 8.

Table 9-1

ESTIMATED DOLLAR VALUE OF ANNUAL SHIPMENTS OF PORTABLE AIR COMPRESSORS: 1967-1972

Year	Value of Shipments (millions)
1967	$58.7
1968	59.9
1969	75.3
1970	70.3
1971	74.1
1972	89.7

Portable Air Compressor Prices

The Bureau of Labor Statistics maintains wholesale price indices on two capacity classes of portable air compressors, 100 to 300 cfm and 600 cfm. The price indices for both classes fell between February 1968 and February 1972 (13 and 11 percent, respectively) By May 1975, prices for both classes had risen substantially, 22 percent for the smaller compressors and 35 percent for the larger ones. Table 9-2 presents average list prices of portable

Table 9-2

ESTIMATES OF PORTABLE AIR COMPRESSOR
AVERAGE 1975 LIST PRICES

Capacity (in cfm) and Power Source Type	Estimated Average List Price
75 - 124 Gas	$ 5,667
124 - 250 Gas	7,867
124 - 250 Diesel	9,614
251 - 750 Diesel	35,661
600 - 899 Diesel	60,493
900 and over Diesel	87,588

air compressors by power source and rated air flow capacity computed from data collected by EPA in the spring of 1975.*

Percent Distribution by Type Compressor

The portable air compressors currently manufactured are primarily powered by gasoline or diesel engines. Three basic types of compressors are used in portable air compressors: rotary screw, sliding vane, and reciprocating. Table 9-3 illustrates the distribution of engine and compressor type according to engine capacity.

Unit Sales

Data on total unit shipments tabulated in Table 9-4 presents another picture of the portable air compressor market. From 1967 through 1972, portable air compressors experienced moderate by cyclical growth, averaging approximately 3 percent annually. Sales surged dramatically from 1972 to 1973, increasing by approximately one third. Although recent sales data are not available, it is understood that the surge continued into 1974.

*All portable air compressor pricing is based on discounts from published list prices. The manufacturers published discount schedule typically ranges from 20 to 25 percent. However, discounts to distributors can vary from 15 to 45 percent, depending on volume and other transaction factors.

Table 9-3

DISTRIBUTION OF ENGINE TYPES AND COMPRESSOR DESIGN TYPES
ACCORDING TO RATED ENGINE CAPACITY IN CFM AT 100 PSIG

Compressor Type	75-200 cfm			201-500 cfm			Above 500 cfm		
	Gasoline	Diesel	Gasoline and Diesel	Gasoline	Diesel	Gasoline and Diesel	Gasoline	Diesel	Gasoline and Diesel
Reciprocating	16.6%	10.3%	26.9%	0%	30.8%	30.8%	0%	6.8%	6.8%
Vane	25.6%	19.2%	44.8%	10.3%	33.3%	43.6%	0%	17.0%	17.0%
Screw	15.4%	12.8%	29.2%	2.6%	23.1%	25.7%	0%	76.3%	76.3%
All types	57.6%	42.3%	99.9%	12.9%	87.2%	100.1%	0%	100.1%	100.1%

Table 9-4

UNIT SALES OF PORTABLE AIR COMPRESSORS,
1967 - 1973

Year	Rated Air Flow Capacity		Total
	Below 251	Above 250	
1967	8,313	1,656	9,969
1968	8,156	1,563	9,719
1969	9,586	1,691	11,277
1970	9,233	1,740	10,973
1971	8,138	1,763	9,901
1972	10,183	1,971	12,154
1973	13,286	2,697	15,983

Table 9-5 presents 1972 portable air compressor sales by power source type and capacity.

Table 9-5

PORTABLE AIR COMPRESSOR 1972 SALES BY POWER SOURCE TYPE AND CAPACITY CATEGORY

Power Source Type and Capacity cfm	Unit Shipments	Total
75 - 124 gasoline	3,082	25.4
125 - 250 gasoline	4,827	39.7
125 - 249 diesel	2,101	17.3
250 - 599 diesel	576	4.7
600 - 899 diesel	1,095	9.0
900 and over diesel	473	3.9
Total	12,154	100.0

Price Per CFM

In its initial assessment of the portable air compressor market EPA divided compressors into six categories based on engine type, rated air flow capacity, and whether or not they were standard or quieted units. This division was made to get a definitive picture of price and sound level differentials.

Table 9-6 presents a summary of the state of noise emissions and price of portable air compressors in 1973, showing, for each category, the mean price per cfm and sound levels at 7 meters (measured according to ISO 2151-1972).

The price differential between standard and quieted compressors is greatest for the larger (i.e., above 250 cfm) compressors. The sound levels of both standard and quieted versions of the large compressors are presented in the table.

Table 9-6

NOISE EMISSIONS AND 1973 PRICE PER RATED cfm OF STANDARD AND QUIETED VERSIONS OF PORTABLE AIR COMPRESSORS OF THE SAME MODEL

	Gasoline Driven		Diesel Driven			
			Below 251 cfm		Above 250 cfm	
	Standard	Quieted	Standard	Quieted	Standard	Quieted
Number of Units	23	23	21	22*	24	24
Mean Price Per cfm	$38.83	$42.51	$45.91	$49.51	$44.20	$49.53
Mean SPL at 7m (dBA)	84.1	76.5	84.3	76.6	92.2	78.3
Price Increase, Standard to Quiet:						
Amount	$3.76		$3.60		$5.33	
Percent	9.5		7.8		12.1	

*Includes one model that had two quieted versions.

REGULATORY OPTIONS INVESTIGATED

In an initial analysis, noise levels associated with three broad categories of portable air compressor capacities were evaluated to assess the attendant impacts associated with the application of quieting technology. The levels selected for study were based on noise emission data of 194 portable air compressors, which represented about 55 to 65 percent of the models offered for sale. The levels selected for study are listed in Table 9-7 along with underlying rationale for their selection.

Table 9-7

INITIAL SOUND LEVEL LIMITS SELECTED FOR STUDY

	Gasoline Driven All cfm Ratings	Diesel Driven Below 501 cfm	Diesel Driven Above 500 cfm
Level One	76 dBA	76 dBA	76 dBA
Level Two	73 dBA	70 dBA	73 dBA
Level Three	65 dBA	65 dBA	65 dBA

Note: Levels constitute a "not to exceed" criteria.

Subsequent analysis considered the cost and economic impacts of several regulatory options, the primary dimensions of which were the maximum allowable sound pressure level (76 dBA or 78 dBA) and the time allowed for compliance. These options are listed in Table 9-8 and include lead times to compliance ranging from 12 to 30 months. Available data are not sufficient to allow an analysis of the sensitivity of the direct cost of compliance to variation in the lead time (e.g., the addition to costs of achieving compliance in 18 months instead of 30 months).

Consideration of the adjustments required for manufacturers to achieve compliance and estimates provided by BBN [7] suggest a lower bound on the time required for orderly adjustment of 12 to 15 months and an upper bound of 24 to 30 months. The manufacturer adjustments referred to include the acquisition of such new components as quieter engines, better mufflers, and new acoustical enclosures in addition to the design modifications required to incorporate these new components into the air compressors.

Table 9-8

REGULATORY OPTIONS

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)
1	All	76	12
2	All	76	18
3	All	78	18
4	Under 251 Above 250	76 76	18 24
5	Under 251 Above 250	76 76	12 24
6	Under 251 Above 250	76 78	12 18
7	Under 251 Above 250	76 76	12 18
8	Under 251 Above 250	76 78	18 24
9	All	76	24
10	All	78	24
11	Under 251 Above 250	 76	24 30
12	Under 251 Above 250	76 78	24 30

In the spring of 1975, EPA conducted a survey of the portable air compressor industry to obtain estimates of the time required to achieve compliance with the 76 dBA and 78 dBA standards. The resulting data, presented in Table 9-9, shows the percent noise impact reduction, the average percent list price increase, the annual aggregate increase in purchase cost, and the first year annualized user costs that would accrue as a result of each regulatory option.

The table also presents the percentage of units in each major capacity class, that would be brought into compliance in the time frame specified for each regulatory option. The major finding of the industry survey was that a significant number (59 percent) of portable air compressors could not be made to comply with a 76-dBA standard in the 12 months (option 1) specified in the proposed rulemaking for portable air compressors (*Federal Register*, October 29, 1974). The additional analysis performed was limited to regulatory options allowing, at a minimum, 18 months' lead time for compliance.

IMPACTS ON LIST PRICES OF ALTERNATIVE NOISE EMISSION STANDARDS

Two procedures were used to evaluate the impact of possible increases in list prices resulting from the adoption of noise emission standards. For the first procedure, data presented in Table 9-6 were used to estimate the percent increase in prices resulting from quieting standard portable air compressors to the average sound level of quieted (76 or 77 dBA for most engine/capacity classes). The second procedure (based on a regression analysis of the data listed in Table 9-6) was used to estimate the price effects of additional quieting down to a sound pressure level of 73 dBA.* Each evaluation is based on an analysis of matched pairs, i.e., pairs of portable air compressor models in which the first model of each pair is a standard unquieted version and the second model is a quieted version.**

The estimates of price impacts given in this report should be interpreted as applying to a lead time that allows orderly adjustments, corresponding to the conditions presumably reflected in the list price/sound level data used for the estimates. The term orderly adjustment, as used here, implies that sufficient lead time to compliance has been allowed so that there are no serious adverse impacts on manufacturers, suppliers, or users that could be avoided by a reasonable extension of the time to compliance. In other words, there would be no plant shutdowns, serious supplier or user disruptions, or precipitous changes in market

*73 dBA corresponds to a 76 dBA emission standard and a 3 dBA production tolerance.
**See Reference 33 for a more complete description of the methodology.

Table 9-9

IMPACT OF PORTABLE AIR COMPRESSOR NOISE EMISSION REGULATION

Option	cfm	SPL dBA	Time Months	Health & Welfare	Cost of Compliance				
				Noise Impact Reduction[1] (%)	Average List Price Increase %	Annual Aggregate Increase In Purchase Cost[3] $ Million	1st Year User Annualized Costs[4] $ Millions	Potential Percent of Compressors Not Ready for Sale	
								≤250 cfm	>250 cfm
1	All	76	12	14.7	(16)[2]	(22)[2]	(3.8)[2]	54	80
2	All	76	18	14.7	12.3	25.0	5.0	21	57
3	All	78	18	14.0	10.0	20.3	4.1	1	47
4	≤250 >250	76 76	18 24	14.7	12.3	25.4	5.1	21	16
5	≤250 >250	76 78	12 24	14.7	12.3	25.4	5.1	54	16
6	≤250 >250	76 78	12 18	14.6	11.2	23.4	4.7	54	47
7	≤250 >250	76 76	12 18	14.7	12.3	25.4	5.1	54	57
8	≤250 >250	76 78	18 24	14.6	11.2	23.4	4.7	21	10
9	All	76	24	14.7	12.3	25.0	5.0	0	16
10	All	78	24	14.0	10.0	20.3	4.1	0	10
11	≤250 >250	76	24 30	14.7	12.3	25.4	5.1	0	0
12	≤250 >250	76 78	24 30	14.6	11.2	23.4	4.7	0	0

1 Baseline is 27.4 million people exposed to construction site noise with levels above 55 L_{dn}.

2 These numbers were derived on the premise that manufacturers could accomplish the redesign of their entire product line in 12 months. According to new data and information acquired, this assumption and resulting estimates based on it are in error.

3 Based on estimated $206 million in sales in 1977-1978.

4 Based on estimated 10% depreciation and an estimated 10% cost of financing.

shares that result from a severe increase in adjustment costs to a manufacturer and that could be substantially reduced if the manufacturer had additional lead time to bring his product line into compliance.

Estimates were made assuming not-to-exceed sound level standards of 78 and 76 dBA (at 7 meters) and production tolerances of both 2 and 3 dBA. These standards and production tolerances result in four production sound level targets:

1. 76 dBA = 78 dBA standard with a 2 dBA tolerance

2. 75 dBA = 78 dBA standard with a 3 dBA tolerance

3. 74 dBA = 76 dBA standard with a 2 dBA tolerance

4. 73 dBA = 76 dBA standard with a 3 dBA tolerance

The resulting estimated percent increases in list price associated with the sound level targets are listed in Table 9-10.

Table 9-10

ESTIMATED PORTABLE AIR COMPRESSOR LIST PRICE INCREASES
BY MAJOR ENGINE/CAPACITY CLASS AND ALL MODELS

SPL Target	Percent Increase in Price			
	Gasoline	Diesel Below 251 cfm	Diesel Above 250 cfm	All Models
76 dBA*	8.5%	7.0%	11.4%	10.0%
75 dBA**	10.3	8.2	12.1	11.1
74 dBA*	12.1	9.6	13.0	12.3
73 dBA**	14.2	10.9	13.9	13.6

*2 dBA tolerance
**3 dBA tolerance

For compressors with rated capacity above 250 cfm, the estimates given in Table 9-10 used data that excluded 600 cfm compressors. The reason for this exclusion is that compressors with 600 cfm and 750 cfm rated air flow appear to be relatively close performance substitutes for each other, and the data suggest substantially more quieting experience and lower incremental costs of quieting for the 750 cfm machines. Should the cost differential persist, one may anticipate a substantial shift of market shares away from 600 cfm compressors in favor of the 750 cfm machines. The estimates are made under the assumption that 600 cfm machines either adopt the cost-of-quieting characteristics of or are replaced in the market by the 750 cfm machines.

An additional set of estimates was computed to test the sensitivity of the results to the use of less optimistic assumptions; that is, the 600 cfm compressors retain their share of the market and remain relatively expensive to quiet. Table 9-11 lists the estimated list price increases resulting from the less optimistic assumption. For comparative purposes, list price increases associated with the more optimistic approach are also listed in the table.

Table 9-11

COMPARISON OF ESTIMATED PORTABLE AIR COMPRESSOR LIST PRICE INCREASES DERIVED UNDER TWO ASSUMPTIONS

SPL Target dBA	Percent List Price Increase for Compressors Above 250 cfm	
	Assumption 1*	Assumption 2**
73	13.9	19.4
75	12.1	16.4

*600 cfm compressors replaced by 750 cfm units.
**600 cfm compressors retain their market share.

As was mentioned earlier, there are significant differences between the list prices and actual transaction prices of portable air compressors. Discounts from list prices of up to 45 percent are reportedly common. Ideally, the estimates should be based on actual transaction prices. Also, the sound level and price data are 2 years old. Portable air compressor prices have increased substantially during this period, and it is likely that the price behavior of quieted and standard models have not always coincided. Additionally, the industry has 2 years of quieting experience not reflected in the data.

It is not now possible to assess the effect that improved data would have on these estimates; however, there is no reason to believe that better data would show a significant increase in the estimated price impacts given.

ECONOMIC IMPACTS OF ALTERNATIVE REGULATORY OPTIONS

The economic impact analysis that follows is built upon the price in the preceding impact analysis. The economic impact analysis study was separated into six segments:

1. *Price and Sales Impacts.* This segment includes the analysis of price impacts and results and changes in industry sales that occur relative to a baseline forecast.

2. *Cost of Compliance.* This segment includes the cost of the resources used to achieve compliance with the regulatory options and reflects the increased costs of producing quieted equipment and the cost associated with changes in performance and maintenance.

3. *Market Impacts.* This segment includes an analysis of broad changes in industry and market conditions that might accompany the adoption of alternative noise emission standards.

4. *Foreign Trade.* This segment covers an assessment of the impacts on exports, imports, and balance of trade.

5. *Individual Impacts.* This segment gives an assessment of market impacts that fall differentially on specific companies or industry segments, such as unemployment, lowered sales and profits, or changes in market shares.

6. *Disruptive Impacts.* This segment considers changes that may occur in response to various shutdowns, unemployment, etc., that may be caused by the regulation of portable air compressors.

Two approaches were used to assess economic impact: (1) making direct estimates based on field interviews and (2) using published information and making indirect estimates by projecting market conditions with and without noise emission standards.

The data on which to base the estimated impacts were obtained from several sources including manufacturers of portable air compressors.

The assumed portable air compressor industry/market reactions to noise regulations are:

1. The total costs to manufacture the equipment will increase.

2. The manufacturers will pass this cost on in the form of an increase in the distributor price (list price).

3. The distributor will pass its cost increase on in the form of an increase in the negotiated customer price.

4. The portable air compressor end user will pass the increase in his equipment purchase costs on to his customers as an increase in the price of products and services provided.

5. Final changes in industry prices and volumes will reflect the changes in portable air compressor purchase prices and operating costs.

6. Ultimately, the consumer will pay a higher price for products due to the required increased cost to reduce noise.

If there are overall cost reductions, as opposed to cost increases, from the adoption of noise control technology, competitive pressures will cause cost decreases to be passed on up the economic chain to the consumer in the form of lower prices.

The scenario under which the economic impacts were estimated is based on the technology and costs contained in References 5, 7, and 33. The estimates of impacts given here assume that the conditions reflected in the 1973 sound level/price data represent the actual technology adopted and costs to be incurred in the future. It is likely that new technologies at lower costs will be developed. Thus, if the current costs, based on an assessment of on-the-shelf technology, are reasonably accurate, they give upper bound estimates. Noise standards can be attained at these costs, but possibly they will be attained at less cost based on better future technology.

Price and Sales Impacts

It is assumed that purchasers of portable air compressors will be presented with a price increase associated with each noise emission standard selected for study. Estimated price increases attributable to compliance with various regulatory options were presented in Table 9-10. The list price was selected as the basis for the economic impact analysis because it is conservatively constructed and is based on the broadest sample of cost and noise suppression data available.

Table 9-12 presents estimates of average list price percentage increases and resulting decreases in sales associated with manufacturer compliance with the regulatory options, assuming a price elasticity of demand of –0.35.

Rising prices can be expected to result in reduced sales as demand falls off because users will either find more efficient ways to use gasoline or diesel-engine driven air compressors, in an effort to cut costs, or will switch to substitute products that provide a lower cost alternative method of performing the same work. The degree to which sales will fall depends on the ease with which buyers can change their compressor use habits in different applications in order to cut costs.

With price increases below 20 percent (constant dollars) air compressor users will probably refrain from widespread immediate substitution because:

1. Portable air compressors are a convenient power source for many applications.

2. Users currently have a high investment in tools that operate on compressed air (costing 10 to 200 percent as much as the compressor).

3. Costs of using compressors can be lowered somewhat without substitution through more renting of equipment and other practices.

Demand may fall off more rapidly in response to price increases in excess of 20 percent as it becomes worthwhile to substitute hydraulic or electric systems for compressed air systems.*

Decreased industry sales for all options range between 3 and 5 percent. The largest sales impact generally falls on the diesel-driven compressors with more than 250 cfm capacity. These impacts are equivalent to 1 or 2 years of sales growth at the rates experienced by the industry from 1967 to 1972, but are less than one-fifth of the industry sales growth from 1972 to 1973. (Sales data for 1974 are not available.)

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*The response to price increases in this discussion is considered under the assumption that the prices of substitutes remain constant. To the extent that substitutes for portable air compressors experience comparable price increases, e.g., due to other government regulations, the demand response to increasing air compressor prices will be dampened.

Table 9-12

ESTIMATES OF INCREASED PRICES AND DECREASED SALES
ASSOCIATED WITH THE REGULATORY OPTIONS

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	Percent Price Increase		Percent Decrease In Sales (elasticity of -0.35)	
				2 dBA Tolerance	3 dBA Tolerance	2 dBA Tolerance	3 dBA Tolerance
2	All	76	18	12.3	13.6	4.3	4.8
3	All	78	18	10.0	11.1	3.5	3.9
4	Under 251 Above 250	76 76	18 24	- 12.3	- 13.6	- 4.3	- 4.8
8	Under 251 Above 250	76 78	18 24	- 11.2	- 12.5	- 4.0	- 4.3
9	All	76	24	12.3	13.6	4.3	4.8
10	All	78	24	10.0	11.1	3.5	3.9
11	Under 251 Above 250	- 76	24 30	- 12.3	- 13.6	- 4.3	- 4.8
12	Under 251 Above 250	76 78	24 30	- 11.2	- 12.5	- 4.0	- 4.3

Impact on Industry Employment

Decreased industry sales will tend to lower employment in the industry. However, the labor required per manufactured compressor will tend to increase, due to the quieting requirements. Data are not available to determine the net effect of these two counteracting forces.

A portion of any net decrease in employment could be accomplished by normal attrition. It has been common in recent years for between 2 and 3 percent of the labor force in all manufacturing to leave their job voluntarily. Data on labor turnover in the portable air compressor industry are not available.

Based on the estimated impacts on industry sales, industrywide employment impacts of any of the regulatory options would not appear severe, provided sufficient compliance time is allowed.

COST OF COMPLIANCE

The total cost of achieving compliance with any of the regulatory options is composed of many parts. Additional resources – labor, materials, and capital – must be used in the production of the quieter compressors.* To the extent that the users of portable air compressors go to substitute technologies (e.g., electric and hydraulic equipment) or make other adjustments to avoid purchasing the higher priced compressors, they may adopt alternative methods of production that presumably would have been more costly than the lower priced unquieted compressors. Users are therefore avoiding the cost of higher priced compressors by incurring the cost of previously less favored methods of production. And to the extent that new air compressor sales are reduced, labor in the industry may be unemployed while moving their present employment to alternatives – a third type of resource cost.

Data are not available to assess the value of each of these components of the costs of complying with the regulatory options and the distribution of these costs among different segments of society (e.g., labor, the construction industry, the purchasers of new construction, and the compressor manufacturing industry). As an alternative, an assessment has been made under the assumption that the only societal adjustment to the new regulations is to reallocate the required resources to the air compressor industry to produce quieter equipment. This assumption implies that there is no decrease in industry sales in response to higher prices and, consequently, no associated unemployment. The assumption is also made

*Increased user operating and maintenance costs are assumed to be negligible. See Reference 8.

that the increase in list price includes a normal profit or return on capital resources utilized in the quieting of compressors.

With these assumptions, the total cost of compliance with a regulatory option may be approximated by the dollar value increase in compressor sales under the assumption that prices increase by the percentages given in Table 9-10 and that unit sales are not changed in response to the higher prices. This assessment makes no statement as to the manner in which these costs are distributed among the different segments of society.

Using these assumptions, an annual aggregate increase in purchase cost was calculated for the first year of full compliance for each regulatory option. The base year sales used in the calculation is for the 12 months beginning on the date all new compressors (regardless of capacity) are covered by the regulation, assuming the regulation is promulgated in July 1975. EPA has estimated that total portable air compressor retail sales in 1977--1978 will be approximately $206 million.

The results of the calculations are presented in Table 9-13, where it is shown that the annual aggregate increase in purchase cost relating to the regulatory options range from $20 to $28 million.

User Costs

If a user purchases a new quieter and more expensive portable air compressor, the higher price paid represents an increase in his investment expenditures. The book value of his equipment (carried at cost) will be increased by the amount of the higher price. This amount will be depreciated over the accounting life* of the equipment in order to allocate the cost of equipment over the revenue received through its operation.

If the user borrows the funds required to finance the purchase, he bears an additional interest cost attributable to the higher purchase price of the equipment. If he uses equity financing, he foregoes the opportunity of investing the additional funds in other income generating activities and thus incurs an opportunity cost just as real as the interest cost of debt financing. In either case, the user bears an increased cost of financing the equipment purchase that may be associated with the higher price.

It is assumed depreciation is 10 percent of the original cost of the equipment and that 10 percent of the purchase price gives an appropriate cost of the increased purchase price to

*Accounting life and true useful life need not coincide.

Table 9-13

ESTIMATES OF THE ANNUAL AGGREGATE INCREASE IN PURCHASE COST RELATED TO ALTERNATIVE REGULATORY OPTIONS

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	Annual Aggregate Increase In Purchase Cost ($ millions)	
				2 dBA Tolerance	3 dBA Tolerance
2	All	76	18	25.0	27.6
3	All	78	18	20.3	22.6
4	Under 251 Above 250	76 76	18 24	- 25.4	- 27.9
8	Under 251 Above 250	76 78	18 24	- 23.4	- 25.7
9	All	76	24	25.0	27.6
10	All	78	24	20.3	22.6
11	Under 251 Above 250	76	24 30	- 25.4	- 27.9
12	Under 251 Above 250	76 78	24 30	- 23.4	- 25.7

his operating costs each year. It is also assumed that all other costs incurred by the user as a result of the noise regulations are negligible.*

For the first full year of compliance, the increased cost to appear in the income statements of the users of the new quieted equipment is, with the assumptions given above, equal to 20 percent of the annual aggregate increase in purchase cost given in Table 9-13. These first year user annualized costs are presented in Table 9-14 and range between $4 and $6 million.**

To calculate the corresponding user annualized cost for the first year of a 100-percent quieted portable air compressor population, the following assumptions were made:

- All new quieted equipment survives at least 10 years.
- No existing unquieted equipment survives more than 10 years.
- Portable air compressor sales grow at a constant rate over the first 10 years of the regulation.

Two sets of growth rates are used. The first set is the average annual rate of unit sales growth experienced from 1967 through 1972 (i.e., 2.8 percent for small compressors and 3.6 percent for large compressors) and the second rate of growth is that experienced from 1967 through 1973 (i.e., 6.0 percent for small compressors and 7.0 percent for large compressors).***

These growth rates result in 100-percent quieted populations at the end of 10 years equal to 11.61 and 13.56 times the number of new compressors purchased during the first full year of compliance. These 100-percent quieted user annualized costs are presented in Table 9-15, with the values ranging between $48 and $76 million.

These values are small relative to the total value of construction, corresponding to the relatively small portable air compressor industry. The 100-percent quieted user annualized cost of $76 million, for example, is only 0.06 percent of the $135 billion value of new construction in 1973.

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*See Reference 8.

**These costs may be considered a component of the annual aggregate increase in purchase cost and should not be added to the values given in Table 9-13.

***It is not anticipated that the higher (i.e., 6 and 7 percent) growth rates will be maintained. The use of these growth rates therefore yields an upper bound on the difference between first-year and 100-percent quieted estimates.

Table 9-14

FIRST YEAR USER ANNUALIZED COSTS OF ALTERNATIVE REGULATORY OPTIONS

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	First Year User Annualized Costs ($ millions)	
				2 dBA Tolerance	3 dBA Tolerance
2	All	76	18	5.0	5.5
3	All	78	18	4.1	4.5
4	Under 251 Above 250	76 76	18 24	- 5.1	- 5.6
8	Under 251 Above 250	76 78	18 24	- 4.7	- 5.1
9	All	76	24	5.0	5.5
10	All	78	24	4.1	4.5
11	Under 251 Above 250	- 76	24 30	- 5.1	- 5.5
12	Under 251 Above 250	76 78	24 30	- 4.7	- 5.1

Table 9-15

100 PERCENT QUIETED POPULATION USER ANNUALIZED COSTS OF ALTERNATIVE REGULATORY OPTIONS

Regulatory Option	Air Flow Capacity (cfm)	Sound Pressure Level (dBA at 7 meters)	Time to Compliance (months)	User Annualized Cost, 100% Population ($ million)			
				1967-1972 Growth Rate*		1967-1973 Growth Rate**	
				2 dBA Tolerance	3 dBA Tolerance	2 dBA Tolerance	3 dBA Tolerance
2	All	76	18	58.1	63.9	67.8	74.6
3	All	78	18	47.6	52.2	55.6	61.0
4	Under 251 Above 250	76 -	18 24	- 59.0	- 65.0	- 68.9	- 75.9
8	Under 251 Above 250	76 78	18 24	- 54.6	- 59.2	- 63.7	- 69.2
9	All	76	24	58.1	63.9	67.8	74.6
10	All	78	24	47.6	52.2	55.6	61.0
11	Under 251 Above 250	- 76	24 30	- 58.1	- 63.9	- 67.8	- 74.6
12	Under 251 Above 250	76 78	24 30	- 54.6	- 59.2	- 63.7	- 69.2

*2.8 percent for small compressors and 3.6 percent for large.
**6.0 percent for small compressors and 7.0 percent for large.

This implies that any regulation that does not cause significant disruptions in the supply of portable air compressors will probably have relatively little aggregate impact outside the portable air compressor industry.

Market Impact

The impact of promulgating noise emission levels for portable air compressors on the market and industry as a whole is discussed in greater detail in Reference 8. However, this discussion treats in a summary form those impacts on the market that can be expected from the adoption of noise control technology. Included in this summary are the impacts on upstream components suppliers, downstream distributors, and end users.

Suppliers

The suppliers of components to (1) engine manufacturers, (2) muffler manufacturers, (3) fan manufacturers, and (4) enclosure and vibration isolator manufacturers will generally experience higher dollar sales. General suppliers to portable air compressor manufacturers will not be adversely affected by the adoption of noise control technology primarily because most suppliers to the industry derive only a small portion of their business from manufacturers of portable air compressors.

Distribution

Channels of distribution and portable air compressor operations are not expected to materially change due to the noise emission standards.

End Users

It has been estimated that the increased costs to be incurred by portable air compressor owners will be less than 0.1 percent of total operating costs of end user industries. Therefore, little, if any, change in portable air compressor end user industries are expected.

Foreign Trade

This discussion addresses the impact of the adoption of noise standards on export and import patterns for portable air compressors. Noise regulations do not apply to export products but do apply to products imported for use in the United States.

Exports

Domestic portable air compressor manufacturers will be able to export both quieted and unquieted products to foreign countries, depending upon their respective noise regulations. To the extent that some foreign markets presently require quiet compressors, domestic manufacturers will be in an improved competitive position. Study inputs from portable air compressor manufacturers indicated that no changes in export patterns are expected.

Imports

Imports currently account for between 5 and 10 percent of the total domestic portable air compressor unit consumption. Imported portable air compressor prices are generally competitive with or lower than domestic manufacturer prices. However, imports have not significantly penetrated the United States market because of lack of effective distribution networks, poor product quality in some instances, poor service and parts delivery, and intensive competition by domestic producers. Quieted imported portable air compressors are not expected to make significant inroads into the domestic market since the costs associated with quieting, plus import costs would exceed the costs incurred by domestic producers.

Balance of Trade

Based on the factors reviewed, no material impact on the balance of trade is anticipated.

Individual Impacts

This discussion addresses differential impacts that may develop affecting a single firm or set of firms.

Small Portable Air Compressor Manufacturers

Small manufacturers may not have sufficient manpower and/or funds to immediately allocate to the required development programs. However, costs and quieting technology are not expected to create a problem for small manufacturers provided they are given adequate time to adjust.

Firms Experienced in Noise Technology

Those firms having already attained experience in quieting technology and currently having quieted products on the market are much better prepared to meet Federal noise emission levels. Thus, they are expected to hold an advantage in the market for a limited period of time.

Disruptive Impacts

Given adequate lead time and appropriate planning, no significant disruptive economic impacts are predicted due to the establishment of noise standards per se.

Cost changes are on the order of 10 to 13 percent. However, volume changes are small relative to baseline conditions. The portable air compressor industry would be expected to continue its normal growth pattern. Some small unemployment (measured in tens) may occur in specific communities.

SUMMARY

1. Compressor list prices may increase as shown in Table 9-16.

Table 9-16

SUMMARY OF ESTIMATED PRICE INCREASES
(in percent, with 2 dBA tolerances)

Engine/Capacity Class	Option 2	Option 3	Option 4	Option 8	Option 9	Option 10	Option 11	Option 12
Gasoline (All)	12.1	8.5	12.1	12.1	12.1	8.5	12.1	12.1
Diesel (≤250 cfm)	9.6	7.0	9.6	9.6	9.6	7.0	9.6	9.6
Diesel (>250 cfm)	13.0	11.4	13.0	11.4	13.0	11.4	13.0	11.4
Average	12.3	10.0	12.3	11.2	12.3	10.0	12.3	11.2

The price increases will be passed on to end users.

2. Sales may be affected as indicated in Table 9-17

Table 9-17

SUMMARY OF ESTIMATED SALES REDUCTIONS
(in percent, with 2 dBA tolerances)

Engine/Capacity Class	Option 2	Option 3	Option 4	Option 8	Option 9	Option 10	Option 11	Option 12
Gasoline (All)	4.2	3.0	4.2	4.2	4.2	3.0	4.2	4.2
Diesel (≤ 250 cfm)	3.4	2.4	3.4	3.4	3.4	4.0	3.4	3.4
Diesel (>250 cfm)	4.6	3.5	4.3	4.0	4.6	3.5	4.6	4.0
Average	4.3	3.5	4.3	4.0	4.3	3.5	4.3	4.0

3. The estimated annual aggregate increase in purchase price for noise abatement for portable air compressors is presented in Table 9-18.

Table 9-18

SUMMARY OF ESTIMATED ANNUAL AGGREGATE INCREASE IN PURCHASE PRICE (In $ million, with 2 dBA tolerances)

Option 2	Option 3	Option 4	Option 8	Option 9	Option 10	Option 11	Option 12
$25.0	$20.3	$25.4	$23.4	$25.0	$20.3	$25.4	$23.4

4. There will be little effect on upstream component suppliers. Distributors and end users may be affected in that alternative air sources and competitive systems will become a more important factor in working on or moving material.

5. There will be no significant effect on factory operations.

6. No significant unemployment is expected to occur.

7. No changes in export or import patterns should occur because of noise regulations.

8. No significant impact will be transmitted to the national or a regional economy, provided adequate lead time to compliance is allowed.

Section 10

EVALUATION OF EFFECTS OF PORTABLE AIR COMPRESSOR NOISE ON PUBLIC HEALTH AND WELFARE OF THE U.S. POPULATION

Pursuant to the Noise Control Act of 1972, EPA has selected and published noise measures believed to be most useful for describing environmental noise and its effects on people, independent of the source(s) of noise. In addition, information has also been published on the noise levels "requisite to protect the health and welfare" including personal comfort and well being, as well as the absence of clinical symptoms (e.g., hearing loss). Using information published in References 1 and 2, analyses were performed to evaluate the effects of the air compressor regulation on the health and welfare of the U.S. population exposed to construction site noise.

The approach taken for the analyses was to evaluate the effects, in terms of percent changes, in the impact of construction site noise on U.S. population resulting from the reduction of portable air compressor noise alone and then in combination with the reduction of truck noise. Truck noise is a major contributor to construction site noise and is currently the subject of noise emission control. The methodology presented in Appendix B has been applied to the specific case of construction noise to evaluate potential public health and welfare benefits derived from portable air compressor and truck noise regulations.

The analyses considered construction of residential and nonresidential buildings, city streets, and public works that normally occur in places where population density is high. Heavy construction, such as highways and civil works, has been omitted from the study since the bulk of this activity generally occurs in thinly populated areas where the extensiveness of potential noise effects on people is minor. In the framework of the analysis, construction is viewed as a process that can be categorized according to the type of construction, as well as to the separate and distinct activity phases that occur.

The basic unit of construction activity is the construction site. A construction site exists in both time and space. Four different types of construction sites were evaluated in the analysis:

1. Domestic housing and residential.

2. Nonresidential, office buildings, hotels, hospitals, schools, government buildings, including highrise.

3. Industrial, parking garage, religious monuments, amusement and recreation, stores, service stations, but no highrise.

4. Public works, municipal streets, and sewers.

Construction activity is generally carried out in several discrete steps, each of which has its own mix of equipment and attendant noise output. The phases of construction studied were those of Reference 2. The data presented in Reference 2, adopted for the present analysis, provide all the necessary input for deriving the variation in noise output with time. Basically, the process involved in deriving the noise history at each site consists of identifying the equipment found at each site in each construction activity phase in terms of:

- The number of equipment types typically present at the site in a given phase.
- The duty cycle of each type of equipment.
- The average noise level of each equipment type during the construction activity operation.

The original information given in Reference 2 has been reviewed and revised to include data that has since become available in Reference 32. The revisions appear in Tables 10-1 a, b, c and d.

The usage factors presented in Tables 10-1 a through d, were combined with typical periods of use (hours) of equipment operated for a particular task, to yield a site L_{eq} as measured 50 feet from the site. For the purpose of this analysis, a construction site is viewed as a complex source in which equipment is centered at a point 50 feet from an observer. This consideration provides a model with which to establish a base set of data.

The L_{eq} obtained using this model was converted to an L_{dn} for a 24-hour day and then converted to an annual L_{dn}. Thus, each construction site was viewed as a complex noise source with a fixed annual value of L_{dn}. The analysis was repeated for each type of site.

The human impact of construction noise was brought into the analysis by use of the data presented in Reference 2 with regard to the number of construction sites of various types in a number of geographical regions, as well as the population densities within the regions. The number of sites per year was taken from Table IV of Reference 32, and the population density data was taken from Table XI of Reference 2. For the nonresidential

Table 10-1 a

USAGE FACTORS OF EQUIPMENT IN DOMESTIC HOUSING CONSTRUCTION

Equipment		Construction phase					Leq (50') during work periods for each item, over one project
		Clearing	Excavation	Foundation	Erection	Finishing	
Air compressor	(81)*	-	0.1	-	-	0.25	68.7
Backhoe	(85)	0.02	0.2	-	-	0.02	69.5
Concrete mixer	(85)	-	-	0.4	0.08	0.16	76.5
Concrete pump	(82)	-	-	-	-	-	-
Concrete vibrator	(76)	-	-	-	-	-	-
Crane, derrick	(88)	-	-	-	-	-	-
Crane, mobile	(83)	-	-	-	0.10	0.04	69.5
Dozer	(87)	0.10	0.1	-	-	0.04	72.0
Generator	(78)	0.4	-	-	-	-	64.5
Grader	(85)	0.05	-	-	-	0.02	65.0
Paving Breaker	(88)	-	-	-	-	0.01	61.0
Loader	(84)	0.2	0.1	-	-	0.04	70.0
Paver	(89)	-	-	-	-	0.025	66.0
Pile driver	(101)	-	-	-	-	-	-
Pneumatic tool	(85)	-	-	0.04	0.1	0.04	72.5
Pump	(76)	-	0.1	0.2	-	-	63.0
Rock drill	(98)	-	0.005	-	-	-	65.5
Roller	(80)	-	-	-	-	0.04	59.0
Saw	(78)	-	-	0.04[2]**	0.1[2]	0.04[2]	68.5
Scraper	(88)	0.05	-	-	-	0.01	67.0
Shovel	(82)	-	0.2	-	-	-	65.5
Truck	(88)	0.04	0.1	-	-	0.04	70.0
		L_{eq} (50') per site during work periods =					82.0 dBA
Hours at site		24	24	40	80	40 Σ =	208 hrs.
						=	26 days

Total number of sites = 514,424 (Table IV(a) of reference 32)

* Numbers in parentheses ( ) represent average noise levels (dBA) at 50 ft.
** Numbers in brackets [ ] represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

Table 10-1 b

USAGE FACTORS OF EQUIPMENT IN NONRESIDENTIAL CONSTRUCTION
($190K-4000K)

Equipment		Construction phase					Leq(50') during work periods for each item, over one project
		Clearing	Excavation	Foundation	Erection	Finishing	
Air compressor	(81)*	-	1.0[2]**	1.0[2]	1.0[2]	0.4[2]	83.5
Backhoe	(85)	0.04	0.16	0.4	-	0.04	76.5
Concrete mixer	(85)	-	-	0.4	0.4	0.16	79.0
Concrete pump	(82)	-	-	0.08	0.4	0.08	74.5
Concrete vibrator	(76)	-	-	0.2	0.2	0.04	67.0
Crane, derrick	(88)	-	-	-	0.16	0.04	76.0
Crane, mobile	(83)	-	-	-	0.16[2]	0.04[2]	74.0
Dozer	(87)	0.16	0.4	-	-	0.16	78.0
Generator	(78)	0.4[2]	1.0[2]	-	-	-	75.0
Grader	(85)	0.08	-	-	-	0.02	63.5
Paving breaker	(88)	-	0.1	0.04	0.04	0.04	75.0
Loader	(84)	0.16	0.4	-	-	0.16	75.0
Paver	(89)	-	-	-	-	0.1	70.0
Pile driver	(101)	-	-	0.04	0.16[2]	0.04[2]	85.0
Pneumatic tool	(85)	-	-	0.04	0.16[2]	0.04[2]	76.0
Pump	(76)	-	1.0[2]	1.0[2]	0.4	-	76.5
Rock drill	(98)	-	0.04	-	-	0.005	78.0
Roller	(80)	-	-	-	-	0.1	60.5
Saw	(78)	-	-	0.04[3]	1.0[3]	-	76.5
Scraper	(88)	0.55	-	-	-	-	73.0
Shovel	(82)	-	0.4	-	-	-	72.0
Truck	(88)	0.16[2]	0.4	-	-	0.16	80.0
		$L_{eq(50')}$ per site during work periods =					91.0 dBA
Hours at site		80	320	320	480	160 Σ =	1360 hrs.
						=	170 days

Total number of sites = 12,710 (Tables IV(b) of reference 32)

* Numbers in parentheses ( ) represent average noise levels (dBA) at 50 ft.
** Numbers in brackets [ ] represent average number of items if number is greater than one. Blanks indicate zero or very rare usage.

Table 10-1 c

USAGE FACTORS OF EQUIPMENT IN INDUSTRIAL CONSTRUCTION
($30K-820K, no high-rise)

Equipment		Construction phase					Leq(50') during work periods for each item, over one project
		Clearing	Excavation	Foundation	Erection	Finishing	
Air compressor	(81)*	-	1.0	0.4	0.4	0.4	78.0
Backhoe	(85)	0.04	0.16	0.4	-	0.04	76.5
Concrete mixer	(85)	-	-	0.4	0.16	0.16	77.5
Concrete pump	(82)	-	-	0.05	0.16	0.08	71.0
Concrete vibrator	(76)	-	-	0.2	0.1	0.04	65.5
Crane, derrick	(88)	-	-	-	0.04	0.02	70.0
Crane, mobile	(83)	-	-	-	0.08	0.04	68.0
Dozer	(87)	0.2	0.4	-	-	0.04	77.5
Generator	(78)	0.4	0.4	-	-	-	68.5
Grader	(85)	0.05	-	-	-	0.02	62.5
Paving breaker	(88)	-	0.1	0.04	0.04	0.04	75.0
Loader	(84)	0.16	0.4	-	-	0.04	74.5
Paver	(89)	-	-	-	-	0.12	70.5
Pile driver	(101)	-	-	0.04	-	-	81.0
Pneumatic tool	(85)	-	-	0.04	0.1[3]**	0.04	76.0
Pump	(76)	-	0.4	1.0[2]	0.4	-	53.0
Rock drill	(98)	-	0.02	-	-	0.003	75.0
Roller	(80)	-	-	-	-	0.1	60.5
Saw	(78)	-	-	0.04[2]	0.1[2]	-	67.5
Scraper	(88)	0.14	-	-	-	0.08	70.5
Shovel	(82)	-	0.4	-	-	0.06	72.0
Truck	(88)	0.16[2]	0.26[2]	-	-	0.16	78.5
		Leq(50') per site during work periods =					88.0 dBA
Hours at site		80	320	320	480	160Σ	= 1360 hrs. = 170 days

Total number of sites = 50,839 (Tables IV(c) of reference 32)

* Numbers in parentheses ( ) represent average noise levels (dBA) at 50 ft.
** Numbers in brackets [ ] represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

Table 10-1 d

USAGE FACTORS OF EQUIPMENT IN PUBLIC WORKS CONSTRUCTION
(Municipal streets and sewers)

Equipment		Construction phase					$L_{eq(50')}$ during work periods for each item, over one project
		Clearing	Excavation	Foundation	Erection	Finishing	
Air compressor	(81)*	1.0	1.0	0.4	0.4	0.4[2]**	79.0
Backhoe	(85)	0.04	0.4	-	-	0.16	74.5
Concrete mixer	(85)	-	-	0.16[2]	0.4[2]	0.16[2]	81.0
Concrete pump	(82)	-	-	-	-	-	-
Concrete vibrator	(76)	-	-	-	-	-	-
Crane, derrick	(88)	-	0.1	0.04	0.04	-	74.0
Crane, mobile	(83)	-	-	-	0.16	-	69.5
Dozer	(87)	0.3	0.4	0.2	-	0.16	79.5
Generator	(78)	1.0	0.4	0.4	0.4	0.4	75.0
Grader	(85)	0.08	-	-	0.2	0.08	74.0
Paving breaker	(88)	0.5	0.5	-	0.04	0.1[2]	80.5
Loader	(84)	0.3	0.3	0.2	-	0.16	76.0
Paver	(89)	-	-	0.1	0.5	-	81.5
Pile driver	(101)	-	-	-	-	-	-
Pneumatic tool	(85)	-	-	0.04[2]	0.1	0.04	72.5
Pump	(76)	-	0.4[2]	1.0[2]	0.4[2]	-	75.5
Rock drill	(98)	-	0.02	-	-	-	82.5
Roller	(80)	-	-	0.01	0.5	0.5	73.5
Saw	(78)	-	-	0.04[2]	0.04	-	63.5
Scraper	(88)	0.08	-	0.2	0.08	0.08	78.0
Shovel	(82)	0.04	0.4	0.04	-	0.04	71.0
Truck	(88)	0.16[2]	0.16	0.4[2]	0.2[2]	0.16[2]	84.5
		$L_{eq(50')}$ per site during work periods =					91.0 dBA
Hours at site:		12	12	24	24	12Σ =	84 hrs.
						=	10 ½ days

Total number of sites = 485,224 (Table IV(d) of reference 32)

* Numbers in parentheses ( ) represent average noise levels (dBA) at 50 ft.
** Numbers in brackets [ ] represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

building category, the transfer of people from the suburbs to the central city during the average working day was considered by adjusting the population data, consistent with the model presented in Reference 2, which is summarized in Table XI of the reference. This adjustment was necessary to account for the fact that most construction in cities occurs during the working day. Thus, population estimates were obtained for 20 different cases corresponding to the four construction types (residential, nonresidential, municipal streets and public works) and five categories of regions.

1. Large high-density central city

2. Large low-density central city

3. Other Standard Metropolitan Statistical Areas central cities

4. Urban fringe

5. Metropolitan areas outside the urban fringe.

Two models were used for the propagation of site noise into the community. In residential areas and other lightly built up areas, noise was assumed to be attenuated at the rate of 6 dB per doubling of distance away from the source. Accordingly, around each site there exists a series of annulations, each of which represent successive 3 dB areas of greater attenuation. A mean noise level L_{dn} (annual L_{dn}) was associated with each annulus, as well as the area in square miles. The latter figure, when multiplied by the population density typical of the region, yielded the average number of people, (P), living within that annulus. It was assumed that on the average, only half of these people are affected by the noise because it is reasoned that only half of the rooms in a structure in proximity to the site face the site. This assumption appears reasonable but must be recognized as being somewhat arbitrary.

In the case of the nonresidential (office) building category, a different model was considered. For this situation it was assumed that noise confined in a built up area is attenuated by only 3 dB per doubling of distance for the first 400 feet, due to the canyon effect, and then attenuates at 6 dB per doubling of distance, since at that point noise is free to decrease by classical spherical divergence. Further, it was assumed that only 25 percent of the people in each annulus were affected by the construction noise since in most office buildings not all the rooms have outside exposure. This assumption appears reasonable, but it is also somewhat arbitrary.

CONSTRUCTION SITE NOISE IMPACT

The impact of an environmental noise has two basic dimensions: extensiveness and intensity. Extensiveness of impact is measured in terms of the total numbers of people impacted regardless of the severity of individual impact. Intensity, or severity, of an individual's impact is measured in terms of the level of the environmental noise.

For analytic purposes, it is desirable to have a single number representing the magnitude of the total noise impact in terms of both extensiveness and intensity in a specific environmental situation. With a single number descriptor of noise impact, relative changes in impact can be described in terms of simple percentage changes of relief from an initial value. In this method, presented in Appendix B, the intensity of an environmental noise impact at a specific location is characterized by the Fractional Impact (FI).

In the computation of the fractional impact (FI) associated with each annulus around a construction site for office buildings and industrial facilities, computations were performed relative to an exterior L_{dn} of 65 dB rather than the 55 dB assumed for residential areas and public work areas. The rationale for this assumption was that in office buildings adjoining construction sites, windows are normally closed, which increases the noise reduction between outside and inside (Reference 30). The window-closed condition provides at least 10 dB more attenuation than does the window-open condition. Accordingly, exterior levels of 65 dB in the window-closed condition and 55 dB with windows open will generally produce identical interior noise levels.

From knowledge of the various fractional impacts and the number of people contained in each annulus, the equivalent population impacted in each annulus was obtained and then summed to obtain the total impact (P_{eq}).*

Computations were performed to assess the change in the equivalent population impacted by construction site noise, relative to the new regulation condition for portable air compressor noise when reduced to levels of 76 dBA, 73 dBA, 70 dBA, and 65 dBA at 7 meters from the compressor housing. Since new-truck noise regulations currently being formulated will, in time, produce lower truck noise levels at construction sites, the effect of the combined reduction of portable air compressors and new-truck noise were additionally evaluated. The benefits of reducing portable air compressor and new truck noise levels are summarized in Table 10-2 in terms of both P_{eq} and the percent reduction of impact upon the change on U.S. population exposed to construction site noise.

To further illustrate the significant benefits and relief afforded the population by reducing new portable air compressor noise levels, Figure 10-1 has been prepared from the data of Table 10-2. As shown in Figure 10-1, a sizeable reduction (approximately 15 percent) in the magnitude of the impact by construction site noise is achieved by regulating

* P_{eq} is numerically equal to the equivalent number of people having a fraction impact equal to unity (100 percent impacted). See Appendix B for further details.

Table 10-2

SUMMARY OF BENEFITS TO THE POPULATION IMPACTED BY CONSTRUCTION SITE NOISE RESULTING FROM REGULATION OF PORTABLE AIR COMPRESSOR AND TRUCK NOISE

	P_{eq}	Percent Reduction
Baseline data	1,245,622	0
Only air compressors reduced:		
a) 76 dBA	1,062,800	14.7
b) 73 dBA	1,053,810	15.4
c) 70 dBA	1,049,266	15.8
d) 65 dBA	1,046,133	16.0
Trucks reduced 83 dBA		
a) Air compressors @ 76 dBA	781,000	37.3
Trucks reduced 75 dBA		
a) Air compressors @ 76 dBA	677,660	45.6

portable air compressor noise to 76 dBA; more stringent regulation of the air compressor is not warranted at this time due to the little (approximately 1 percent) added health and welfare benefits.

The results, shown in Figure 10-1 and Table 10-2, derived from the regulation of new portable air compressors and new trucks are time dependent; that is, the benefits accrued occur in time as the current unregulated compressor and truck population is replaced by quiet regulated units. Figure 10-2 illustrates the magnitude by which the health and welfare benefits accrue in time using the assumption that quiet portable air compressors and trucks replace unquieted units at the rate of 10 percent per year.

The data clearly demonstrates that the reduction of portable air compressor noise to an average of 76 dBA at 7 meters produces significant and desirable relief to the population from construction site noise. In terms of acoustic energy contribution to construction site noise, Table 10-3 shows that the reduction of portable air compressor noise to 76 dBA reduces its energy contribution to nonresidential construction site noise (present worst case) by 15.8 percent, for a total site contribution of approximately 1.0 percent.

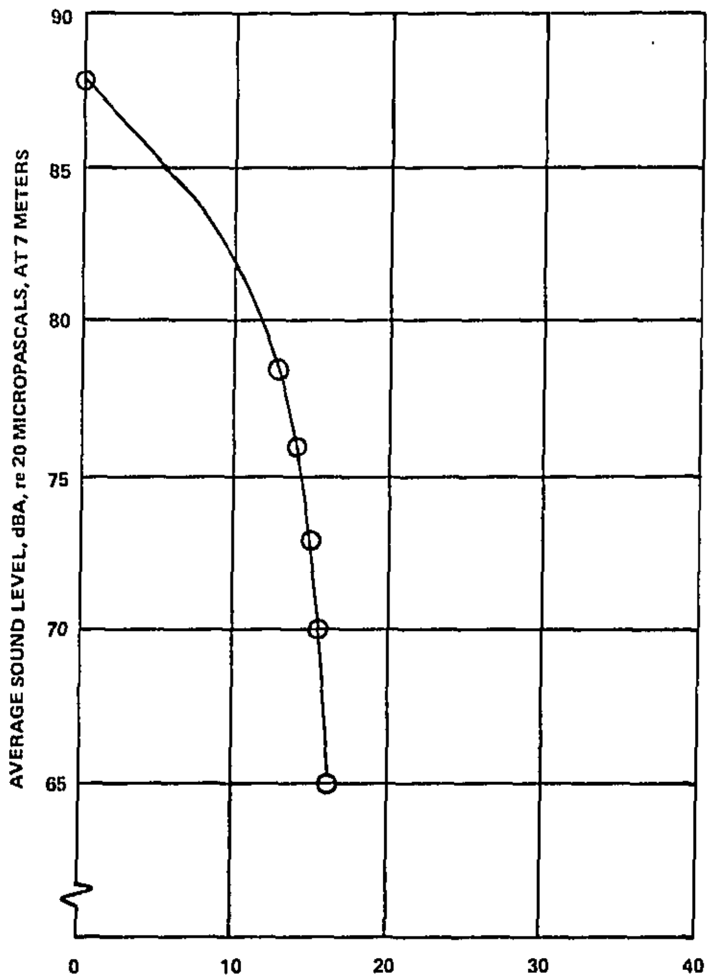

Figure 10-1. Effect of Portable Air Compressor Noise Reduction on the U. S. Public Impacted by Construction Site Noise

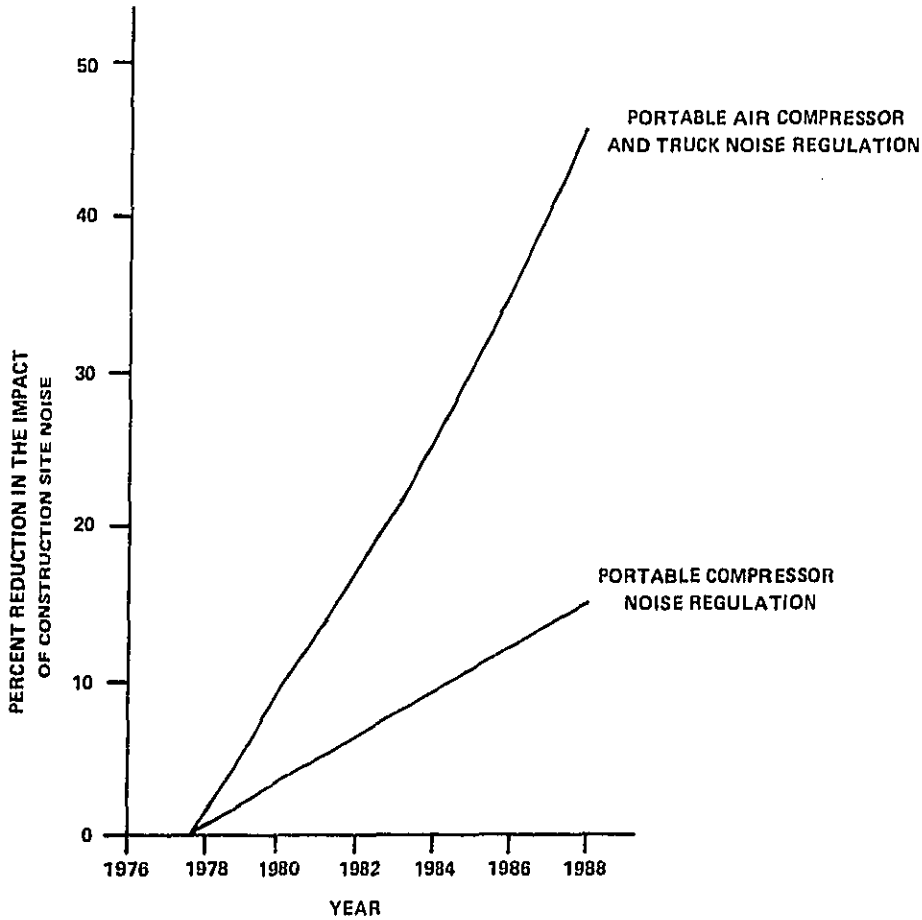

Figure 10-2. Construction Site Noise Impact Reduction Caused by Portable Air Compressor and Truck Noise Regulation

Table 10-3

CONTRIBUTION OF PORTABLE AIR COMPRESSOR NOISE TO CONSTRUCTION SITE NOISE

Site	Percent* of site noise		Rank* at site	
	Compressor Noise at 88 dBA**	Compressor Noise at 76 dBA	Compressor Noise at 88 dBA**	Compressor Noise at 76 dBA
Residential	4.6	.3	7th	16th
Public works	6.1	.4	7th	16th
Industrial	10.0	.6	3rd	17th
Nonresidential	16.9	1.1	2nd	17th

* On an energy basis

** Current average level at 7 meters of all compressors.

The data show the decreasing importance of portable air compressors (in terms of total emitted acoustic energy) from the second most predominant construction site noise source after trucks (at present) to the 16th noisiest piece of equipment comprising the hardware mix of 20 pieces of equipment typically used at construction sites.

Further public health and welfare analyses were performed to assess the benefits derived by splitting the portable air compressor population at 250 cfm and reducing noise of compressors larger than 250 cfm to a different level. Table 10-4 lists the case studied.

Table 10-4

PORTABLE AIR COMPRESSOR NOISE REDUCED BY CATEGORY

Air flow capacity (cfm)	Reduced noise level (dBA)
⩽ 250	76
>250	78

The rationale for this case study is as follows:

1. Eighty-two percent of the portable air compressors sold (by 1972 sales figures) have air flow capacity of less than 250 cfm.

2. Many of the portable air compressors in the 18 percent greater than 250 cfm category are used in remote areas where the impact on public health and welfare is minimal.

3. Data indicate it is more difficult to quiet large portable air compressors.

4. The mean noise level of the population of quiet portable air compressors in the marketplace today, with flow capacity greater than 250 cfm, is 77.9 dBA.

The analysis demonstrates a resultant 0.1 percentage point loss of effectiveness; that is, a 14.6-percent impact relief from construction site noise as compared with the 14.7-percent relief when all portable air compressors are reduced to 76 dBA.

ACTUAL POPULATION EXPOSED TO CONSTRUCTION SITE NOISE

To further assess the benefits of reducing portable air compressor and truck noise in terms of the reduction in actual population exposed to construction site noise, the cumulative number of people exposed to construction site noise levels above L_{dn} 55, 60, 65, 70, and 75 was determined for:

- No construction equipment noise reduction, i.e., today's equipment noise levels.

- Portable air compressors reduced to 76 dBA.

- Portable air compressors reduced to 76 dBA and trucks (concrete mixers and dump trucks) reduced to 83 dBA.

The estimated cumulative number of people currently exposed to construction site noise and the attendant reduction in the number of people exposed to reduced portable air compressor and truck noise levels is tabulated in Table 10-5. As shown, the reduction of portable air compressor noise alone reduces the number of people exposed to levels above L_{dn} 55 (the noise level identified as protective of health and welfare with an adequate margin of safety) by 4.2 million, while reduction of both portable air compressor and truck noise reduces the number of people exposed by 7.4 million. With portable air

Table 10-5

EFFECT OF PORTABLE AIR COMPRESSOR AND TRUCK NOISE EMISSION REGULATIONS ON THE U.S. POPULATION EXPOSED TO CONSTRUCTION SITE NOISE

L_{dn}	No Regulation Cumulative Population exposed to Construction Site Noise	Construction Equipment Regulated — Portable Air Compressors Regulated*		Portable Air Compressors and Trucks Regulated**	
		Cumulative Population Exposed	Δ	Cumulative Population Exposed	Δ
55	27,457,000	23,242,000	4,215,000	20,045,000	7,412,000
60	7,723,000	6,456,000	1,267,000	5,569,000	2,154,000
65	2,079,000	1,714,000	365,000	1,526,000	553,000
70	587,000	472,000	115,000	412,000	175,000
75	93,000	61,000	32,000	50,000	43,000

* 76 dBA @ 7m (23 ft.)
** Portable air compressors regulated at 76 dBA @ 7m (23 ft.) and trucks regulated at 83 dBA @ 15.2m (50 ft.)

compressor and truck noise reduced, 20 million people will remain exposed to construction site noise levels above L_{dn} 55; this being so because the 18 other pieces of construction equipment continue to contribute significant acoustic energy to the site environment.

Section 11

ENFORCEMENT

Enforcement of new product noise emission standards applicable to new portable air compressors will be accomplished through:

- Production verification testing of compressor configurations.
- Assembly process testing using selective enforcement auditing of production compressors and
- In-use compliance programs.

The predominant portion of any production verification testing and assembly process testing will be carried out by the manufacturer and audited or confirmed by EPA personnel, as necessary.

Any test used for production verification testing and any test used for assembly process testing of production compressors should be the same test as that specified in the regulations or correlative so that compliance may be accurately determined. The standard measurement methodology, which can be used both for production verification testing and assembly process testing of portable air compressors, is a modified version of the CAGI/PNEUROP test method that appears in Section 6.

Analyses have been performed to assess potential product verification and selective enforcement auditing testing costs. Appendix C presents the estimates and lists the underlying assumptions used in the analyses.

PRODUCTION VERIFICATION

Production verification is the testing of early production models by a manufacturer or by EPA to verify that a manufacturer has developed the necessary technology and is capable of applying the technology in a manufacturing process.

Production verification does not involve any formal EPA approval or issuance of certificates subsequent to manufacturer testing, nor is any extensive testing required by EPA. A compressor configuration must undergo production verification prior to or soon after its distribution in commerce. Like configurations may be grouped into a category, as defined in the regulations. A compressor model would be considered to have been production verified after the manufacturer has shown, based on the application of the noise measurement testing methodology, that a configuration or configurations of that model conform to the standard. Production verification testing of all configurations produced by a manufacturer may not be required if a manufacturer can show that the noise levels of some configurations in a category are consistently higher than others in a category. In such a case, the noisiest configuration would be the only configuration requiring verification. Manufacturers must reverify whenever they implement engineering changes to their products that are likely to adversely affect noise emissions. Additionally, some further testing on a continuing or other basis of production products may be necessary to assure that all products manufactured conform to the standards.

Production verification provides EPA with confidence that production models will conform to the standards and also limits the possibility that nonconforming compressors will be distributed in commerce. If the possibility exists that subsequent models may not conform to the standard, selective enforcement auditing may be used to determine whether production compressors continue to actually conform to the standard.

Selective Enforcement Auditing

The regulations provide for sample testing based on an audit of production compressors (Selective Enforcement Auditing). Selective Enforcement Auditing (SEA) is the term used to describe the testing of a statistical sample of production compressors, from a particular compressor category or configuration selected, to determine whether production compressors conform to the standard and to provide the basis for further action in the case of nonconformity. SEA testing is performed pursuant to an administrative request in accordance with the proposed test procedure.

The sampling strategy adopted by EPA does not attempt to impose a quality control or quality assurance scheme upon a manufacturer but merely audits the conformity of his products.

Testing is initiated by a test request that will be issued to the manufacturer by the Assistant Administrator for Enforcement or his designated representative. A test request may be directed to a category, a configuration, or several configurations in a category. The test request will require the manufacturer to test a sample of compressors of the specified category or configuration produced at a specified plant.

An important influencing factor regarding the decisions of the Administrator to issue a test request is whether the manufacturer is conducting noise emission testing of production compressors under his own quality control scheme. If a manufacturer can provide evidence that his compressors are meeting standards based on test and sampling methods acceptable to EPA, issuance of a test request may not be necessary.

The general type of sampling strategy developed by EPA employs attributes-type sampling plans applied to a specific number of batches of compressors. Under inspection by attributes, items are inspected or tested to determine whether they meet the prescribed specification. The basic decision criterion is the number of compressors having parameters that meet the specification rather than the average value of some parameter. The particular specification for compressors is the noise emission standard established by regulation.

Two types of sampling plans for inspection of batches are employed, single and multiple sampling. For single sampling, only one test sample of compressors is selected from the batch subject to testing. Single sampling is used when the batch size ranges from 4 to 15; while multiple sampling is used for batch sizes over 15 compressors. Multiple sampling differs from single sampling in that small consecutive test samples are drawn from a batch rather than one large sample. Multiple sampling offers the advantage of keeping the number of compressors tested to a minimum when the compressors are meeting the standard. The samples required under the single sampling plan range from 3 to 4 per batch, depending on the batch size. Under the multiple plan sample size ranges from 2 to 14.

The sampling plans are arranged according to the size of the batch from which a sample or samples are to be drawn. Each plan specifies the sample size and acceptance and rejection numbers associated with an acceptable quality level (AQL) of 10 percent. As applied to compressor noise emissions, the AQL is the maximum percentage of compressors that fail to meet the noise emission standard; but, for purposes of sampling, inspection can be considered acceptable. An AQL of 10 percent was chosen to take into account some test variability and random production errors.

The sampling plans provide for audit of a manufacturer's product noise emission standard conformance as based on tests performed on a sequence of production batches of his products. As a result of the acceptance or rejection of the prescribed number of batches, the determination is made as to whether the manufacturer is producing compressors within the prescribed acceptable quality level of 10 percent.

Batches tested are accepted or rejected based on tests performed on samples of compressors. The number of noncomplying compressors in a sample is compared to the acceptance and rejection numbers for the appropriate sampling plans. If the number of failures is less than or equal to the acceptance number, the batch is said to be accepted. On the other hand, if the number of failing compressors in the sample is greater than or equal to the rejection number, then the batch is said to be rejected. The probability that a batch will be accepted if the percentage of noncomplying compressors is less than the AQL is high. The probability that a batch will be rejected if the actual number of noncomplying compressors is greater than the AQL increases as the percentage of noncomplying compressors increases.

When the sampling strategy involves a multiple sampling plan, there may be some instances in which the number of failures in a test sample may not allow acceptance or rejection of a batch. When this occurs continued testing may be required until a decision can be made to either accept or reject a batch.

Regardless of whether a batch is accepted or rejected, noncomplying compressors will have to be repaired or adjusted and will have to pass a retest before they can be distributed in commerce.

The fact that one batch of compressors is accepted or rejected does not provide sufficient information as to whether the particular category or configuration(s) selected for testing is in compliance with the standard. This is because the number of compressors tested in inspecting one batch is not of a large enough sample to determine production quality on an extended basis. To provide a large enough sample on which to base production quality, the manufacturer must inspect a sequence of batches. As in the case for the sampling plans for inspecting batches, the sequences of batches that must be inspected are arranged according to the size of the batch. Associated with each batch size is the number of consecutive batches required to be inspected and batch sequence acceptance and rejection numbers. Pairs of consecutive batches are inspected and the number of rejected batches are compared to the batch sequence acceptance and rejection numbers. If the number of accepted batches is less than or equal to the batch sequence acceptance number, the manufacturer will not be required, at that time, to conduct further sampling and testing of the category or configuration selected pursuant to the initial test request. If the number of rejected batches is greater than the batch sequence acceptance number but less than the rejection number, the manufacturer must continue to inspect consecutive batches. If the number of rejected batches is equal to or greater than the batch sequence rejection number, the manufacturer may be required to institute 100 percent testing for all compressors identified in the request.

The sampling and batch sequence inspection plans in this regulation were designed so that the maximum manufacturer's risk is 5 percent. That is, if the percentage of noncomplying compressors a manufacturer produces is 10 percent or less, there is a maximum probability of 0.05 that he will be requested to institute 100 percent testing.

Since the number of compressors tested in response to a test request may vary considerably, a fixed time limit cannot be placed on completing all testing. The proposed approach is to establish the time limit for complying with an SEA request on the basis of a maximum specified test time per compressor, taking transportation requirements, if any, into consideration. The manufacturer would be allowed a reasonable amount of time for transport of compressors to a test facility if one were not available at the assembly plant.

The sampling plans developed by EPA for use in the regulations can be characterized by operating characteristic (OC) curves. The OC curves for the EPA plans are presented in Figure 11-1, which graphically demonstrates how the probability of accepting a batch sequence varies with the percentage of noncomplying compressors. The maximum manufacturer's risk

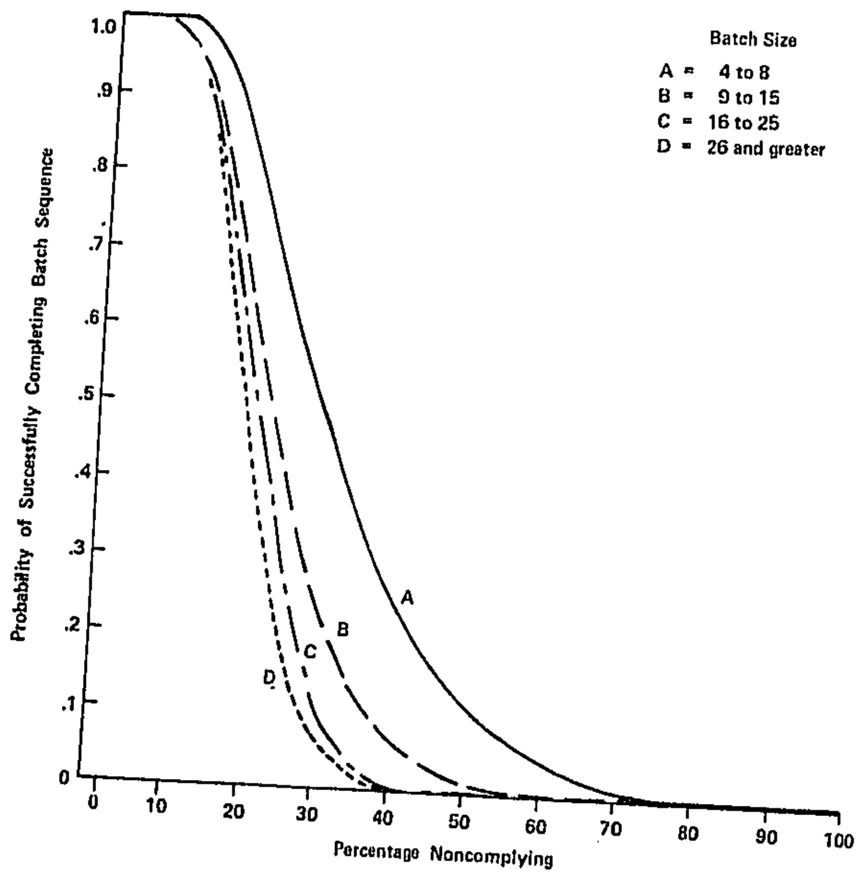

Figure 11-1. Operating Characteristic Curves for Sampling Plans

previously referred to can be read directly from the OC curves. For each batch size, the manufacturer's risk is one minus the probability of accepting the batch sequence when the percentage nonconforming is 10 percent. The consumer's risk, which is the probability of a batch sequence being accepted when the percentage nonconforming exceeds the AQL, can also be read directly from the OC curves.

If a manufacturer can provide evidence that his compressors are meeting the standard using tests and sampling methods acceptable to EPA, issuance of a test request may not be necessary. For batch-type sampling plans, EPA will judge the acceptability of a manufacturer's sampling plan in terms of the OC curve or curves characterizing the plan. The OC curve or curves for a manufacturer's sampling plan must be comparable to the OC curves for the EPA plans.

If a manufacturer employs a continuous-type sampling plan (such as Department of Defense Handbook H106, "Multi-level Continuous Sampling Procedure and Table for Inspection by Attributes"), then the average outgoing quality limit (AOQL) must not exceed 10 percent, where the AOQL is the worst average outgoing quality that will result from employing a given sampling plan, regardless of the incoming quality.

Both attributes and variable type sampling plans will be considered by EPA for use by a manufacturer in his quality control scheme. In the event a manufacturer elects to use a variables-type plan, he must demonstrate to EPA that the sampling plan is appropriate for the type of distribution that noise emissions from compressors manufactured by him exhibit. To demonstrate suitability of either an attribute- or variable-type sampling plan, the manufacturer must provide data to EPA on test results from a sufficiently large sample of compressors to enable statistically valid conclusions to be drawn regarding the underlying distribution. He must also include the analysis of the data.

It is the manufacturer's responsibility to derive the OC curves or AOQL for his plan or plans for presentation to EPA before EPA will make a judgment relative to the acceptability of both the plan and test results, on the basis of such a plan, as an alternative to issuance of a test request

ENFORCEMENT ACTION

The prohibitions in the Act would be violated in the following instances:

1. If the manufacturer fails to properly verify the conformance of production compressors.

2. If it is determined, on the basis of selective enforcement audit testing or other information, that nonconforming production compressors are knowingly being distributed into commerce.

3. If the manufacturer fails to comply with an Administrator's order specifying appropriate relief where nonconformity is determined.

4. If the noise control system of a compressor is "tampered with," as defined in the Act.

Remedies

In addition to the criminal penalties, fines and imprisonment, associated with violations of the prohibitions of the Act, the Administrator has the option of issuing an order specifying such relief as he determines necessary to protect the public health and welfare. Such orders could require that a manufacturer recall products distributed into commerce not in conformity with the regulations, whether or not the manufacturer had knowledge of the nonconformity. Recall orders will be issued in situations in which selective enforcement testing demonstrates that compressors of a particular configuration that do not conform with the applicable emission standard have been distributed in commerce.

The Administrator may also issue an order requiring the manufacturer to cease distribution in commerce of compressors when the requirements of production verification have not been met.

Any orders would be issued only after manufacturers had been afforded notice and an opportunity for a hearing.

Labeling

The label will provide notice to buyers and users that the product is sold in conformity with the regulations and that the compressor is equipped with noise attenuation devices, which should not be removed or rendered inoperative, as prohibited under Federal law. The label also states that the use of a product that has been tampered with is prohibited.

In-Use Compliance

The intent behind this requirement is to ensure that the public health and welfare benefits derived from the portable air compressor standard are fully achieved over time. The Agency maintains that product noise emission standards developed to protect public health and welfare must not degrade during the product's life. However, where degradation cannot be reasonably prevented through periodic preventive maintenance and repair, standards may include a degradation allowance.

Currently, no data are available to determine whether and to what degree the noise from a properly maintained and repaired portable air compressor would degrade in time. Accordingly, the Agency is reserving a section for useful life requirements in the regulation and will defer action on setting a useful life standard until necessary and sufficient data are collected on which to base a standard. The delay in promulgating a useful life standard should not be construed as a deemphasis of this requirement, but merely as a means to assure that an accurate and fair useful life requirement may be imposed.

The manufacturer is required (by Section 6 (d) (1) of the Act) to warrant to the first purchaser and each subsequent purchaser that the compressor was designed, built, and equipped to conform at the time of sale to the Federal noise emission standards. Thus, the manufacturer is required to remedy all defects in design, assembly, or in any part of the system, that at the time of retail sale caused the Federal noise emission standard to be exceeded. Although the warranty covers only date-of-sale nonconformity, the consumer may make a claim under the warranty at any time during the life of the product, as long as he can establish noncompliance on the date of sale.

Recall is generally the appropriate remedy (under Section 11 (d) (1)) to require the manufacturer to repair or replace a class of compressors that fails to conform to Federal standards at the time of sale. Such recall may be used, for example, when products are discovered in use with defects relating back to the date of sale that would cause noncompliance.

Tampering with (removing or rendering inoperative) the noise control devices and elements of design, so that Federal noise emission levels are exceeded, is prohibited under Section 10 (2) (A) of the Act. The use of a product after it has been tampered with is also prohibited.

Finally, manufacturers are required (pursuant to regulations under Section 6 (c) (1)) to provide instructions to purchasers specifying the maintenance, use, and repair necessary to minimize or eliminate any possible degradation from the initial noise emission levels.

Section 12

ENVIRONMENTAL EFFECTS OF NOISE EMISSION REGULATION OF PORTABLE AIR COMPRESSORS

IMPACT RELATED TO ACOUSTICAL ENVIRONMENT

The regulation will limit the magnitude of noise emission of newly manufactured portable air compressors and will produce a 14.7 percent reduction in the impact of construction site noise on people. When viewed in concert with new truck noise regulations, a reduction in total impact of 45 percent is anticipated when the current population of compressors and trucks is replaced by quiet units. This regulation is a first step in a comprehensive noise abatement effort aimed at reducing the total environmental noise to which the population is subjected. The composite impact of all Federal noise emission regulations will be aimed at a level of environmental noise consistent with protecting human health and welfare.

IMPACT RELATED TO LAND

Portable air compressor regulations will have no adverse effects relative to land.

IMPACT RELATED TO WATER

Portable air compressor regulations will have no adverse effects on water quality or supply.

IMPACT RELATED TO AIR

These regulations will have no adverse impact on air quality.

There exists a possibility of market shifts from gasoline-powered to diesel-powered portable air compressors. If these shifts occur in favor of diesel-engine powered compressors, total air emissions might be reduced since diesel engines produce less pollutants as the byproduct of combustion than do gasoline engines.

IMPACT RELATED TO ENERGY

Portable air compressor regulations will have little, if any, impact on fuel consumption.

There exists considerable disagreement among the industry regarding any potential increase in fuel use by quieted portable air compressors. It is EPA's belief that fuel consumption increases that may result from increased cooling requirements will be offset through the use of more efficient fans in the quieted compressors.

REFERENCES

1. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Environmental Protection Agency, 550/9-74-004, March 1974.

2. "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances," Environmental Protection Agency NTID 300.1, December 1971.

3. "Report to the President and Congress on Noise," 92d Congress, 2d Session, 92-63, February 1972.

4. Patterson, W. N., *et.al,* "Specialty Construction Trucks: Noise and Cost of Abatement," Bolt Beranek and Newman, Report No. 2566a, September 1973.

5. Freeze, T. W., *et al.* "Portable Air Compressor: The Costs, Benefits and Penalties of Reducing Their Noise," EPA Contract No. 68-01-1539, Bolt Beranek and Newman, Report No. 2566c, March 1, 1974.

6. Patterson, W.N., *et al.* "Portable Air Compressor Noise," Bolt Beranek and Newman, Report No. 2795a, March 29, 1974.

7. Patterson, W. N., *et al.* "Portable Air Compressor Noise: Diagnosis and Control," Bolt Beranek and Newman, Report No. 2795b, March 29, 1974.

8. Kearney, A. T., "A Study to Determine the Economic Impact of Noise Emission Standards in the Construction Equipment Industry: Portable Air Compressor Report."

9. Steele, S. and the Noise Information Program, "A Study of Local and State Laws for the Noise of Construction Equipment," EPA Contract No. 68-01-2229, Informatics, Inc., Rockville, Md., May 1, 1974.

10. The Noise Information Program, "Foreign Regulations for Construction Equipment: A Status Report," EPA Contract No. 68-01-1894, Informatics, Inc., Rockville, Md., March 25, 1974.

11. Holmer, C.I., "Measurement Methodology and Supporting Documentation for Portable Air Compressors," National Bureau of Standards, Washington, D.C., January 1975.

12. "Identification of Products as Major Sources of Noise," *Federal Register*, Vol. 39, No. 121, June 21, 1974.

13. "Standards on Noise Measurement, Rating Schemes, and Definitions: A Compilation," National Bureau of Standards, Washington, D.C., Publication 386, November 1973.

14. "Exterior Sound Level Measurement Procedure for Powered Mobile Construction Equipment," Proposed SAE Recommended Practice x588.

15. "Construction Site Sound Level Measurements," Proposed SEA Recommended Practice.

16. "CAGI-PNEUROP Test Code for the Measurement of Sound from Pneumatic Equipment," ANSI S5,1-1972, 1969.

17. Peterson, A.P.G. and Gross, Jr., E.E., *Handbook of Noise Measurement*, General Radio Co., 1972.

18. Griffiths, Lt. Col., J.D., "The Design of a Low Cost Sound Level Meter," USAF TR-74-6, EPA 550/9-74-008, April 1974.

19. Francois, P., and Fleury, M., "Noise Measurement on Mobile Compressors for Construction Sites," Cour, de la Norm., No. 220-VII-VIII: 467-474 (in French), 1971.

20. Oncley, P.B., "Correction Procedure for Outdoor Noise Measurement," Inter-Noise 72 Proceedings, Washington, D.C., 1972.

21. Bettis, R.A., and Sexton, M.X., "The Effect of Test Site Topography in Vehicle Noise Measurement," presented at the 85th Meeting of the Acoustical Society of America, Boston, Mass., 1973.

22. Anderson, G.S., Miller, R.L., and Schwartz, R.M., "1972 Noise Levels and Noise Models for Urban Truck Traffic: West Side Highway Project," Bolt Beranek and Newman Report No. 2519A, 1973.

23. Wiener, F.M., Malme, C.I., and Gogos, C.M., "Sound Propagation in Urban Areas," *Journal of the Acoustical Society of America*, 37: 739-747, 1965.

24. Kurze, U.J., and Anderson G.S., "Sound Attenuation by Barriers," *App. Acoust.*, 4: 35-53, 1971.

25. Kessler, F.M., "Portable Compressor Noise Reduction-Final Report," Ingersoll Rand Research, Inc., TND-362, August 1968.

26. Hinck, D.C. and McGahan, W.A., "Sound Reduction of Large Portable Air Compressors," Ingersoll Rand Research Inc.

27. Heinrick Flottman, K.G., letter to Informatics, February 5, 1974.

28. "Public Health and Welfare Criteria for Noise," Environmental Protection Agency Report 550/9-73-002, July 1973.

29. "Standard for the Calculation of the Articulation Index," ANSI S3.5-1969.

30. "House Noise - Reduction Measurements for Use in Studies of Aircraft Flyover Noise," Society of Automotive Engineers, Inc., AIR 1081, October 1971.

31. "Construction Noise Survey," Bureau of Noise Control, New York Department of Environmental Conservation, April 1974.

32. Patterson, W.N., *et al.* "Regulation of Construction Activity Noise," Bolt Beranek and Newman Report No. 2887, November 27, 1974.

33. General Electric TEMPO, "Proposed New Portable Air Compressor Regulation: Supplementary Economic Impact Analysis." June 1975.

34. "Population Distribution of The United States as a Function of Outdoor Noise Level," Environmental Protection Agency Report 550/9-74-009, June 1974.

APPENDIX A

DOCKET ANALYSIS

Appendix A

DOCKET ANALYSIS

INTRODUCTION

The Environmental Protection Agency is committed by statute and policy to in-depth public participation in the decision making process for its environmental regulations. This policy encourages and solicits contributions from the public on technology, costs, health and welfare and economic impact or benefits and any other attributes of the particular subject. Contributions are desired from as many diverse views as are possible, and when such information, after thorough analysis by the Agency, indicates a need for change, appropriate action is taken to insure that the regulation being promulgated incorporates such changes.

Pursuant to the Agency's policy, three opportunities were provided for the public to comment on the proposed noise emission regulation for portable air compressors. On October 29, 1974, concomitant with publication of the Notice of Proposed Rulemaking (NPRM) for portable air compressors (39 F.R. 38186), a docket was opened to receive written public comments regarding the NPRM. The period for public comment extended from October 29, 1974, to December 31, 1974, to allow interested persons 2 months to formulate comments and respond.

On February 18, 1975, a public hearing on the proposed regulation was held in Arlington, Virginia, to provide additional opportunities for the public to comment on the proposed rulemaking. This was followed by a second public hearing on February 25, 1975, in San Francisco, California. A public hearing docket was opened to accommodate written materials submitted to the Agency pursuant to the hearings. This docket closed on March 10, 1975.

All public comments received by EPA/ONAC in the form of written docket submissions, as well as from public hearing testimony, have been reviewed and analyzed by the Agency. Where the analysis indicated changes were appropriate, the Agency incorporated these into the regulation being promulgated.

Summarized in this section are the comments received by the Agency resulting from public participation in the portable air compressor rulemaking. Also included are the Agency's responses to the comments. The docket analysis is organized into two sections. Section 1 identifies and summarizes the major issues raised by the various commenters. The issues have been separated into five categories: (1) Technical, (2) Health and Welfare, (3) Economic, (4) Legal, and (5) Miscellaneous. Each issue is identified by number and is followed by a list of those who raised the issue. Opposite the name of each individual is a descriptor referring to the location of the comment in the Agency's records. Comments received as submissions to the NPRM docket are identified by a number preceded by the letter C, while those arising from public hearings are identified by the word "Transcript." Section 2 presents the Agency's response to each issue raised in Section 1.

All dockets and public hearing transcripts are available for public inspection between 9:00 A.M. and 4:30 P.M. at:

EPA/ONAC
Room 1105, Crystal Mall #2
1921 Jefferson Davis Highway
Arlington, Virginia

PORTABLE AIR COMPRESSOR REGULATION
DOCKET ANALYSIS

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LIST OF ISSUES

RESPONSE TO ISSUES

1. TECHNOLOGY

Issue	Docket No.	Originator
1.1	COMMENT:	A 76 dBA limit does not represent currently available technology.
	C036	Richard Gimer Compressed Air and Gas Institute
	Transcript	Richard Gimer Compressed Air and Gas Institute
1.2	COMMENT:	The technology to quiet portable air compressors is available.
	Transcript	J. A. Mills Director of Research Industrial Noise Services, Inc.
	Transcript	Richard S. Anderson Vice President General Acoustics Corporation
1.3	COMMENT:	Data relating to degradation of noise emission characteristics is insufficient to predict degradation patterns for air compressors.
	C039	F. A. Dellecave Ingersoll-Rand Corporation
	C036	Richard Gimer Compressed Air and Gas Institute
	Transcript	Richard Gimer Compressed Air and Gas Institute
	Transcript	Richard Ostwald Engineer Gordon Smith and Company
	Transcript	Richard Geney Atlas Copco
	Transcript	Lawrence H. Hodges J. I. Case Co.

Issue	Docket No.	Originator
1.4	COMMENT:	Fuel consumption can be expected to increase as a result of the regulation.
	C033	R. D. Harlow Schramm, Inc.
	Transcript	Robert Harlow Schramm, Inc.
	Transcript	H. T. Larmore CIMA
1.5	COMMENT:	Fuel consumption may be expected to remain the same or decrease as a result of the usage of high efficiency fans.
	Transcript	Paul Laesch Sullair Corporation
1.6	COMMENT:	Quieting technology is not the same for all sizes and configurations of air compressors.
	Transcript	Paul Laesch Sullair Corporation
	Transcript	Richard Gimer CAGI
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	Richard Geney Atlas Copco
1.7	COMMENT:	The availability of quiet engines is a problem found by manufacturers in their efforts to comply with the regulation.
	C015	C. M. Copeland P. K. Lindsay Co.
	C036	Richard Gimer CAGI
	Transcript	Richard Gimer CAGI

Issue	Docket No.	Originator
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	Paul Laesch Sullair Corpration
1.8	COMMENT:	"Band aid" measures for controlling noise emissions are more expensive than integrated design changes.
	Transcript	Lawrence H. Hodges J. I. Case Company
	C032	D. E. Kipley Gardner-Denver Company
1.9	COMMENT:	Portable air compressor noise should be measured in terms of C-weighted decibels.
	C038	Don L. Kerstetter Pennsylvania Dept. of Environmental Resources
1.10	COMMENT:	Portable air compressors should be required to have cut off devices for shutdown when access doors are opened.
	Transcript	Alvin Greenwald Private Citizen
1.11	COMMENT:	Problems with component parts availability may affect manufacturers' abilities to comply with the effective date of the regulation.
	C036	Richard Gimer CAGI
	Transcript	Richard Gimer CAGI
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Richard Ostwald Gordon Smith and Company

Issue	Docket No.	Originator
	Transcript	Paul Laesch Sullair Corporation
1.12	COMMENT:	EPA measurement methodology should be compatible with proposed international methodology.
	C017	William W. Lang Institute of Noise Control Engineering
	C023	N. J. E. Hartwell Perkins Engine Company
	C036	Richard Gimer CAGI
	Transcript	George Diehl Ingersoll-Rand Company
1.13	COMMENT:	The test specification for a fifth microphone above the compressor should be reconsidered
	C023	N. J. E. Hartwell Perkins Engine Company
1.14	COMMENT:	There is no separately identifiable "noise control system" per se for portable air compressors
	C031	A. J. Cox CIMA
	C036	Richard Gimer CAGI
1.15	COMMENT:	The regulation should provide for a simplified manufacturer pre-production testing procedure
	C032	D. E. Kipley Gardner-Denver Company
	C040	Joseph O'Neill Quincy Compressor
	C036	Richard Gimer CAGI

Issue	Docket No.	Originator
1.16	COMMENT:	The present method for classification of portable air compressors should be simplified to accommodate small volume production
	C037	William Price Worthington Compressors, Inc.
	C039	F. A. DelleCave Ingersoll Rand
	C036	Richard Gimer CAGI
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Lawrence H. Hodges J. I. Case Company
	Transcript	Robert L. Grievell Koehring Company
1.17	COMMENT:	In order to comply with the regulation, manufacturers must design for well below the standard.
	C009	D. E. Kipley Gardner-Denver Company
	C010	Richard Gimer CAGI
	C016	Richard Ostwald Gordon Smith and Company
	C032	D. E. Kipley Gardner-Denver Company
	C033	R. D. Harlow Schramm, Inc.
	C037	W. S. Price Worthington Compressors, Inc.
	C039	F. D. Dellecave Ingersoll-Rand

Issue	Docket No.	Originator
	C040	Bruce J. Smith Bucyrus-Erie
	C036	Richard Gimer CAGI
	Transcript	Richard Gimer CAGI
	Transcript	Richard Ostwald Gordon Smith and Company
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Richard Geney Atlas Copco
1.18	COMMENT:	A single incident maximum dB(C) level should be included in the regulation
	Transcript	Alvin Greenwald Private Citizen
1.19	COMMENT:	The EPA measurement methodology is not suitable for in-use testing at a construction site
	Transcript	Robert Levy City of San Francisco
	Transcript	John W. Ross, Jr. City and County of San Francisco
1.20	COMMENT:	The Agency neglected in its background studies to investigate or-test machines larger than 1200 cfm
	Transcript	Richard Geney Atlas-Copco
	Transcript	Paul Laesch Sullair Corporation
1.21	COMMENT:	A conflict between noise suppression technology and safety considerations may exist regarding the flame retardant properties of acoustical insulation laggings

Issue	Docket No.	Originator
	Transcript	Paul Laesch Sullair Corporation
1.22	COMMENT:	The regulation should include controls of pure tone noise from portable air compressors
	Transcript	Alvin Greenwald Private Citizen
1.23	COMMENT:	A tolerance in the standard should be allowed on field tests to account for environmental and instrumentation variance likely to occur when portable air compressors are tested in environments different from the controlled environment of the manufacturer's facility
	Transcript	Richard Gimer CAGI

2. HEALTH AND WELFARE

Issue	Docket No.	Originator
2.1	COMMENT:	Consideration should be given to usage conditions and amount of exposure to the public for different types of machines in setting the regulation.
	C032	D. E. Kipley Gardner-Denver Company
	C036	Richard Gimer CAGI
	Transcript	Richard Gimer CAGI
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	Paul Laesch Sullair Corporation
2.2	COMMENT:	Benefits to public health and welfare do not justify the economic impact of the regulation.
	C024	R. W. Wiedow Northern Illinois Gas Company
	C028	Hugh I. Myers Private Citizen
	C030	Robert F. Hand Clark Equipment
	C034	American Road Builders Association
	Transcript	William Heckenkamp Gardner-Denver Company
2.3	COMMENT:	The regulation will have a beneficial impact on the public health and welfare.
	C029	Thomas F. Scanlan Grossmont College
	Transcript	David Staples Environment Health Administration Washington, D. C.

Issue	Docket No.	Originator
	Transcript	Don Gallay Department of Environmental Control City of Chicago
	Transcript	Dr. Donna Dickman Washington Hearing and Speech Society
	Transcript	Alvin Greenwald Private Citizen
2.4	COMMENT:	EPA should undertake a more thorough cost/benefit study.
	C024	R. W. Wiedow Northern Illinois Gas Company
	C034	American Road Builders Association

3. ECONOMICS

Issue	Docket No.	Originator
3.1	COMMENT:	The portable air compressor regulation is inflationary.
	C011	Bruce J. Smith Bucyrus-Erie
	C014	W. J. Cowan Barber-Greene Company
	C018	Lawrence H. Hodges J. I. Case
	C022	Lawrence H. Hodges J. I. Case
	C030	Robert F. Hand Clark Equipment
	C031	A. J. Cox CIMA
3.2	COMMENT:	Smaller manufacturers in the industry will be those most severely impacted by the regulation.
	C016	Richard Ostwald Gordon Smith and Company
	C028	Hugh I. Myers, Jr. Private Citizen
	C030	Robert F. Hand Clark Equipment
	C036	Richard Gimer CAGI
	Transcript	Robert L. Grievell Koehring Company
	Transcript	Paul Laesch Sullair Corporation
	Transcript	Richard Gimer CAGI

Issue	Docket No.	Originator
	Transcript	George Diehl Ingersoll-Rand
	Transcript	Richard Ostwald Gordon Smith and Company
3.3	COMMENT:	The economic impacts of the useful life provision were not included in the cost of compliance studies.
	C006	J. M. Ombrello LeRoi Division, Dresser Industries
	C009	D. E. Kipley Gardner-Denver Company
	C010	Richard Gimer CAGI
	C022	Lawrence H. Hodges J. I. Case
	C027	George J. Shadtner Grimmer-Schmidt Corporation
	C030	Robert F. Hand Clark Equipment
	C031	A. J. Cox CIMA
	C033	R. D. Harlow Schramm, Inc.
	C035	Caterpillar Tractor Co.
	C036	Richard Gimer CAGI
	C037	William S. Price Worthington Compressors, Inc.
	C039	F. A. Dellecave Ingersoll-Rand
	Transcript	Richard Gimer CAGI

Issue	Docket No.	Originator
	Transcript	Robert Harlow Schramm, Inc.
	Transcript	Richard Ostwald Gordon Smith and Company
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Richard Geney Atlas-Copco
	Transcript	Lawrence H. Hodges J. I. Case Co.
	Transcript	H. T. Larmore CIMA
3.4	COMMENT:	The cost of constructing a test facility at a manufacturer's plant location is economically infeasible.
	C006	J. M. Ombrello Le Roi Division, Dresser Industries
	C027	George J. Stradtner Grimmer-Schmidt Corporation
	C036	Richard Gimer CAGI
	C040	Bruce J. Smith Bucyrus Erie
3.5	COMMENT:	The 16% estimated per unit price increase is an underestimation of the true cost to comply with the regulation due to the compliance and enforcement provisions.
	C006	J. M. Ombrello Le Roi Division, Dresser Industries
	C009	D. E. Kipley Gardner-Denver Company

Issue	Docket No.	Originator
	C010	Richard Gimer CAGI
	C016	Richard Ostwald Gordon Smith and Company
	C022	Lawrence H. Hodges J. I. Case
	C027	George J. Stradtner Grimmer-Schmidt Corp.
	C031	A. J. Cox CIMA
	C032	D. E. Kipley Gardner-Denver
	C033	R. D. Harlow Schramm, Inc.
	C035	Caterpillar Tractor Co.
	C039	F. A. DelleCave Ingersoll-Rand
	C040	Joseph O'Neill Quincy Compressor
	C036	Richard Gimer CAGI
	Transcript	Richard Gimer CAGI
	Transcript	Robert Harlow Schramm, Inc.
	Transcript	William Heckenkamp Gardner-Denver Co.
	Transcript	Lawrence Hodges J. I. Case Co.
	Transcript	H. T. Larmore CIMA
	Transcript	Paul Laesch Sullair Corporation

Issue	Docket No.	Originator
3.6	COMMENT:	There is no need for a Federal noise regulation for portable air compressors because marketplace pressures will force production of quieted machines without a regulation
	C030	Robert F. Hand Clark Equipment
3.7	COMMENT:	Maintenance of dB(C) levels is costly and unnecessary
	C023	N. J. E. Hartwell Perkins Engines
	C036	Richard Gimer CAGI
3.8	COMMENT:	The regulation will have a harmful impact on foreign trade patterns in the industry
	C022	Lawrence H. Hodges J. I. Case Company
	C030	Robert F. Hand Clark Equipment
	C023	N. J. E. Hartwell Perkins Engines
	C036	Richard Gimer CAGI
3.9	COMMENT:	The regulation will have the effect of increasing air compressor rentals, to the detriment of industry sales volume
	Transcript	Paul Laesch Sullair Corporation
3.10	COMMENT:	A board of review should be established to ensure that manufacturer costs are not prohibitive
	C0032	D. E. Kipley Gardner-Denver

Issue	Docket No.	Originator
3.11	COMMENT:	Large manufacturers can be expected to stockpile standard machines before the effective date of the regulation
	Transcript	Paul Laesch Sullair Corporation
3.12	COMMENT:	The cost of sound attenuation for a small manufacturer will be higher per unit than for a larger company
	C016	Richard Ostwald Gordon Smith and Company
3.13	COMMENT:	The one-year effective date of the regulation is an insufficient amount of time and will cause an increased economic burden on the manufacturers
	C002	Richard Gimer CAGI
	C015	C. M. Copeland P. K. Lindsay Company
	C016	Richard Ostwald Gordon Smith and Company
	C027	George J. Stradtner Grimmer-Schmidt Corporation
	C032	D. E. Kipley Gardner-Denver Company
	C033	Robert Harlow Schramm, Inc.
	C037	W. S. Price Worthington Compressors, Inc.
	C039	F. A. DelleCave Ingersoll-Rand
	C040	Joseph O'Neill Quincy Compressors
	C036	Richard Gimer CAGI

Issue	Docket No.	Originator
	Transcript	Richard Gimer CAGI
	Transcript	Robert Harlow Schramm, Inc.
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Paul Laesch Sullair Corporation
3.14	COMMENT:	The regulation will force the discontinuation of some manufacturer's compressor models
	C032	D. E. Kipley Gardner-Denver Company
	C033	Robert Harlow Schramm, Inc.
	C037	William Price Worthington Compressors, Inc.
	C039	F. A. DelleCave Ingersoll-Rand
	C036	Richard Gimer CAGI
	Transcript	Richard Gimer CAGI
	Transcript	Robert Harlow Schramm, Inc.
	Transcript	William Heckenkamp Gardner-Denver Company
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Richard Geney Atlas-Copco

Issue	Docket No.	Originator
3.15	COMMENT:	The regulation will cause the non-productive expenditure of labor and materials.
	C028	Hugh I. Myers Private Citizen
	Transcript	Richard Geney Atlas Copco
	Transcript	John McNally Caterpillar Tractor Company

4. ENFORCEMENT

Issue	Docket No.	Originator
4.1	COMMENT:	The compliance and enforcement aspects of the regulation were derived from unrelated industries and could not realistically or practically be applied to air compressor manufacturing. The proposal is unreasonable, unjustified, and impossible to comply with, because of the more restrictive fashion in which the proposed rules, which were derived from those promulgated for control of air pollution from new motor vehicles and new motor vehicle engines, have been applied.
	C018	Lawrence H. Hodges J. I. Case
	C036	Richard Gimer CAGI
4.2	COMMENT:	The regulation manifests a basic distrust of American industry accompanied by a desire for EPA to keep its responsibilities to a minimum.
	C030	Robert F. Hand Clark Equipment
4.3	COMMENT:	Production verification would delay and unnecessarily burden the manufacturer's distribution process since distribution in commerce could not take place until production verification has been completed.
	C025	Walter L. Black Clark Equipment Co.
	C037	William S. Price Worthington Compressors, Inc.
	C040	Joseph O'Neill Quincy Compressor
	Transcript	George Diehl Ingersoll-Rand

Issue	Docket No.	Originator
4.4	COMMENT:	The number of configurations should be minimized and only those parameters for configurations that directly affect noise emissions should be used. The definition of configuration should be revised, based on cfm engine type and RPM, with category being defined by cfm only.
	C037	William Price Worthington Compressors, Inc.
	C039	F. A. DelleCave Ingersoll-Rand
	C036	Richard Gimer CAGI
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Lawrence H. Hodges J. I. Case Company
	Transcript	Robert L. Grievell Koehring Company
4.5	COMMENT:	Sampling plans are based on high volume production, and the concept of using a modification of a well known attribute plan is inconsistent with small volume production
	C037	William Price Worthington Compressors, Inc.
	Transcript	William Price Worthington Compressors, Inc.
	Transcript	Lawrence H. Hodges J. I. Case Co.
	Transcript	Robert L. Grievell Koehring Company
4.6	COMMENT:	The Selective Enforcement Auditing strategy which has a proposed AQL of 6.5% contradicts the requirement that every new compressor conform to the applicable noise emission standard, since inherent in such a strategy is the

Issue	Docket No.	Originator
		assumption that some non-conforming products will be distributed into commerce.
	C036	Richard Gimer CAGI
4.7	COMMENT:	The Selective Enforcement Auditing process places an unnecessary burden on a manufacturer and all that is required is the "certification" from the manufacturer that he has tested a number of units and that they conform to the regulation.
	C025	Walter L. Black Clark Equipment
4.8	COMMENT:	The Selective Enforcement Audit should be invoked only when the Administrator has cause to believe that a configuration is being sold in commerce which fails to comply with the regulation.
	C036	Richard Gimer CAGI
4.9	COMMENT:	The production verification and Selective Enforcement Auditing Scheme will provide a high assurance of product conformity and further that a major savings in administrative costs for both the manufacturer and EPA should be realized because this particular enforcement scheme has definite benefits over the enforcement scheme employed in certification of automobiles pursuant to the Clean Air Act of 1970.
	C020	Mary Ann Zimmerman Cummins Engine
4.10	COMMENT:	The Administrator's discretion to refuse to grant a hearing in situations where Section 11(d) orders are issued is a matter of concern.
	C035	Caterpillar Tractor Company
	C036	Richard Gimer CAGI

Issue	Docket No.	Originiator
	C037	William S. Price Worthington Compressors, Inc.
4.11	COMMENT:	The limitation of the right to counsel in the regulation should be stricken.
	C035	Caterpillar Tractor Co.
	C036	Richard Gimer CAGI
4.12	COMMENT:	The need and validity of EPA to make broad inspections and have the right to inspect and photograph all and any literature and test records is questionable. Such provisions extend far beyond the authority conveyed to EPA and far in excess of any Agency needs.
	C013	Robert A. Heath Walker Manufacturing
	C035	Caterpillar Tractor Co.
	C036	Richard Gimer CAGI
	C037	William S. Price Worthington Compressor, Inc.
4.13	COMMENT:	The information recording and reporting requirements are burdensome and costly.
	C032	D. E., Kipley Gardner-Denver Co.
	C013	Robert A. Heath Walker Manufacturing
	C030	Robert F. Hand Clark Equipment
	C036	Richard Gimer CAGI
4.14	COMMENT:	The proposed regulation in some instances requires the repetitive submission of information.

Issue	Docket No.	Originator
	C022	Lawrence H. Hodges J. I. Case Co.
4.15	COMMENT:	Cease to distrubute orders are beyond the statute and should be modified.
	C036	Richard Gimer CAGI
4.16	COMMENT:	The statement contained in the proposed regulation "all costs associated with recall and remedy of non-complying compressors shall be borne by the manufacturer" could be interpreted very broadly.
	C013	Robert A. Heath Walker Manufacturing
4.17	COMMENT:	The costs of the administrative enforcement provisions would be significant because of the large number of products that would be required to be tested as a result of the production verification and audit tests required, the record keeping and recording requirements and the costs of constructing added test facilities to accomplish all the required testing.
	C010	Richard Gimer CAGI
	C015	C. M. Copeland P. K. Lindsay Co.
	C016	Richard Ostwald Gordon Smith and Co.
	C019	R. D. Harlow Schramm, Inc.
	C022	Lawrence H. Hodges J. I. Case Co.
	C027	George J. Stradtner Grimmer-Schmidt Co.
	C030	Robert F. Hand Clark Equipment

Issue	Docket No.	Originator
	C031	A. J. Cox CIMA
	C033	R. D. Harlow Schramm, Inc.
	C035	Caterpillar Tractor Co.
	C036	Richard Gimer CAGI
	C039	F. A. DelleCave Ingersoll-Rand
	C040	Joseph O'Neill Quincy Compressor
	Transcript	H. T. Larmore CIMA
	Transcript	Richard Gimer CAGI
	Transcript	Robert Harlow Schramm, Inc.
	Transcript	Willaim Heckenkamp Gardner-Denver
	Transcript	Lawrence H. Hodges J. I. Case Co.
4.18	COMMENT:	The warranty required by §204.58-1 is a useful life performance warranty.
	C018	Robert A. Heath Walker Manufacturing
	C002	Richard Gimer CAGI
	C016	Richard Ostwald Gordon Smith and Co.
	C018	Lawrence H. Hodges J. I. Case Co.
	C025	Walter L. Black Clark Equipment Co.

Issue	Docket No.	Originator
	C036	Richard Gimer CAGI
	C030	Robert F. Hand Clark Equiplment
	C031	A. J. Cox CIMA
	C037	W. S. Price Worthington Compressors, Inc.
	C035	Caterpillar Tractor Co.
4.19	COMMENT:	Which "manufacturer" must issue the noise emission warranty requires clarification.
	C022	Lawrence H. Hodges J. I. Case Co.
4.20	COMMENT:	That which constitutes tampering should be defined, and whether or not the use of after-market parts (parts not manufactured or authorized by the original equipment manufacturer) would constitute tampering should be clarified.
	C030	Robert F. Hand Clark Equipment
	C035	Caterpillar Tractor Co.
4.21	COMMENT:	In the tampering requirements submissions of information 90 days before introduction into commerce of the compressor represents an excessively long time period for the manufacturer.
	C036	Richard Gimer CAGI
4.22	COMMENT:	The requirements for lists of noise control devices, performance specifications for such device, and acts which constitute tampering are unfair, voluminous, and unduly costly.
	C031	A. J. Cox CIMA

Issue	Docket No.	Originator
	C037	William S. Price Worthington Compressors, Inc.
	C036	Richard Gimer CAGI

5. MISCELLANEOUS

Issue	Docket No.	Originator
5.1	COMMENT:	Noise regulations directed at the end product are preferable to those for individual component parts.
	C020	Mary Ann Zimmerman Cummins Engines
5.2	COMMENT:	The regulation should be rewritten to improve the prose relating to numerical descriptors of noise.
	C021	Dr. Robert W. Young Acoustical Society of America
5.3	COMMENT:	The definition of a portable air compressor should be clarified so as to exclude any products not intended to be subject to the regulation.
	C026	M. E. Rumbaugh, Jr. Schwitzer Engineered Components

RESPONSE TO ISSUES

The EPA has carefully considered all of the comments received regarding the proposed noise emission regulation for portable air compressors. A discussion of these comments with the Agency's response thereto follows:

1. Technology

1.1, 1.2 One commenter stated that the 76 dBA limit does not represent currently available technology.

The "Background Document for Proposed Portable Air Compressor Noise Emission Regulations" presents data from several compressors that emit noise levels of 76 dBA and lower at 7 meters. Technological availability is, EPA believes, adequately met when mass produced commercially available products are in commerce today which produce noise at or below the standard.

1.3 Several commenters asserted that data relating to degradation of noise emission characteristics are insufficient to predict degradation patterns for air compressors.

The Agency pursued this issue by soliciting industry comment and supportive data regarding the escalation of compressor noise that would accrue during compressor usage. Responses to the solicitation indicated that data were not available at this time, since in the past there was not a need for the assessment.

Accordingly EPA has undertaken studies to develop these data. Industry representatives have also agreed to begin to collect and to make available to the Agency such noise emission degradation data so that proper analysis and decisions regarding useful life standards, including degradation effects, can be made at a later date.

1.4, 1.5 Several industry commenters stated that fuel consumption can be expected to increase as a result of the regulation, while another industry commenter stated that fuel consumption could be expected to remain the same or actually decrease.

As has been indicated, there is substantial disagreement within the industry itself regarding the impact of the regulation on fuel consumption. From a technical standpoint, those commenters contending that fuel consumption may increase indicate that it will be due primarily to an increase in static pressure within the portable air compressor enclosure due to added noise control components. This, in turn, would cause increased fan loading and a concomitant increase in fuel consumption on the order of 3 - 8 percent. Another industry commenter stated that there would be no fuel consumption increase that would result from the quieting efforts. That commenter indicated that the fuel savings derived from the use of more efficient fans would balance increased fuel consumption resulting from increased fan loading.

The Agency, in the course of its technology studies, attempted to assess fuel usage differences between standard and quieted compressors of the same model. All attempts proved futile because changes in fuel usage were within the manufacturing tolerance variances and thus there was no apparent significant effect.

1.6 Several commenters stated that the quieting technology is not the same for all sizes and configurations of air compressors.

The Agency assessed the quieting technology applied to several models of compressors on the market today. The assessment revealed that, while the large, high air flow capacity compressors generally required greater silencing effort than did the smaller, lower air flow capacity units, similar techniques were applied to achieve the silencing. Accordingly, the effective date of the regulation has been modified to provide manufacturers with a longer lead time to integrate noise control features into the design and manufacture of larger portable air compressors.

1.7, 1.11 Several commenters were concerned about the problems they may encounter regarding availability of component parts, especially quieter engines, necessary to manufacture portable air compressors which will comply with the standard.

The withdrawal from the market of certain engines used by portable air compressor manufacturers because of other reasons than noise control became known during the comment period. In assessing the impact of this action, the Agency questioned the portable air compressor manufacturers about the problems they anticipated as a result of this action by engine manufacturers. All who responded to the questions indicated that the action would have a dramatic adverse impact on the engineering design and manufacturing time required to develop compressors meeting the standard and further indicated that component delivery problems could be handled if the effective date of the regulation were extended. The Agency considered all aspects of this problem and, accordingly, extended the time for compliance with the regulation since the results of studies showed that such extension would not significantly compromise health and welfare benefits to be derived from the regulation. It is the Agency's belief that the additional time allotted affords the lead time stipulated by the manufacturers to allow them to overcome any delivery problems they are likely to encounter regarding component parts.

1.8 Two commenters stated that "band aid" measures for controlling noise emissions are more expensive than integrated design changes.

The Agency recognized this, and accordingly, solicited comments from portable air compressor manufacturers as to the time it would take to make and implement the necessary design changes to produce quiet machines. The effective date of the regulation is based to a substantial degree on the data supplied by the respondent manufacturers. It is the Agency's opinion that the time span before the regulation becomes effective provides manufacturers with the requisite lead time to accomplish the necessary design changes, if they so desire, to preclude the "band aid" approach.

1.9, 1.18 Two commenters responded to the solicitation, in the preamble of the proposed regulation, for views as to whether a standard should be imposed on portable air compressors measured in C-weighted sound pressure level.

The intent of the solicitation was to elicit information in regard to imposing a C-weighted noise emission standard to guard against design practice that would shift the major spectral components of portable air compressor noise to low frequencies discriminated against by the A-weighted sound pressure, at the possible expense of escalated low frequency noise, which in turn could cause vibration problems in structures located in proximity to construction sites.

At the time the proposed regulation was developed, the Agency had limited data to support a C-weighting sound pressure level standard. The public solicitation for data in this regard has provided little information and no new data to show the need for a dBC standard. Accordingly, only a dBA standard is being promulgated.

1.10 One commenter suggested that devices be installed that would shutdown a compressor if the access doors were opened.

The Agency considered the validity and practicality of such a requirement and decided not to require the installation of such devices for the following reasons: 1) One use of portable air compressors is to supply breathing air to workmen involved in activities underground where the naturally occurring air supply is minimal. An inadvertent shutdown of the compressor in this situation could have catastrophic consequences. 2) Users could easily circumvent automatic shutdown devices if such devices proved to be an annoyance or otherwise hindered the user's normal operating procedures. However, the Agency recognizes that the doors of portable air compressors may be an element of design incorporated into the product to achieve compliance with the regulation. Accordingly, and as stated in the tampering section of the regulation, the removal or rendering inoperative, for purposes other than maintenance, repair or replacement, of such a device is prohibited.

1.12 Several commenters responded to the solicitation in the Preamble of the Notice of Proposed Rulemaking, for comments in regard to the proposed measurement methodology and/or the advisability of expressing the portable air compressor standard in terms of sound power rather than average sound pressure level.

During the development of the proposed regulation, EPA carefully considered the various measurement methodologies and sound descriptions suitable for the assessment and characterization of portable air compressor noise. As a result of these studies, it is EPA's opinion that the methodology as proposed will provide data to accurately characterize portable air compressor noise with the simplicity that is requisite to facilitate product verification at the manufacturer's plant and enforcement in the field. The following private and public proclamation by portable air compressor manufacturers is significant in this regard:

> "Members of CAGI have carefully studied the measurement methodology and at the January 19, 1975, meeting of the Compressed Air and Gas Institute, Portable Air Compressor Section, it was resolved the physical measurement procedures contained in the proposed EPA measurement methodology be accepted by CAGI."

While the Agency has opted for a measurement methodology with which industry is most familiar at this time, and which supports its compliance requirements, and has opted to use A-weighted sound pressure level as the descriptor of portable air compressor noise, it recognizes that situations may exist or arise where other methodologies and descriptors may be just as appropriate and, for that matter, have more utilitarian use. Such instances or situations may exist within a particular product industry when one wishes to describe the energy output of devices for noise emission diagnostic evaluation and for comparing the noise emission of devices which are similar in size and kind. Accordingly, the Agency encourages industry to proceed toward standardization of methods to determine sound power with attendant sound energy descriptors, as it is endeavoring to do at this time. The Agency has carefully reviewed two recent efforts toward standardization developed by the National Bureau of Standards (NBS) and Technical Committee 43 of the International Organization for Standardization (ISO) and it is EPA's opinion that these test methodologies are feasible and viable, and EPA would recommend their use for the determination of portable air compressor sound power in situations requiring such assessment.

1.13 One commenter stated that the test specification for a fifth microphone above the compressor should be reconsidered.

The Agency included an overhead microphone location to guard against compressor design that would direct major sound energy upwards which could be of significance to persons working or residing in high rise buildings adjacent to construction sites and/or where portable air compressors are located below ground level and the noise impacts on those above the equipment affected. The Agency reconsidered the need for the overhead microphone position and concluded that its imposition is indeed requisite to control upward radiated compressor noise, for without it there is no practicable way to assure that upward radiated noise will not exceed the stipulated level.

1.17 Several commenters stated that, in order to comply with the regulation, manufacturers must design for levels well below the standard.

In developing the regulation, the Agency recognized that a class of compressors, for that matter a single compressor, may emit noise levels that vary by as much as ± 2 dBA as the result of manufacturing tolerances. Accordingly, the Agency does not recognize the need for manufacturers to design "well below" the standard to ensure compliance with the regulation.

1.19 Several commenters stated that the EPA measurement methodology is not suitable for in-use testing at a construction site, with reasons such as anticipated difficulty in measuring 7 meters above a compressor, difficulty in teaching noise inspectors to perform noise level averaging on an energy basis, and problems with high ambient noise as the rationale for the statement.

In the development of the proposed measurement methodology, it was the Agency's intent to arrive at a test method that could facilitate both noise emission testing in the controlled environment at the manufacturer's test site as well as noise emission level assessment in the uncontrolled environment of construction sites. What has evolved is a simple, practicable test method which, while not patently ideal for both test environments, provides manufacturers of portable air compressors a method to assure compliance with the noise emission standard. It also provides State and local noise inspectors with a methodology or, at a minimum, a methodology base on which to build or modify as local conditions may dictate, for their development of equivalent test procedures for in-use noise emission evaluation.

1.20 One commenter stated that no machine larger than 1200 cfm was tested as the basis for the EPA background document.

While it is true that the Agency did not conduct tests on portable air compressors larger than 1200 cfm, test data on machines with air flow capacities up to 2000 cfm were made avilable to the Agency and are in fact included in a listing presented in Table 7-5(c) of the "Background Document for Proposed Portable Air Compressor Noise Emission Regulations."

1.21 One commenter stated that a conflict between noise suppression technology and safety considerations may exist regarding the flame retardant properties of acoustical insulation laggings.

EPA interprets this comment to mean that acoustical materials that may be employed within compressor enclosures might tend to support combustion. In addition, those materials that might be employed would act as a sponge to soak up fuel and oil and thus create a potentially hazardous condition should the oil/fuel flash point temperature be exceeded. As most acoustical materials may be chemically treated with a flame retardant to prevent combustion, and it is common practice to encapsulate acoustical foams and fiberglass in mylar and other thin filmed impervious protective coverings to preclude absorption of liquids, EPA is of the opinion that no conflict exists between safety considerations and noise suppression technology.

1.22 One commenter responded to the preamble solicitation for comment on whether the regulation should address portable air compressor pure tones.

Currently, major pure tone spectral components generated by today's portable air compressors occur at low frequencies, less than 500 hertz, and are not particularly annoying as the frequencies are below the range of acute ear sensitivity. However, the Agency recognizes that as portable air compressor designs change, so too may the spectral character of the pure tone generating components to cause annoying pure tones. Accordingly, the Agency will continue to address the potential problems of pure tone noise with respect to portable air compressors, and it solicits on a continuing basis such information from concerned parties. Should evidence in the future show this to be a significant problem, the Agency is prepared to propose such control measures as may be necessary.

1.23 Several commenters felt that some tolerance on the standard should be allowed on field tests to account for environmental and instrumentation variances likely to occur when portable air compressors are tested in environments different from the controlled environment of the manufacturer's facility.

The Agency recognizes that, due to environmental and instrumentation differences, noise emission data measured at State and local test sites may differ from that measured during SEA and PV testing, and the Agency will take this into account when reviewing test data.

2. Health and Welfare

2.1 Several commenters stated that in setting the regulation, consideration should be given to usage conditions and amount of exposure to the public for different types of machines.

In developing the regulation, the Agency considered the usage conditions and amount of exposure to the public for different types of machines. In the analysis, the Agency employed portable air compressor usage factors and noise levels to investigate health and welfare benefits derived from the regulation of the total population of portable air compressors. A second analysis was conducted for the population of compressors split into units typically used in urban areas and those typically used in rural areas. The studies considered the usage of compressors in five phases of construction: domestic housing, non-residential, industrial, and public work construction. The "Background Document for Portable Air Compressor Noise Emission Regulations" presents further details of the analysis.

2.2, 2.3 Several commenters stated that the benefits to public health and welfare do not justify the economic impact of the regulation.

It must be kept in mind that society is now paying billions of dollars for noise pollution associated with lost productivity, higher medical bills and health insurance premiums, payments in successful noise offense litigation and assessment of property value in high noise exposure areas without accruing any direct benefit for such payments. Implementation of the Noise Control Act of 1972 will accomplish a shift in the economic burden from the impacted population to the users of the products and their customers and hence will provide society with direct benefits in the form of quieter products and a quieter environment.

It is estimated that over 27 million people are exposed to construction site noise levels that jeopardize their health and welfare. Since construction site noise is typically comprised of contributions from more than twenty different types of construction equipment, regulation of the majority of the pieces of equipment will be required to appreciably and effectively reduce this type of noise. The portable air compressor has been identified as the first piece of construction equipment requiring noise emission control to foster, in the long term, less construction site noise. While portable air compressors may not provide the highest sound level at construction sites, they do contribute significantly to community noise exposure. Air compressors rank with dump trucks and concrete trucks in producing the highest sound energy per day. The noise emission regulation for portable air compressors is requisite to protect the health and welfare of the American public.

Studies performed in accordance with the requirements of the Noise Control Act of 1972 indicate that compliance with the regulation will reduce the impact upon people from construction site noise by 14.7 percent with an estimated attendant 12.3 percent increase in the list price of portable air compressors. Upon regulation of noise emissions from dump trucks and concrete trucks, a reduction in total impact by approximately 45 percent is anticipated when the current population of compressors and trucks is replaced by quiet units. Further reduction in total impact is contingent upon effective noise emission regulations of other construction equipment. Considering the health and welfare benefit obtained from the regulation, the Agency believes that the added cost of compressors is a productive expenditure.

2.4 Several commenters suggested that EPA undertake a more thorough cost/benefit study.

The Agency conducted additional economic impact and health and welfare impact analyses employing data and information made available to it as the result of the written comment period and public hearings regarding the proposed regulation. The Agency also solicited information from portable air compressor manufacturers regarding the lead time necessary to comply with various standard levels. The regulation being promulgated is based, in part, on the results of these analyses.

3. Economics

3.1 Several commenters indicated that they felt that the Portable Air Compressor Regulation is inflationary.

The EPA, in promulgating a noise source emission regulation for newly manufactured products, is directed by the Noise Control Act of 1972 to consider the cost of compliance, best available technology, and impact on the public health and welfare. The Agency has carefully weighed the potential adverse economic impacts associated with the promulgation of the regulation and compared them to the benefits that would accrue to the population affected by the reduction in noise emitted by portable air compressors. The conclusion is that the 12.3 percent list price increase is cost effective in terms of the benefits derived. The health and welfare benefits of the proposed regulations have been discussed previously in paragraph 2.2 and 2.3.

3.2, 3.12 Several commenters indicated that they felt that the smaller manufacturers will be more severely impacted and their costs per unit will be higher than those for larger portable air compressor manufacturers.

The Environmental Protection Agency pursued this issue through visits and communications with large, medium, and small portable air compressor manufacturers in an effort to determine the validity of the comment. As a result of the Agency's investigations and data surfaced in pursuit of the issue, it became apparent that the effective date of the regulation was the single major factor controlling the degree of economic impact on the portable air compressor industry of the proposed standard, particularly on the smaller manufacturer. According to the data, a smaller manufacturer faced a greater potential for serious economic impact from the 12-month effective date because of limited resources and manpower to accomplish the requisite redesign of his product line to achieve product compliance in a timely fashion. As such, the smaller manufacturer could be constrained by the regulation from introducing his units into commerce and thereby accrue a severe economic impact. Accordingly, after determining that a limited extension of the effective date of the regulation would not severely impact the health and welfare benefits to be derived, the Agency has extended the effective date of the regulation to 24 months for compressors with air-flow capacity less than or equal to 250 cfm, and 30 months for compressors with air-flow capacity greater than 250 cfm. It is the Agency's belief that this extension allows adequate lead time for an orderly readjustment by all manufacturers to preclude potential economic hardships associated with time constraints imposed by the proposed effective date.

3.3 Many commenters indicated that the economic impacts of the useful life provision contained in the proposed regulation were not included in the cost of compliance studies that were undertaken.

The Agency reviewed the useful life provision contained in the proposed regulation in light of the comments made in the various dockets. The Agency has elected not to specify at this time a specific requirement for portable air compressor useful life noise emission standard. The Agency has chosen, however, to defer a useful life provision in the Portable Air Compressor Regulation until further studies regarding the degradation of noise emissions of portable air compressors and the associated costs of compliance have been completed and assessed against the health and welfare benefits which could result from the imposition of such a useful life standard.

3.4 Several commenters stated that the cost of constructing a test facility at a manufacturer's location is economically infeasible.

The Agency does not feel that the required measurement/testing procedure will necessitate the construction of elaborate, expensive test facilities for portable air compressor manufacturers. Accordingly, the test procedure, including the description of the test site, as it appeared in the proposed regulation stands as the EPA test procedure which will be utilized to determine compliance with the standard. However, as now stated in the regulation, alternate test procedures which are approved by EPA by virtue of demonstrated correlation with the prescribed procedure, may be employed by the manufacturers.

3.5 Many commenters stated that the estimated 16 percent per unit price increase underestimates the true cost to comply with the regulation due to the enforcement provisions.

The 16 percent preliminary estimate of list price increase included in the preamble to the proposed regulation did not include costs for enforcement and useful life provisions. In the final analysis performed by the Agency, the deferment of a useful life standard and further consideration of the enforcement scenario led to the following estimated list price increases for newly manufactured portable air compressors:

1. 11.2 percent for compressors with rated flow capacity less than or equal to 250 cfm.
2. 13.0 percent for compressors with rated flow capacity greater than 250 cfm.
3. An additional estimated 0.4 percent list price increase may accrue through the costs of the revised enforcement scenario of the regulation.

3.6 One commenter indicated that there was no need for Federal regulation of portable air compressors because marketplace pressures will force the production of quieted machines without a regulation.

This assertion has, in fact, not been demonstrated. Although there are models of compressors that are quieted, the noise emissions of the compressor population as a whole have not been reduced to a level that is protective of the public health and welfare. Additionally, there are no indications that the industry as a whole was moving in the direction of quieting the compressor fleet to levels that are considered to be protective of the public health and welfare.

3.8 Several commenters indicated that the regulation will have a harmful impact on the foreign trade patterns in the industry.

The Agency assessed the impact of the regulation on trade patterns. The analysis showed that there would be no change in import patterns and no material impact on the balance of trade. Since the Noise Control Act specifically exempts units manufactured solely for export there will be no changes in portable air compressor export patterns resulting from this rulemaking.

3.9 One manufacturer indicated that the regulation will have the effect of increasing air compressor rentals, to the detriment of industry sales volume.

The Agency reviewed this issue during its background study to assess the impact of the proposed regulation. Today without Federal regulation, approximately 50 percent of portable air compressor unit shipments reach the end user through rental or rental/purchase agreements. The reason for this rests with cost effectiveness; that is, in many instances, it is probably more economical to rent a unit for a specific job taking place in a finite period of time than to tie up capital in a unit not receiving full usage.

While it is recognized that rental usage could increase, by virtue of its apparent economic advantage, the Agency has no quantitative data to show any increase solely due to imposition of the regulation. The Agency has, however, estimated that imposition of the regulation would cause no more than a 4.3 percent decrease in total unit sales.

3.10 One manufacturer suggested that a board of review be established to ensure that manufacturers' costs are not excessive.

The Noise Control Act of 1972 does not contain any provision for the establishment of such a panel. The EPA has, however, made every attempt to estimate the economic impact on the portable air compressor manufacturing industry. The regulation does not in EPA's judgment impose any unreasonable or excessive costs on the industry.

3.11 One commenter stated that large manufacturers can be expected to stockpile standard machines before the effective date of the regulation.

The Noise Control Act prohibits distribution in commerce of products manufactured after the effective date which do not meet the standard. Thus, under the Act, Congress intended that products manufactured earlier shall be exempt and may be distributed in commerce at any time even if they do not meet the standards. The nature of portable air compressor manufacturing and marketing is such that distributors are expected to have several pre-regulation compressors available for sale at the time the regulation becomes effective, and this probability was considered in the assessment of health and welfare impact of the regulation.

The analysis of this issue focused on industry production capacity, i.e., basic ability to stockpile. On an average across the industry current production capacity is such that limited stockpiling is possible, if the assumption is made that the compressor market will remain relatively stable until the regulation is effective. Combined in this analysis is the historical flexibility of the portable air compressor industry in responding to market demand fluctuations. Consideration of these factors and the general expense of stockpiling inventory led to the Agency conclusion that the stockpiling possibility will be evenly assessed by industry and that individual manufacturers will be able to avert market disruptions in that event.

3.13 Several manufacturers stated that the 1-year effective date of the regulation is an insufficient amount of time and will cause an increased economic burden on the industry.

In further study and discussions with the various manufacturers, the Agency was able to better estimate the time dependency of successful compressor redesign. The presence in the industry of several manufacturers who have little or no quieting experience, and additional information which showed that quieting is more difficult to achieve in the larger compressors, led us to extend the time for compliance. In addition, our further study revealed that many of the costs for redesign are fixed, and lengthening of the time for compliance should allow for more orderly adjustment in the industry.

3.14 Various industry members commented that the regulation will force the discontinuation of some manufacturers' compressor models.

This issue was considered in further economic impact studies following the public comment period. Obviously, for those manufacturers who now market both standard and quiet compressors in identical cfm categories, it would be implied that they would discontinue the so-called standard model as a result of the regulation. The more critical possibility is the unforeseen, forced temporary or permanent discontinuation of a compressor model because of added expense to quiet in the time frame specified, or because of assembly delays resulting from component part deliveries approaching or exceeding the effective date of the regulation. Analysis of the problem included this possibility and the Agency concluded that the extended time now allowed for compliance with the standard as opposed to the time frame originally proposed will allow manufacturers to effectively compensate for design and assembly problems of this nature. However, some manufacturers now market marginally profitable models, and the possibility of discontinuation of these models because of this regulation exists. In instances of discontinuance of marginally profitable models, it is the Agency's position that this is not necessarily a detrimental effect of the regulation; the Agency has no specific information indicating the likelihood of this occurring.

3.15 Three commenters stated that the regulation will cause the non-productive expenditure of labor and materials.

During the development of the regulation, the Agency conducted studies to arrive at a noise emission standard requisite to protect the public health and welfare with an adequate margin of safety, taking into account the magnitude and conditions of use of portable air compressors, the degree of noise reduction achievable through the application of best available technology, and the cost of compliance. The standard that has evolved, is, in the Agency's opinion, technically feasible, non-inflationary, and protective of the public health and welfare. Accordingly, the regulation will cause productive expenditure of labor and materials.

4. Enforcement

4.1 Two of the commenters felt the compliance and enforcement aspects of the proposed portable air compressor regulation, which is derived from air pollution control regulations, could not realistically or practically be applied to air compressor manufacturing industry.

The regulation being promulgated contains production verification requirements and selective enforcement auditing requirements. The production verification scheme differs from certification under the Clean Air Act. No extensive endurance testing is required by production verification, and the manufacturer is not precluded from selling his product until he has accomplished the requirements of the production verification process. In essence, the Clean Air Act certification process is merely used to allow the manufacturer to demonstrate that he has the requisite technology in hand to produce conforming products. The production verification process is based on the assumption that the manufacturer has the technology available to quiet compressors and must demonstrate that he is able to apply that technology in practice to produce compressors complying with the standard.

The selective enforcement auditing scheme is very similar to that which EPA has proposed for use under the Clean Air Act to verify compliance of production vehicles with the standard. It is a noncontinuous scheme, wherein samples of products are tested to determine whether they conform to the standards. Such a scheme is equally applicable to the testing of completed motor vehicles as it is to testing completed portable air compressors. It should be kept in mind that this testing will only be done on the specific request of the Agency.

4.2 One commenter felt the regulation manifested a basic distrust of American industry accompanied by a desire for EPA to keep its responsibilities to a minimum.

The basic EPA enforcement strategy under the Noise Control Act of 1972 places a major share of the responsibility on the manufacturer for testing to determine compliance of new portable air compressors with the regulation and emission standards. This does not relieve EPA of its responsibilities but merely allows a manufacturer to have his personnel in control of many aspects of the compliance program, thereby minimizing the burden of this regulation on his business. Such manufacturer responsibility and control results from the fact that EPA has faith in the integrity of manufacturers to comply with this regulation. EPA, however, does reserve the right to verify that the manufacturer is in fact complying with the regulation. It is for this reason that EPA provides for monitoring by EPA personnel of tests performed by the manufacturer and other manufacturer actions taken in compliance with this regulation. The final purpose of such monitoring is to assure the Administrator that the information he is receiving is accurate to enable him to make the proper determination that compressors being distributed in commerce by a manufacturer are, in fact, in compliance with this regulation.

4.3 Some manufacturers commented that production verification would delay and unnecessarily burden the manufacturer's distribution process since distribution in commerce could not take place until production verification has been completed.

The regulation has been modified to permit manufacturers to distribute compressors in commerce as soon as production begins. The requirement still remains that the manufacturer must test certain models of his early production units, which for the most part are the loudest configuration of a category. However this testing must now take place, as soon as weather conditions permit, within a 45-day grace period, during which production verification is waived. The 45-day period is designed to accommodate a manufacturer's transportation needs and to accommodate poor weather conditions. In addition, the requirement that the manufacturer provide a 10-day notice of his intent to test has been removed.

4.4 Some manufacturers suggested that the number of configurations be minimized and only those parameters for configurations that directly affect noise emissions be used. One manufacturer endorsed a revision of the definition of configuration to cfm, engine type and rpm, with category being defined by cfm only.

Although the definition of category has remained the same and is based on those elements which most directly affect noise, the definition of configuration has been changed, with the defining parameters significantly reduced. The Agency has calculated, based on available information, the total number of categories that would require testing based on production verification if carried out in accordance with this regulation, and has found that it results in a nominal number of products requiring testing. Any further reduction in the criteria used to define category would not be warranted, on the basis of reducing test burden, since the number of units requiring testing is now realistic.

4.5 Some manufacturers commented that the sampling plans are based on high volume production and that the concept of using a modification of a well-known attribute plan is inconsistent with small volume production.

As a result of such comments, the sampling plans contained in the proposed regulation have been modified to provide for situations in which production volume is small. Additionally, the revised sampling plan significantly reduces the number of products requiring testing.

4.6 One commenter suggested that the selective enforcement auditing (SEA) strategy, which had a proposed acceptable quality level (AQL) of 6.5 percent contradicts the requirement that every new compressor conform to the applicable noise emission standard, since inherent in such a strategy is the assumption that some nonconforming products will be distributed in commerce.

The regulation being promulgated now contains an AQL of 10 percent and, although this AQL may result in some nonconforming products being distributed in commerce, the basic requirements still remain that a manufacturer is prohibited from distributing into commerce any products which do not conform with the standard. The basic intent is that all products being distributed in commerce must conform to the standard. Any product which is tested and which is known not to conform to the standard may not be distributed into commerce until the nonconformity is remedied. Furthermore, every compressor is warranted to conform to the standards at the time of sale. It is merely the intent of EPA not to take enforcement action which addresses the aggregate of the products or the process by which they are produced until the process average as determined by SEA testing exceeds the AQL of 10 percent. That is not to say the EPA permits the distribution in commerce of products that exceed the standard, but only that no enforcement action will be taken on the aggregate by EPA unless an AQL of 10 percent is exceeded. A batch which meets the AQL of 10 percent is considered to indicate compliance by virtually 100 percent of the compressor population. The 10 percent allowance provides for test variability and random human error.

4.7 One commenter suggested that the SEA process placed an unnecessary burden on a manufacturer and all that was required is the "certification" from the manufacturer that he has tested a number of units and that they conform to the regulation.

The selective enforcement auditing scheme is not a continuing requirement. Testing is performed at the request of the Administrator. The testing burdens will exist only when deemed necessary by the Administrator for purposes of gathering information in order to make a determination regarding the conformity of products being distributed in commerce by a particular manufacturer.

The issuance of a test request may not be necessary where the manufacturer can demonstrate through his own test data on production units, using a sampling plan similar to or better than the promulgated plan, that his process average is below the AQL of 10 percent. This amounts to the "certification" procedure suggested by the commenter.

4.8 One commenter suggested that SEA should be invoked only when the Administrator had cause to believe a configuration is being sold in commerce which fails to comply with the regulation.

Although EPA agrees with the spirit of that comment, the Administrator prefers to maintain the discretion that Congress intended by not having placed any such limitations on his testing authority. It is the EPA's intent, however, that such test requests be issued when the need arises and that such need be clearly demonstrated.

4.9 One commenter felt that production verification and the selective enforcement auditing scheme would provide a high assurance of product conformity and further, that a major savings in administrative costs for both the manufacturer and EPA should be realized because this particular enforcement scheme has definite benefits over the enforcement scheme employed in certification of automobiles pursuant to the Clean Air Act of 1970.

4.10 Several commenters were concerned with the Administrator's discretion to refuse to grant a hearing in situations where Section 11(d) orders were issued.

The regulation has been modified to provide that in situations where Section 11(d) orders are issued, notification and an opportunity for a hearing are afforded.

4.11 Several commenters criticized the attempt by the regulation to limit the right of counsel and recommended that such limitation be stricken from the regulation.

As a result of those comments, portions of the regulation which would, in fact, limit the right of counsel have been deleted.

4.12 Several commenters questioned the need and the validity of EPA to make broad inspections and to have the right to inspect and photograph all literature and test records. The commenters indicated that such provisions extend far beyond the authority conveyed to EPA and far in excess of any Agency needs.

The regulation has been modified to limit inspections and acquisition of data to information necessary for the Administrator to make a determination that the manufacturer is distributing conforming products in commerce. The authority of EPA personnel is limited to examining records of tests conducted on production verification products or products tested pursuant to SEA, inspecting areas where testing is conducted and where products are stored prior to testing, and inspecting areas of the assembly plant where the products are being assembled. EPA has no interest in forced entry into developmental laboratory areas. However, where such areas are part of the test site used for compliance testing, it is the intent of the regulation to permit access to such areas regardless of the fact that developmental labs or test sites are near by. If a manufacturer wishes to preclude EPA Enforcement Officers from visiting or inspecting their development testing or laboratory areas, they must be separated from areas where compliance testing is performed.

4.13 Several commenters stated that the information recording and reporting requirements are burdensome and costly.

The regulation has been revised so that information needed to describe a product may be satisfied by the submittal of sales literature and data needed to demonstrate compliance; may be satisfied by submittal of information accrued during manufacturer self-imposed diagnostic testing to assure themselves that conforming products are being distributed in commerce. The regulation has also been revised so that all data may be mailed to EPA in lieu of the proposed telephone reporting requirements.

4.14 Several commenters indicated that the proposed regulations in some instances required the repetitive submission of information.

The final regulation provides that where information has been previously submitted and has remained unchanged, subsequent reports need only refer to the previous submissions.

The regulation has been revised so as to permit execution by an authorized company representative in lieu of a Corporate Vice President of reports required to be filed by a manufacturer.

4.15 One commenter felt that the cease to distribute orders went beyond the statute and should be modified.

The Agency has interpreted Section 11(d) of the Act, which provides for the issuance of administrative orders, as inclusive of the power to issue cease to distribute orders and recall orders. Any such orders would be preceded by notice and opportunity for a hearing.

4.16 One commenter felt that the statement contained in the proposed regulation, "all costs associated with recall and remedy of noncomplying compressors shall be borne by the manufacturer" could be interpreted very broadly.

The costs normally associated with a recall are the costs of conducting the campaign itself, as well as the cost of remedying the nonconformity, including parts and labor. These are the costs the manufacturer would be required to absorb.

4.17 Several commenters felt the costs of the administrative enforcement provisions would be significant because of the large number of products that would be required to be tested as a result of the production verification and audit tests, the record keeping and reporting requirements, and the costs of constructing added test facilities to accomplish all the required testing.

EPA has reexamined the cost impacts of the administrative enforcement provisions of production verification and selective enforcement auditing and has found them to be reasonable. As a result of information gathered during the rulemaking process, which included a public hearing and many written submissions to the docket, modifications were made to the regulation in the area of the administrative enforcement provisions. These modifications have reduced the record keeping and reporting re-requirments, and have made the product verification and selective enforcement audit processes more flexible and tailored to the industry. These changes in themselves have resulted in additional reductions in cost to the manufacturer over those that would have been incurred based on the proposed regulation.

Significant capital expenditures can be eliminated by those manufacturers who avail themselves of the EPA Enforcement Test Facility at Sandusky, Ohio, in lieu of constructing additional facilities.

4.18 Several commenters were concerned that the warranty required by Section 204.58-1 of the proposed regulation was a useful life performance warranty.

The warranty required of the manufacturer is a performance warranty that the air compressor met the noise emission standards on the date of sale to the ultimate purchaser. Because performance is warranted for the date of sale only, warranty claims must relate back to a nonconformity on that day. To make the best case in relating back to the date of sale, the claimant should be able to point to a defect in design, materials, or workmanship which existed on the sale date and which caused noise emissions to exceed the standard. Thus, although the claim may be made against the manufacturer at any time during the life of the compressor, such claim must relate back to noncompliance on the date of sale.

4.19 One commenter wished clarification regarding which "manufacturer" must issue the noise emission warranty.

The manufacturer who is required to issue and honor the noise emission warranty is the manufacturer who is required to production verify. The fact that a defective part, component, or system was purchased from another manufacturer does not alter this warranty. Manufacturers who production verify may seek indemnification from suppliers for liability which is attributable to the supplier.

4.20 Some commenters asked for a definition of what constitutes tampering and whether the use of aftermarket parts (parts not manufactured or authorized by the original equipment manufacturer) would constitute tampering.

A list of acts which could adversely affect the noise control system of a compressor and would constitute tampering, as determined by EPA, will be published in the owner's manual. This will give specific indications of those acts which will be considered tampering by the Agency unless it can be shown that noise emissions are not adversely affected by the act.

In general, in terms of noise-related aftermarket parts, any non-original equipment aftermarket part (including a rebuilt part) may be installed in or on a compressor subject to these regulations if the installer has a reasonable basis for knowing that it will not adversely affect noise emissions. For noise-related replacement aftermarket parts, a reasonable basis exists if (a) the installer reasonably believes that the replacement part or rebuilt part is designed to perform the same function with respect to noise control as the replaced part, or (b) the replacement part or rebuilt part is represented in writing by the part manufacturer or rebuilder to perform the same function with respect to noise control as the replaced part.

For noise-related add-on, auxiliary, augmenting, or secondary parts or systems, a reasonable basis exists if (a) the installer knows of noise emissions tests which show that the part does not cause noise emissions to exceed the time-of-sale standards, or to increase emissions, if the noise emissions already exceed the time-of-sale standards; or (b) the part or system manufacturer represents in writing that tests have been performed with similar results (to (a) above); or (c) a Federal, State or local environmental control agency with appropriate jurisdiction expressly represents that a reasonable basis exists.

4.21 Some commenters indicated that in the tampering requirement, submission of information 90 days before introduction into commerce of the compressor represents an excessively long time period for the manufacturer.

The 90-day requirement in the proposed regulation was established to allow EPA sufficient time to evaluate the tampering data, prepare a list of the acts which tampering enforcement would focus on, and then forward this list to the manufacturer for incorporation into the owner's manual. However, to account for the varying production schedules of manufacturers, the final regulation has been changed to allow for a time period based on the need of the manufacturer. The regulation now requires that the manufacturer submit the requested information within an adequate amount of time to provide EPA with 30 days to review the data and return a tampering list to the manufacturer for printing in the owner's manual. If the Administrator fails to provide the list to the manufacturer within 30 days of the date the information was submitted, the manufacturer is not precluded from distributing the compressors into commerce. In this case, the list of tampering acts required in the owner's manual shall be omitted until the list is provided and the owner's manual is otherwise reprinted.

4.22 Several commenters considered unreasonable and burdensome the requirements for the submission of listings of noise control devices and elements of design (including performance specifications) and acts which might constitute tampering.

The purpose of these requirements in the proposal was to enable the Administrator to determine what acts will constitute tampering. Information submitted by the manufacturer is not to be considered as a final judgment of what constitutes tampering, but will only provide the basic information for determination by the Administrator. The final regulation has been modified so that no separate submission of the list of noise control devices and elements of design is required; this is part of the information required to be provided in the product verification report. The requirement for submission of noise-related performance specifications has been deleted. The generation of the required information by the manufacturer can be performed concurrently with the development of appropriate noise control systems. The testing that will normally be performed in the development of the noise control systems and the manufacturer's engineering experience should provide a substantial basis from which the required information can be generated.

5. Miscellaneous

5.1 One commenter stated that noise regulations directed at the end product are preferable to those for individual component parts.

The Agency has carefully reviewed the possibility of regulating equipment components, for example, an engine as opposed to the total final end product, and reached the conclusion that on a cost effective basis, it is indeed preferable to regulate end products. This is so because in the synthesis of a final product from various regulated components, there is no guarantee that the noise emissions of the final product will be within acceptable limits. Accordingly, there probably still would be a need for a final product regulation.

5.2 One commenter stated that the regulation should be rewritten to improve the language related to the numerical descriptions of noise.

The Agency has taken the comment under advisement, and accordingly changes have been made to the text of the regulation.

5.3 One commenter suggested that the definition of portable air compressor should be clarified to exclude any products not intended to be subject to the regulation.

The suggested changes presented by this commenter were studied and the definitions of portable air compressors now appearing in the regulation incorporates language which the Agency feels adequately defines the product intended for regulation.

APPENDIX B

METHOD TO EVALUATE THE IMPACT OF PORTABLE AIR COMPRESSOR NOISE ON PUBLIC HEALTH AND WELFARE

Appendix B

METHOD TO EVALUATE THE IMPACT OF PORTABLE AIR COMPRESSOR NOISE ON PUBLIC HEALTH AND WELFARE

SPECIFICATION OF NOISE ENVIRONMENT

Environmental noise is defined in the Noise Control Act of 1972 as the "intensity, duration, and the character of sounds from all sources". A measure for quantifying environmental noise must evaluate not only these factors, but must also correlate well with the various modes of response of humans to noise and be simple to measure (or estimate).

EPA has chosen the equivalent A-weighted sound pressure level in decibels as its basic measure for environmental noise. The general symbol equivalent level is L_{eq}, and its basic definition is:

$$L_{eq} = 10 \log_{10} \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2(t)\, dt}{po^2} \right] \qquad \text{(B-1)}$$

where $t_2 - t_1$ is the interval of time over which the levels are evaulated, p(t) is the time varying sound pressure of the noise, and p_o is a reference pressure, standardized at 20 micropascal.

When expressed in terms of A-weighted sound level (L_A), L_{eq} may be defined as:

$$L_{eq} = 10 \log_{10} \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} 10^{\left(\frac{L_A(t)}{10}\right)} dt \right] \qquad \text{(B-2)}$$

The primary interval of interest for residential and similar land uses is a twenty-four hour period, with weighting applied to nighttime noise levels to account for the increased sensitivity of people associated with the decrease in background noise levels at night. This 24-hour weighted equivalent level is called the Day-Night Equivalent Level, and is symbolized as L_{dn}. The basic definition of L_{dn} in terms of A-weighted sound level is:

$$L_{dn} = 10 \log_{10} \frac{1}{24} \left[(15 \times 10^{\frac{L_d}{10}}) + (9 \times 10^{\frac{L_n + 10}{10}}) \right] \quad \text{(B-3)}$$

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. of the following day.

ASSESSING IMPACT FROM ENVIRONMENTAL NOISE

The underlying concept for noise impact assessment in the following analysis is to relate the change in expected impact in terms of the number of people involved to the change that will result in the acoustical environment as a result of the proposed action. Three fundamental components are involved in the analysis:

1. Definition of the initial acoustical environment,
2. Definition of final acoustical environment, and
3. Relationship between noise environment and human impact.

The first two components of the assessment are entirely site or system specific, relating to either estimates or measurement of the environmental noise before and after an action is taken. The same approach is used conceptually whether one is examining one house near a highway, a house near a construction site, the transportation system in general, or whatever noise source is involved. The methodology for estimating the noise environment in each case will vary widely, but the concept remains the same.

In contrast to the large number of methodologies that may be utilized to estimate the noise environment, the relationship to human response can be quantified by a single methodology in terms of the number of people in occupied places exposed to noise of a specified magnitude. This is not to say that individuals have the same susceptibility to noise; they do not. Even groups of people may vary in response depending upon previous exposure, age, socio-economic status, political cohesiveness and other social variables. In the aggregate, however, for residential location the average response of groups of people is quite stably related to cumulative noise exposure as expressed in measures such as L_{dn}. The response considered is the general adverse reaction of people to noise. This response is a combination of such factors as speech interference, sleep interference, desire for a tranquil environment, and the ability to use telephones, radio and TV satisfactorily. The measure of this response is related to the percent of people in a population that would be expected to indicate a high annoyance to noise for a specified level of noise exposure.

For schools, offices, and similar spaces where criteria for speech communication or a possibility of damage to hearing is of primary concern, the same averaging process is used to estimate the potential response of people as a group, again ignoring the individual variation of one person as compared to another.

Hence, in both residential and non-residential areas alike, the variation of the average response of people as a function of environmental noise exposure is considered.

A detailed discussion of the relationship between noise and human response is provided in EPA documents [1, 28] in which hearing damage, speech and other activity interference and annoyance are related to L_{eq} and L_{dn}. For the purposes of this study, criteria presented in the "EPA Levels Document" [1] are used. Further, it is considered that if the levels identified in the document are met, then no impact exists on the public health and welfare. Thus, we define that if the levels identified in the "Levels Document" are met, a zero percent impact exists. That is, if an L_{dn} of 55 measured outdoor exists, then there is no impact in terms of annoyance and general community response from noise. Similarly, if an L_{dn} of 45 exists indoors, which translates to an L_{dn} of 55 outdoors (assuming a 10 dB transmission loss with windows partially opened) then no interference exists with respect to speech.

Observation of the data presented in Appendix D of Reference 1 allows the specification of an upper limit, that is a bound corresponding to 100% impact. It may be observed in Figure D-7 of the "Levels Document" [1] that community reaction data show that the expected reaction to an identifiable source of intruding noise changes from "none" to "vigorous" when the day-night sound level increases from 5 dB below the level existing without the presence of the intruding noise to 19.5 dB above the pre-intrusion level. When the combined values of the intruding noise and the pre-intrusion noise levels are considered, the changing community reaction from "none" to "vigorous" occurs when the level increases by 19.7 above the pre-intrusion level. For simplicity sake, it is reasonable to associate 100 percent impact corresponding to a vigorous community reaction with a change of 20 dB above the L_{dn} value identified as a zero impact level. Thus, for the purpose of this analysis, $L_{dn} = 75$ is considered to be a 100 percent impact.

Furthermore, the data in Appendix D of Reference 1 suggest that within those upper and lower bounds the relationship between impact and level varies linearly, that is, a 5 dB excess constitutes a 25 percent impact, while a 19 dB excess constitutes a 50 percent impact.

The data presented in the "Levels Document" with respect to activity interference (e.g., speech interference) suggests that if the day-night sound level indoors is 45 dB, no impact exists on speech communication since a noise level intelligibility for all types of speech material and would have a calculated articulation index of 1.0.

The intelligibility of speech is a function of the material presented to the listener as well as the signal to noise ratio.

It may be argued that for most conversation, the material the listener normally listens to is in the form of sentences containing a mixture of some known material and some unknown material. Thus, for this analysis it is reasonable to average the data on known and unknown sentences. Observation of Figure 15 of the ANSI Standard[29] reveals that when the noise environment is increased by approximately 19 dB above the level identified in the "Levels Document,"[1] the intelligibility of sentences of unknown material drops 90 percent. Similarily, the intelligibility for sentences of known material drops to 90 percent when the level is increased by 22 dB above the level identified by EPA and 50 percent when the level is increased by approximately 26 dB. Thus, if the values are averaged, it is not unreasonable to assume that a 20 dB increase in the noise level above the level identified by EPA in the "Levels Document" will result in conversational speech deteriorating rapidly with each decibel of increase. For this reason, it is assumed that 100 percent impact will occur on speech intelligibility when the level of the enivronmental noise increases 20 dB above the identified level in the "Levels Document." Furthermore, observation of Figure 15 of the ANSI Standard [29] suggests that it is reasonable to assume that speech varies approximately linearly with the level for the range between 0 and 100% impact. That is, with each 5 dB excess of noise above the level identified in Reference 1, a 20 percent reduction of speech intelligibility occurs while a 10 dB excess results in a 50 percent degradation.

The previous paragraphs presented information to show that increases in noise levels above a certain base level would cause annoyance, adverse community reaction and/or adverse effects on speech interference. With 0 percent impact associated with the base level and 100 percent impact associated with a level 20 dB above the base level, one is able to calculate the percentage impact resulting from any noise level. For convenience of calculation, the percentage impact may be expressed in terms of a Fractional Impact (FI), where FI is calculated in accordance with the following formula:

$$FI = 0.05 \times (L - L_C) \text{ for } L > L_C$$

$$FI = 0 \qquad \text{for } L \leq L_C$$

where L is the environmental noise level, expressed either in L_{dn} or L_{eq}, and L_C is the base level identified in the "Levels Document."

The appropriate level for the computation of FI is L_{dn} = 55 dB for residential area measured outdoors. For those analyses concerned with office buildings and other type of spaces in which speech communication is the principal factor of concern, the identified level is L_{dn} = .doors, which can be translated to an outdoor level by using sound level reduction appropriate to the type of structure.

Data on the reduction of aircraft noise afforded by a range of residential structures are available. These data indicate that houses can be approximately categorized into "warm climate" and "cold climate" types. Additionally, data are available for typical open-window and closed-window conditions. These data indicate that the sound level reduction provided by buildings within a given community has a wide range due to differences in the use of materials, building techniques, and individual building plans. Nevertheless, for planning purposes, the typical reduction in sound level from outside to inside a house can be summarized as follows in Table B-1. The approximate national average "window-open" condition corresponds to an opening of 2 square feet and a room absorption of 300 sabins (typical average of bedrooms and living rooms). This "window-open" condition has been assumed thoughout this chapter in estimating conservative values of the sound levels inside dwelling units that results from outdoor noise.

The final notion to be considered is the manner in which the number of people affected by environmental noise is introduced into the analysis. The magnitude of the total impact associated with a defined level is calculated by formula B-5, i.e., the product of the number of people and the fractional impact associated with the level of the environmental noise:

$$P_{eq} = (FI)\,P \qquad \text{(B-5)}$$

where P_{eq} is the magnitude of the total impact on the population and is numerically equal to the equivalent number of people having a fractional impact equal to unity (100% impacted); FI is the fractional impact for the level and P is the population affected by the noise.

TABLE B-1

TYPICAL ATTENUATION OF OUTDOOR NOISE BY THE EXTERIOR SHELL OF HOUSES

	Windows Open	Windows Closed
Warm climate	12 dB	24 dB
Cold climate	17 dB	27 dB
Approximate national average	15 dB	25 dB

Since the levels of environmental noise associated with the source(s) decrease as the distance between the source and receiver increases, the magnitude of the total impact may be computed by determining the number of people exposed at each level, and summing the resulting impact. The total impact is given by the following formula:

$$P_{eq} = \sum_i P_i FI_i \qquad \text{(B-6)}$$

where FI_i is the fractional impact associated with the i^{th} level and P_i is the population associated with the i^{th} level.

The percentage change in impact associated with an action leading to noise reduction, or change in population through a change in land use, may be assessed, as shown by formula B-7, by comparing the magnitude of the impacts for the "before" and "after" conditions.

$$\Delta = 100 \; \frac{(P_{eq}\,(\text{before}) - P_{eq}\,(\text{after}))}{P_{eq}\,(\text{before})} \qquad \text{(B-7)}$$

Note that the percentage change (Δ) may be positive or negative depending upon whether the impact decreases (positive percentage reduction) or the impact increases (negative percentage reduction). Thus, a 100 percent positive change in in impact means that the environmental noise has been reduced such that none of the population is exposed to noise levels in excess of the levels identified in the "Levels Document."

In the recent EPA study on "Population Distribution of the United States as a Function of Outdoor Noise Level," [34] an estimate is provided for the number of people in the United States exposed to various levels of urban noise. Data in the study are used to illustrate the impact assessment procedure, to show the current impact resulting from urban noise and to assess the change in impact if urban noise were reduced 5, 10, or 15 dB. For this example, the base level (outdoors) is an L_{dn} of 55 dB.

The results, provided in Table B-2, show that a 5 dB noise reduction results in a 55 percent reduction in impact, a 10 dB noise reduction results in an 85 percent reduction in impact, and a 15 dB noise reduction results in a 96 percent reduction in impact.

The impact assessment procedure may be summarized by the following steps:

1. Estimate the L_{eq} or L_{dn} produced by the noise source system as a function of space over the area of interest.
2. Define subareas of equal L_{eq} or L_{dn}, in increments of 5 dB, for all land use areas.
3. Define the population, P_i, associated with each of the subareas of step 2.
4. Calculate the FI_i values for each L_{dn_i} or L_{eq_i} obtained in step 2.
5. Calculate $FI_i \times P_i$ for each subarea in step 2.
6. Obtain the equivalent impacted population for the condition existing before the change being evaluated, by summing the individual contributions of step 5.

$$P_{eq_B} = \sum_i (FI_i \times P_i)$$

7. Repeat steps 1-6 for the noise environment existing over the area of interest after the change being evaluated takes place, thus obtaining P_{eq_A}.

8. Obtain the percent reduction in impact from

$$\Delta = 100 \frac{(P_{eq_B} - P_{eq_A})}{P_{eq_B}}$$

TABLE B-2

ESTIMATE OF THE IMPACT OF SUCCESSIVE REDUCTION OF ALL URBAN NOISE SOURCES IN 5 DECIBEL INCREMENTS

Current Conditions			Noise reduction in decibels							
			0		5		10		15	
L_{dn} -dB	Population exposed to higher Ldn -millions	P_i millions	FI_i -millions	FI_iP_i	FI_i -millions	FI_iP_i	FI_i -millions	FI_iP_i	FI_i -millions	FI_iP_i
55	93.4	34.4	0.125	4.3	0	0	0	0	0	0
60	59.0	34.7	0.375	13.0	0.125	4.3	0	0	0	0
65	24.3	17.4	0.625	10.9	0.375	6.5	0.125	2.2	0	0
70	6.9	5.6	0.875	4.9	0.625	3.5	0.375	2.1	0.125	0.7
75	1.3	1.2	1.125	1.4	0.875	1.1	0.625	0.8	0.375	0.5
80	0.1	0.1	1.375	0.1	1.125	0.1	0.875	0.1	0.625	0.1
Total equivalent people impacted			34.6		15.5		5.2		1.3	
Percent reduction impact			0		55		85		96	

APPENDIX C

COST ANALYSIS OF PRODUCTION VERIFICATION AND SELECTIVE ENFORCEMENT AUDITING FOR THE PORTABLE AIR COMPRESSOR INDUSTRY

APPENDIX C

COST ANALYSIS OF PRODUCTION VERIFICATION AND SELECTIVE ENFORCEMENT AUDITING FOR THE PORTABLE AIR COMPRESSOR INDUSTRY

An analysis has been performed to estimate the costs associated with typical manufacturer production verification testing and selective enforcement audit testing.

For the analysis, it was assumed that most of the testing would be done at the manufacturer's facility. However, because some manufacturers may prefer not to construct a test facility, an EPA facility will be available for their use for a fee, which will cover actual costs incurred by the Government. Data from Reference 8 and the assumptions listed in Table C-1 served as the basis for the analysis.

PRODUCT VERIFICATION TESTING COSTS

Based on results from the analysis, it has been estimated that the total cost to the industry for production verification testing during the first year of compliance might range from $76,000 to $107,117. The $76,000 figure assumes that all testing is done at manufacturer test facilities, whereas the $107,117 figure assumes that all testing is done at the EPA test facility. A single figure for the product verification costs should lie somewhere between these two values. In subsequent years, product verification testing costs can be expected to decrease due to manufacturers' ability to utilize the initial production verification report for compressor models for which no change has been made in the compressor for the next model year.

Estimates of production verification testing costs at individual manufacturer facilities range from a high of $14,000 for the largest manufacturer to a low of $300 for the smallest manufacturer, the mean value being $4471. Estimates of production verification testing conducted at the EPA test facility on an individual company basis range from $19,800 for the largest manufacturer to $354 for the smallest manufacturer, the mean value being $6301.

SELECTIVE ENFORCEMENT TESTING COSTS

Selective enforcement audit (SEA) testing may be conducted by the manufacturer both on his own initiative and upon request by EPA. Costs associated with testing requested

Table C-1

ASSUMPTIONS USED TO ESTIMATE
PORTABLE AIR COMPRESSOR TESTING COSTS

Report Preparation Costs

All report costs are based on $100/test (one day at $25K per man year)

Transportation Costs

(For Two Products)

Fixed

$30.00 (Basic cost of short haul)

Variable

16 cents/mile Driver ($8.00/hr or $16.00/100 miles)
20 cents/mile Truck (12 cents/mi. for fuel, 8 cents/mi. maintenance + depreciation)
36 cents/mile = Total variable cost

Summary

$30.00 + $.36/mi. (Transport 2 Products)
$15.00 + $.18/mi. (Transport 1 Product)

Total Transportation Cost = Number of Categories X ($15 + $.18 X route miles)

Cost of Testing

The cost of conducting the measurement methodology is estimated to be approximately $200. However, if a manufacturer supplied an estimate which reflects his actual costs, then his estimate was used for the analysis.

Total Number of Categories

The total number of categories for the industry requiring production verification is estimated to be 236.

by EPA and conducted at the manufacturer's facility are estimated to total $149,000 for the industry as a whole. Included in the $149,000 figure is an estimate of $42,000 for the largest manufacturer and an estimate of $3000 for the smallest manufacturer. The industry average cost for SEA testing is estimated to be $8,765.

Manufacturers may be expected to request use of the EPA test facility to conduct selective audit testing to primarily determine the level of performance of their products. Costs associated with this testing, including transportation of the test compressors to the facility, are estimated to total $206,522 for the industry during the first year of compliance. The cost breakdown within the industry ranges from a high of $57,628 to low of $3,540, the average value being $12,148. These costs can be expected to decrease following the first year the regulations are effective as manufacturers become more familiar with the compliance scheme, the production variance of their products, and the correlation of results at their facility with those at the EPA facility.

Finally, based on the assumption that SEA testing will be conducted at the EPA test facility upon EPA request, it is estimated that a $72,332 cost per year might accrue to the industry for such testing. This figure represents the cost of transportation only, since EPA would conduct the testing at its own expense. In terms of individual manufacturer transportation costs, it is estimated that a $21,628 cost might accrue for the largest manufacturer and a $540 cost for the smallest manufacturer. The mean transportation cost for the industry is estimated to be $4,255.

Table C-2 summarizes the estimates discussed above.

Table C-2

SUMMARY OF ENFORCEMENT COSTS

PRODUCTION VERIFICATION

	Manufacturer	EPA*
TOTAL	$76,000	$107,117
AVERAGE	$ 4,471	$ 6,301
HIGH	$14,000	$ 19,800
LOW	$ 300	$ 354
MEDIAN	$ 3,300	$ 4,422

*Manufacturer's request

SELECTIVE ENFORCEMENT AUDITING

	Manufacturer	EPA*	EPA**
TOTAL	$149,000	$206,522	$72,332
AVERAGE	8,765	$ 12,148	$ 4,255
HIGH	$ 42,000	$ 57,628	$21,628
LOW	$ 3,000	$ 3,540	$ 540
MEDIAN	$ 3,000	$ 5,094	$ 1,920

* Manufacturer's request
** EPA's request

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