U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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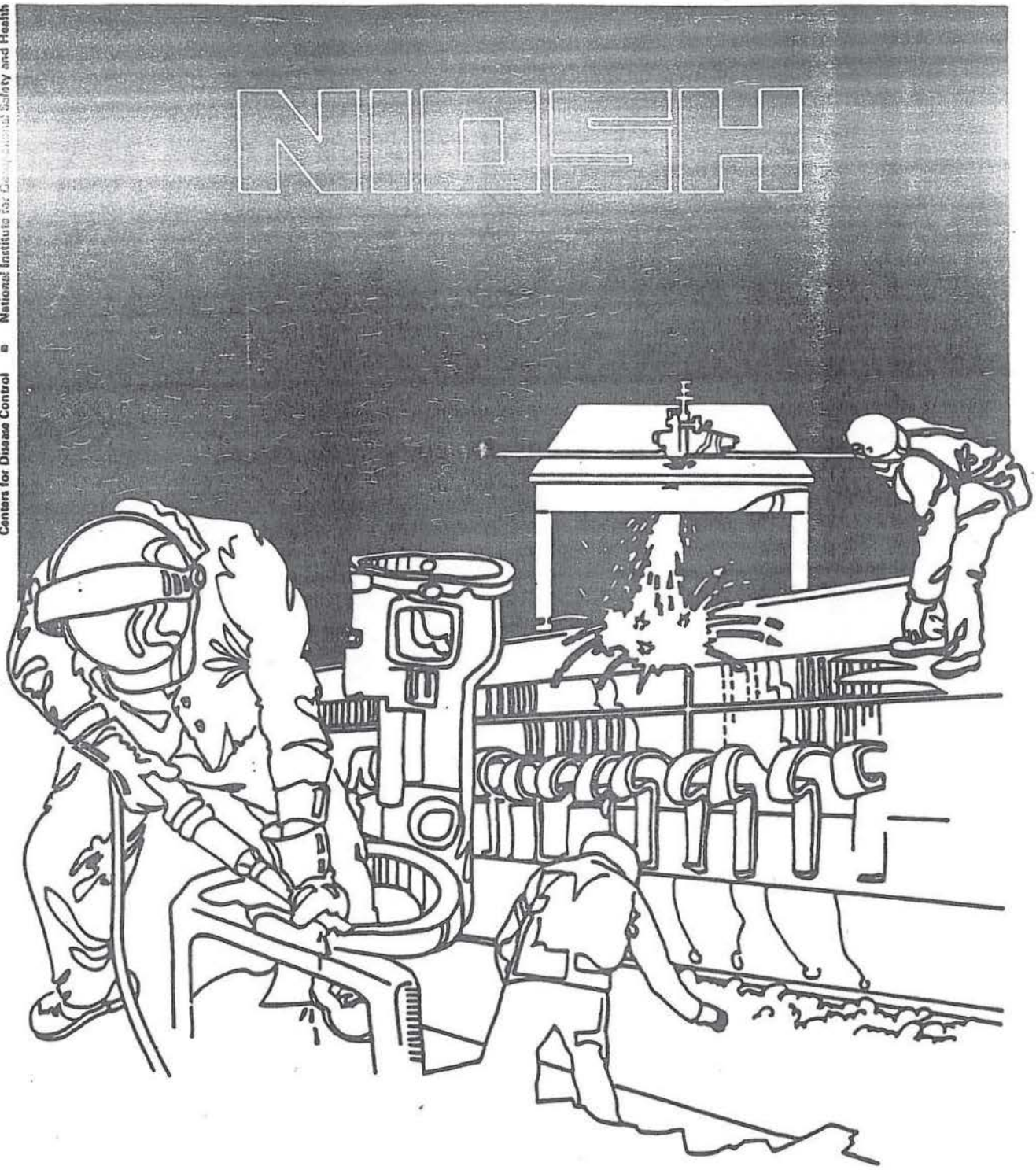
NIOSH



Health Hazard Evaluation Report

HETA 84-493-1583
GENERAL SERVICES ADMINISTRATION
WASHINGTON, D.C.

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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NIOSH INVESTIGATORS:
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I. SUMMARY

In August, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the General Services Administration (GSA) to conduct an evaluation of siren noise in ambulances. GSA requested that NIOSH quantify the noise levels relative to siren location prior to completing a proposed revision of the Federal Specification for emergency medical care vehicles (ambulances).

In October, 1984, NIOSH investigators evaluated the effect of siren speaker location on noise levels within a Type I ambulance. Sound pressure levels (dB SPL) were recorded during siren testing with a GenRad 1982 Precision Sound Level Meter and Analyzer in concert with a Nagra IVD tape recorder inside the ambulance at the driver compartment and the patient compartment positions. Projected siren noise was also recorded at 10 and 100 feet from the vehicle.

Analysis of the recorded tapes demonstrated that when siren speakers were located on the roof of the ambulance driver cab, siren noise within the ambulance was intense (driver - 109 dBA, patient - 91 dBA), and depending upon the duration of exposure may exceed both the OSHA standard (90 dBA, 8-hour TWA) and the NIOSH criterion (85 dBA, 8-hour TWA).

Substantial reduction in overall noise (10-22 dBA) was achieved when siren speakers were located in the grille area of the ambulance (driver - 87 dBA, patient - 76 dBA). Further noise reduction (up to 13 dBA) was achieved in some instances by keeping the driver cab windows closed during operation.

Siren noise outside the ambulance at 10 feet presented an immediate noise hazard - 122 dBA, in excess of the OSHA ceiling of 115 dBA. Noise levels at 100 feet ranged from 98-105 dBA.

Siren spectral distribution data under all conditions show that most of spectral energy was concentrated in the octave bands from 500 Hz to 2 KHz .

A potential hazard was found to exist from ambulance siren noise. Substantial reductions in noise levels (10-22 dBA) were achieved when siren speakers were located in the ambulance grille area. When windows were also kept closed, patient and driver compartment noise levels were 76-80 dBA, the potential hazard of noise-induced hearing loss was eliminated and communicative ability vastly improved. Recommendations to eliminate the potential health and safety hazard are provided in Section VII of the report.

KEYWORDS: SIC 4119, noise, hearing loss, ambulance, siren.

II. INTRODUCTION

In August, 1984, NIOSH was requested by the General Services Administration, Federal Supply and Services in Washington, D.C. to conduct an investigation of siren noise in ambulances. The Engineering and Specifications Division of GSA is responsible for providing the Federal Specification for ambulances (KKK-A-1822) and requested that NIOSH quantify the noise levels relative to siren speaker location prior to completing a proposed revision. This specification is extensively used by state, county and local governments as well as by the Federal Government In December, 1984, NIOSH provided GSA with an interim report of the evaluation results.

III. BACKGROUND

High noise levels have been associated with reduced hearing in drivers of motor vehicles[1], and firefighting equipment[2]. Ambulance paramedics appeared to lose hearing acuity faster than normal[3].

GSA felt that reduction of siren noise inside ambulances was needed not only to control noise trauma, but also to reduce possible additional effects of the noisy environment (e.g. interference in communications, decreased performance of intellectual tasks, and increased stress) and to reduce the anxiety level in unstable patients being transported under emergency conditions.

Based upon previous subjective tests, the GSA suspected that considerable improvement in reduction of noise levels inside ambulances could be achieved by proper location of the siren speakers.

NIOSH agreed to assist GSA in quantifying the noise levels attendant to a variety of ambulance siren operating conditions.

IV. EVALUATION DESIGN AND METHODS

Testing was performed on a Type I ambulance having a conventional, cab-chassis with modular ambulance body. The ambulance, furnished courtesy of the Laurel (MD) Volunteer Rescue Squad, was equipped with a siren, Southern VP, model SA 420-53 and two speakers, Southern VP, model D-60.

Siren speakers were fixed to the ambulance in either of two locations: (1) the roof of the driver's cab which has been the traditional location on most ambulances, or (2) near the grille area or front bumper of the ambulance. (See Figures 1 and 2).

Noise levels were measured using a General Radio Model 1982 Precision Sound Level Meter (SLM) and Analyzer set on the flat response scale. The ac signal from the SLM was fed into a Nagra type IV-D tape recorder. (See Figure 3). The recorded tapes were later analyzed with a Nicolet 444 Mini-Ubiquitous Spectrum Analyzer. Sound survey equipment was calibrated before and after samples were taken according to manufacturers' instructions with traceable calibration sources from the National Bureau of Standards.

Tests were conducted on the end (turnaround) of an unused airport runway. (See Figure 4). The hard paved surface was surrounded by open fields with no structure closer than 1500 feet.

Four locations were monitored during the testing conducted:

1. Driver compartment-driver position, inside the ambulance
2. Patient compartment-patient position, inside the ambulance
3. Ten (10) feet from the siren speakers, on axis to ± 45° outside the ambulance.
4. One hundred (100) feet on axis to ± 45° from the siren speakers, outside the ambulance.

For each siren location, testing conditions also included operating with the driver cab windows in two positions:

1. Driver cab windows open.
2. Driver cab windows closed.

At each test condition, the siren was operated in the three available modes: wail, yelp, and European or Hi-Lo - for a period of about 15 seconds.

For analysis, an 8-second sample of each siren mode was used to determine the "average" sound pressure level. Data are displayed on the dBA scale to simulate response of the human ear. Overall noise levels and selected spectral distribution data will be presented.

V. EVALUATION CRITERIA

Exposure to high levels of noise may cause temporary or permanent hearing loss. The extent of damage depends primarily upon the intensity of the noise and the duration of the exposure. There is abundant epidemiological and laboratory evidence that protracted noise exposure above 90 decibels (dBA) causes hearing loss in a portion of the exposed population.

OSHA's existing standard for occupation exposure to noise (29 CFR 1910.95)[4] specifies a maximum permissible noise exposure level of 90 dBA for a duration of 8 hours, with higher levels allowed for shorter durations. NIOSH, in its Criteria for a Recommended Standard,[5], proposed a limit of 85 dBA, 5 dB less than the OSHA standard.

Time-weighted average noise limits as a function of exposure duration are shown as follows:

Duration of Exposure (hrs/day)	Sound Level, dBA NIOSH	OSHA
8	85	90
4	90	95
2	95	100
1	100	105
1/2	105	110
1/4	110	115*
1/8	115*	-
	-	140 dB**

* No exposure to continuous noise above 115 dBA

**No exposure to impact or impulse noise above 140 dB peak sound pressure level (SPL).

When workers are exposed to sound levels exceeding the OSHA standard, feasible engineering or administrative controls must be implemented to reduce levels to permissible limits.

VI. RESULTS AND DISCUSSION

Sound level measurement data from the ambulance siren testing we conducted on October 25, 1984 are presented in Tables 1 and 2. Each result represents an 8-second sample average from the various measurement locations and conditions tested. Sound levels are expressed on the dBA scale for each siren mode tested - wail, yelp, and European or 2-tone, along with an "overall" average dBA level.

Noise levels are fairly consistent across the 3-modes of siren operation (wail, yelp, 2-tone) under a given test condition. Therefore, additional discussion of the data will be focused on the "overall" average dBA data (average of 3 modes).

With the ambulance siren speakers mounted on the ambulance cab roof (Table 1), resultant overall noise levels (range 85-109 dBA inside the ambulance, range 92-122 dBA outside the ambulance) at all locations/conditions equal or exceed 85 dBA. Thus, dependent upon the duration of exposure, NIOSH criteria and OSHA standards may be exceeded. With the siren speakers mounted in the ambulance grille area (Table 2), resultant noise levels are substantially reduced in the driver compartment and patient compartment-range 76-87 dBA, (3 of 4 conditions are below the NIOSH criterion of 85 dBA). The driver cab, driver windows open position still exceeds 85 dBA although an 8-hour TWA exposure is not likely to exist.

Figure 5 is a histogram which further displays the overall average dBA levels for the driver and patient compartment positions. Table 3 illustrates that a substantial reduction in overall noise is achieved in both the driver cab (16.3 to 22.0 dBA) and the patient compartment (7.5 - 15.3 dBA) when siren speakers are located in the grille area compared to the ambulance cab roof.

Further noise reduction is achieved in the driver cab (7.1 to 12.8 dBA) and the patient compartment (up to 7.1 dBA) when the driver's cab windows are closed rather than open.

Noise levels achieved within the ambulance under the best operating conditions (grille siren, driver cab windows closed) ranged from 76-80 dBA. Although these noise levels may still interfere with some speech and radio communications, the ability to conduct communication and perform necessary tasks is vastly improved. Above 85 dBA direct communications are minimal, requiring a very loud voice or shouting, and radio use is impossible.

Figure 6 illustrates the overall noise levels in dBA outside the ambulance at 10 feet and 100 feet. Siren noise immediately in front of the ambulance is obviously a hazard (122 dBA), and exceeds the NIOSH recommended ceiling level of 115 dBA. Projected siren noise 100 feet down range appears increased by about 5 dBA when siren speakers are located in the grille area. Thus, warning ability may be enhanced in this mode of operation.

Spectral distribution data for siren operations are displayed in Figures 7-10 for various conditions of operations. Siren spectral distribution data in all conditions show most of the spectral energy is concentrated in the octave band centered at 1 KHz to which the human ear is most sensitive. It is of interest to note that the greatest reduction of siren spectral energy achieved by window dampening (closure) is also in the three octave bands from 500 Hz to 2 KHz.

VII. CONCLUSIONS AND RECOMMENDATIONS

A potential hazard was found to exist from ambulance siren noise. Clearly from the various conditions tested, the optimum condition for minimizing noise exposure is that achieved by locating the siren speakers in the grille area, and maintaining the driver cab windows in a closed, rolled up position.

Under these conditions, noise levels in the driver cab and patient compartment are in the 76-80 dBA range which provides an environment not only free of a potential hearing loss problem, but also an atmosphere where communications and performance of necessary tasks by ambulance personnel can be carried out under reasonably acceptable conditions, and a more relaxing atmosphere provided for the patient.

Hazardous noise levels exist immediately in front of the ambulance when sirens are in use.

Based upon the data obtained in this evaluation we recommend:

1. GSA modify the Federal Specification for ambulance operations to include a provision for locating ambulance siren speakers in the grille or bumper area, rather than on the cab roof as had been the usual custom. (GSA included this provision in the revised Federal Specification which is effective June 1, 1985.)

2. Driver cab windows should be maintained in a closed or rolled up position when the ambulance siren is in use.

3. Siren operations should be minimized and utilized only as necessary while the ambulance is in a transport mode. Siren use should be minimized when the vehicle is slowed in traffic, and terminated altogether when the desired destination is reached.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. General Services Administration, Washington, D.C.
2. Laurel Volunteer Rescue Squad, Laurel, MD
3. NIOSH, Region III
4. U.S. Department of Labor - OSHA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

XI. REFERENCES

1. Nerbonne M.A., Accardi A.E.: Noise-induced hearing loss in a truck driver population. J Aud Res 15: 119-122, 1975

2. Tubbs, R.A., Flesch, J.P.: Health Hazard Evaluation Report HETA 81-059-1045, Newburgh Fire Department, NIOSH-CDC, Cincinnati, Ohio 1982

3. Johnson, D.W., Hammond, R.J., Sherman, R.E.: Hearing in an ambulance paramedic population. Ann Emerg Med 9:11, 557-561, November 1980

4. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Safety and Health standards. Federal Register, Vol. 36, No. 105, Part II, May 29, 1971.

5. National Institute for Occupational Safety and Health. Criteria for a recommended standard. Occupational exposure to noise. DHEW pub. no. 73-11001. NIOSH-CDC, 1972.

Table 1: Sound Level Measurements:
Siren Speakers Mounted on Ambulance Cab Roof
October, 1984

	dBA (8-sec. avg.)			
Location/Conditions*	Wail	Yelp	2-Tone	Overall
Driver Cab - WO	108.9	109.5	109.6	109.1
Driver Cab - WC	96.5	97.5	94.5	96.3
Patient Comp - WO	91.9	91.5	90.0	91.2
Patient Comp - WC	85.6	85.2	82.5	84.3
10 Ft. - 45°L	117.6	117.7	119.1	118.1
30°L	119.1	119.0	118.7	118.9
20°L	119.1	120.2	118.7	119.1
10°L	118.7	117.7	114.5	117.1
0°C	123.9	123.4	117.9	122.2
10°R	-	-	-	-
20°R	118.3	117.9	118.0	118.2
30°R	117.9	117.5	115.7	117.4
45°R	118.1	118.3	120.3	118.7
100 ft. - 45°L	92.9	94.8	100.2	97.1
30°L	94.2	92.9	95.7	94.2
20°L	96.7	96.9	96.9	96.6
10°L	94.2	94.2	89.6	92.8
0°C	100.0	99.3	96.5	98.6
10°R	95.7	96.0	88.8	94.4
20°R	99.0	97.7	100.9	99.1
30°R	93.3	92.4	88.8	91.7
45°R	93.4	93.3	96.7	94.5

*Note:

(1) Driver Cab - Driver Position
(2) Patient Compartment - Patient Position
(3) WO/WC - Driver Cab Windows Open/Windows Closed
(4) 10/100Ft. - Distance in front of ambulance siren speakers, at height of 4 ft. from ground.
(5) °L/°R - Degrees left/right from ambulance centerline

Table 2: Sound Level Measurements:
Siren Speakers Mounted in Ambulance Grille Area
October, 1984

	dBA (8-sec. avg.)			
Location/Conditions*	Wail	Yelp	2-Tone	Overall
Driver Cab - WO	87.0	86.9	86.7	87.1
Driver Cab - WC	79.6	79.7	79.9	80.0
Patient Comp - WO	75.5	76.7	74.4	75.9
Patient Comp - WC	75.9	75.9	77.3	76.8
10 Ft. - 45°L	120.6	119.9	119.2	120.2
- 30°L	120.7	120.1	117.9	119.6
- 20°L	113.8	113.9	114.3	113.9
- 10°L	120.5	120.7	121.0	120.9
- 0°C	122.5	122.5	121.9	122.2
- 10°R	121.3	120.8	118.4	120.4
- 20°R	116.4	115.1	114.0	115.6
- 30°R	122.3	120.9	116.4	120.7
- 45°R	117.9	117.7	118.5	118.1
100 Ft - 45°L	100.2	100.9	99.7	100.5
- 30°L	102.5	102.0	92.7	100.9
- 20°L	95.9	95.4	87.9	94.1
- 10°L	101.7	103.0	100.2	101.9
- 0°C	105.9	105.5	104.1	105.3
- 10°R	102.0	101.8	101.0	101.8
- 20°R	97.0	96.6	91.3	95.8
- 30°R	102.1	101.7	95.1	100.6
- 45°R	99.5	99.5	101.3	100.2

*Note:

(1) Driver Cab - Driver Position
(2) Patient Compartment - Patient Position
(3) WO/WC - Driver Cab Windows Open/Windows Closed
(4) 10/100Ft. - Distance in front of ambulance siren speakers, at height of 4 ft. from ground.
(5) °L/°R - Degrees left/right from ambulance centerline

TABLE 3: Sound Level Reduction
As A Function of Siren Location and Operating Conditions

	Overall, dBA		
Location/Condition	Roof Siren	Grille Siren	(R-G)
Driver - Windows Open	109.1	87.1	22.0
Driver - Windows Closed	96.3	80.0	16.3
(WO-WC)	12.8	7.1	
Patient - Windows Open	91.2	75.9	15.3
Patient - Windows Closed	84.3	76.8	7.5
(WO-WC)	6.9	0.9	

Figure 1. Siren Speakers Mounted On Driver Cab Roof

Figure 2. Siren Speakers Mounted In Grille Area Of Ambulance

Figure 3. Gen Rad Sound Level Meter, Calibrator, and Tape Recorder

Figure 4. Airport Runway Where Tests Were Conducted

FIGURE 5. OVERALL NOISE LEVELS INSIDE AMBULANCE

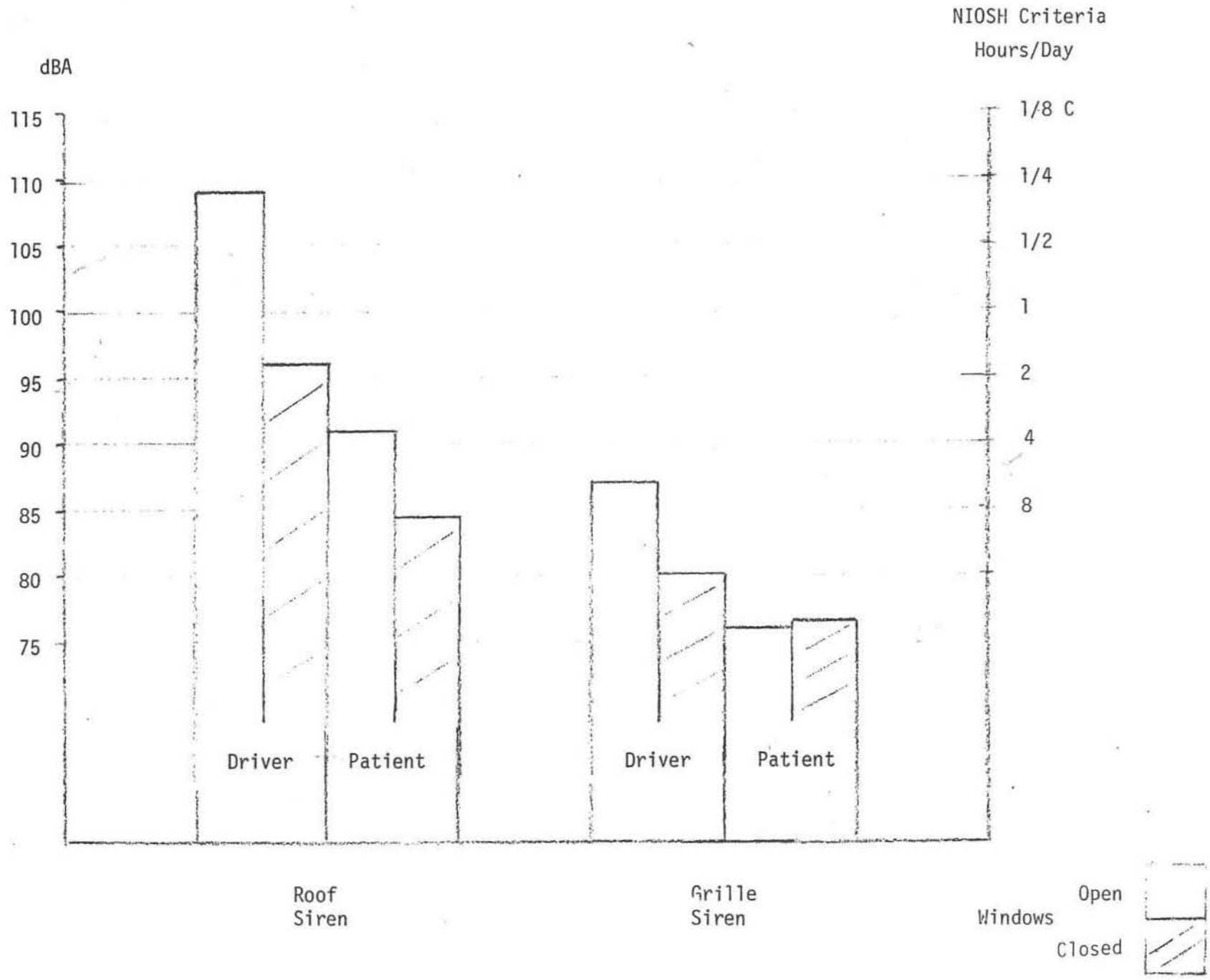


FIGURE 6. OVERALL NOISE LEVELS OUTSIDE AMBULANCE

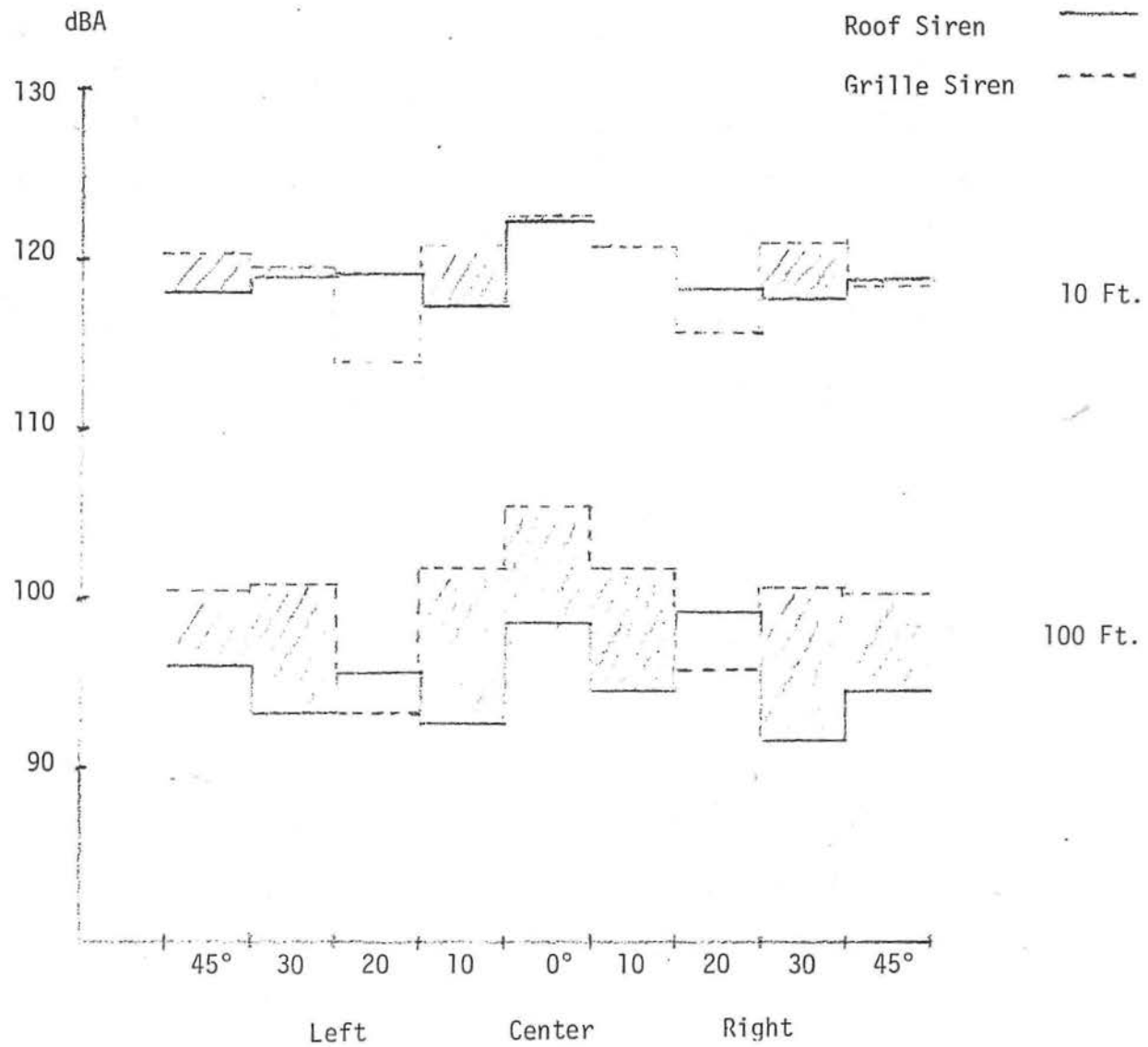
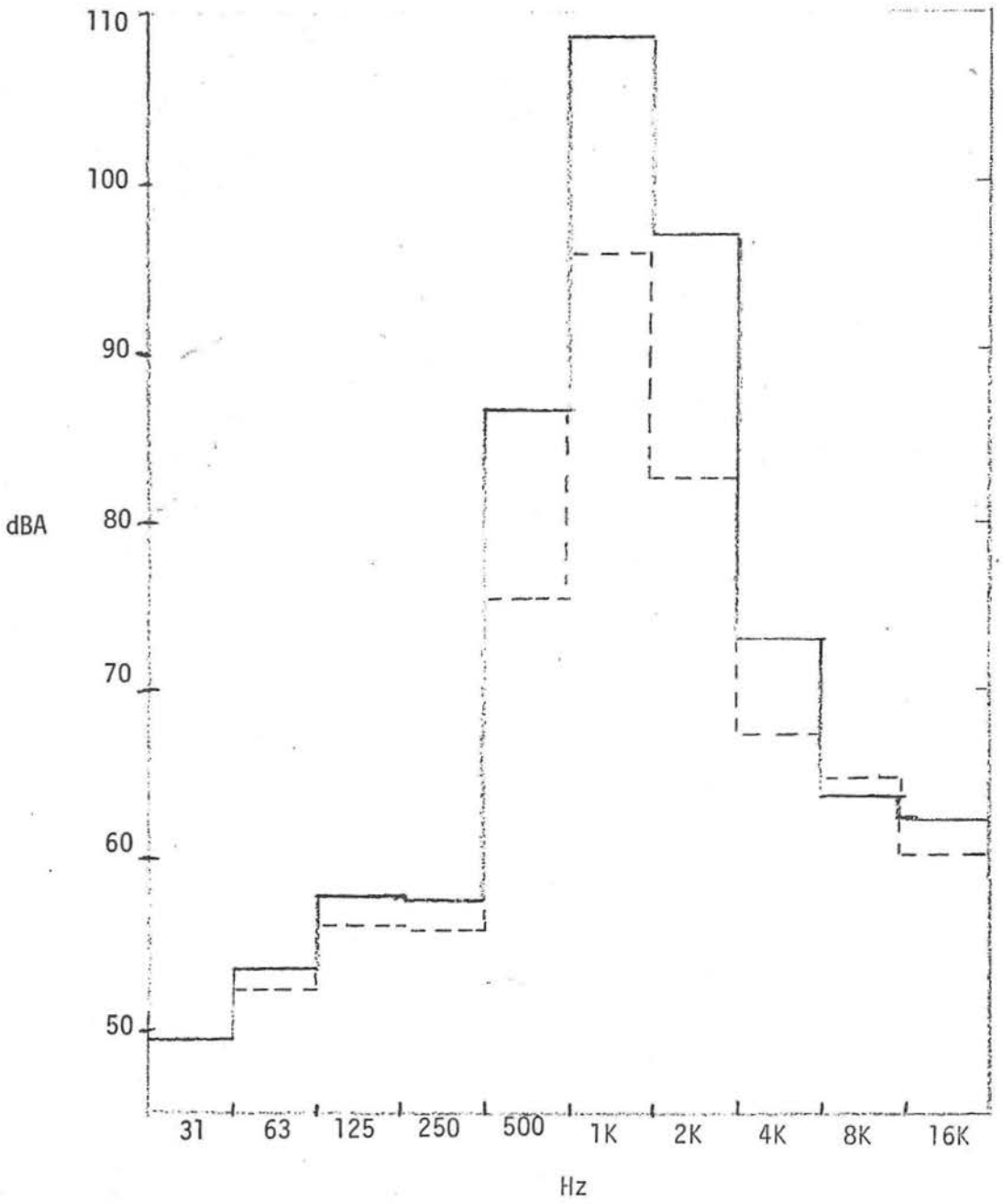
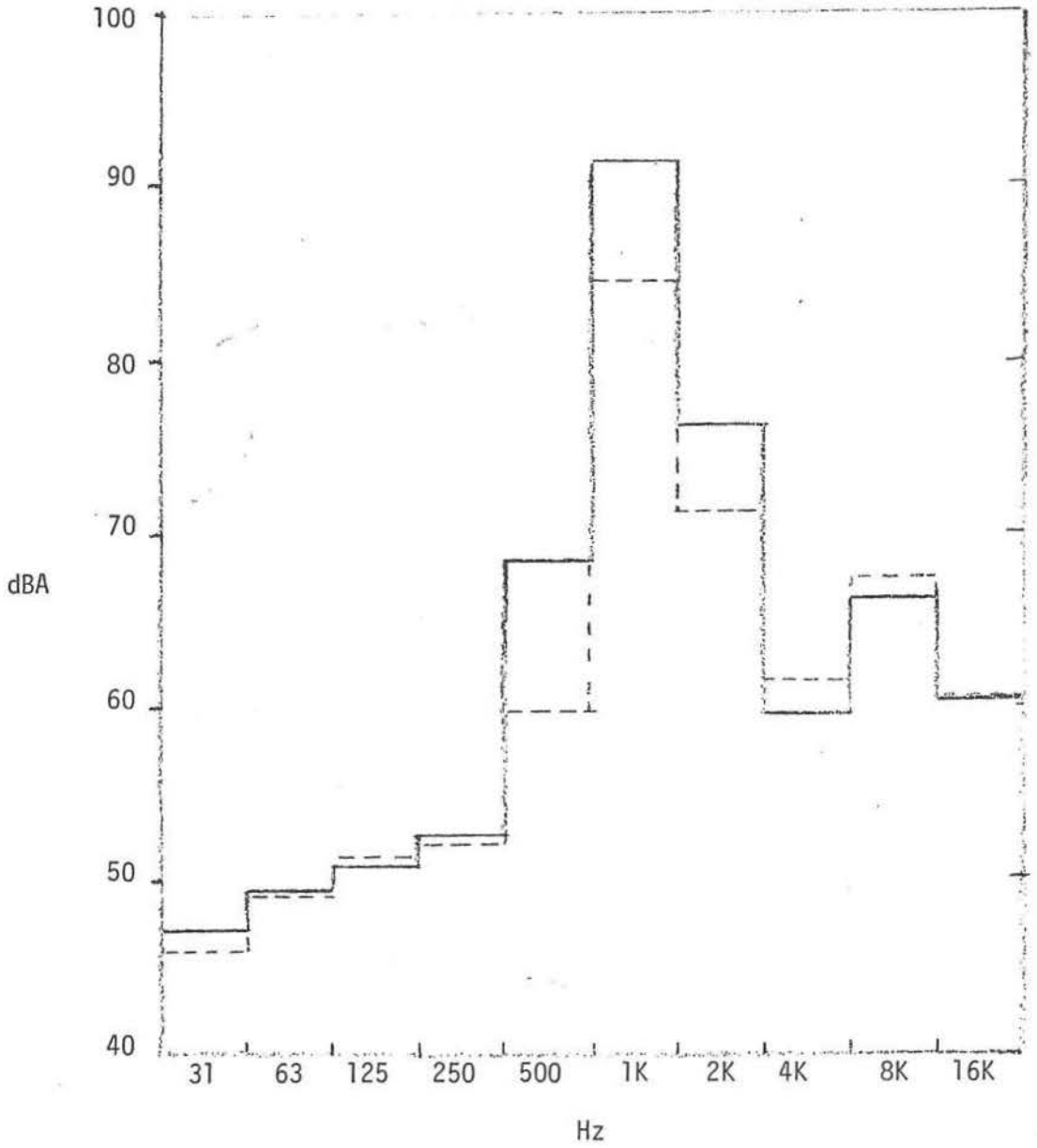


FIGURE 7. SPECTRAL DISTRIBUTION DATA
ROOF SIREN - DRIVER COMPARTMENT



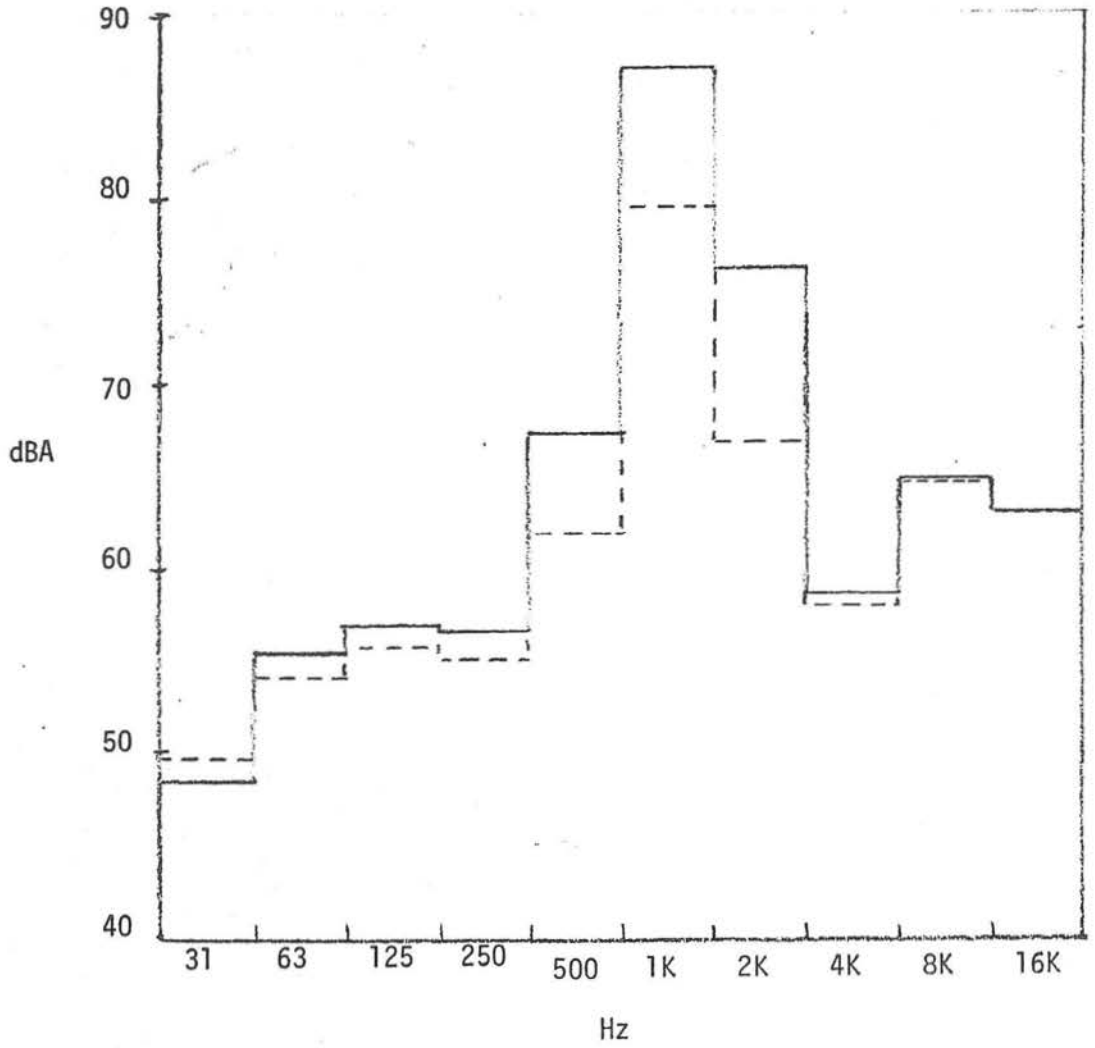
Hz	Windows Open dBA	Windows Closed dBA
31	49.2	50.0
63	53.5	52.6
125	57.9	56.2
250	57.3	55.9
500	86.0	75.5
1K	108.8	96.1
2K	96.8	82.8
4K	74.1	67.6
8K	63.7	64.6
16K	62.2	60.1
Overall	109.1	96.3

FIGURE 8. SPECTRAL DISTRIBUTION DATA
ROOF SIREN - PATIENT COMPARTMENT



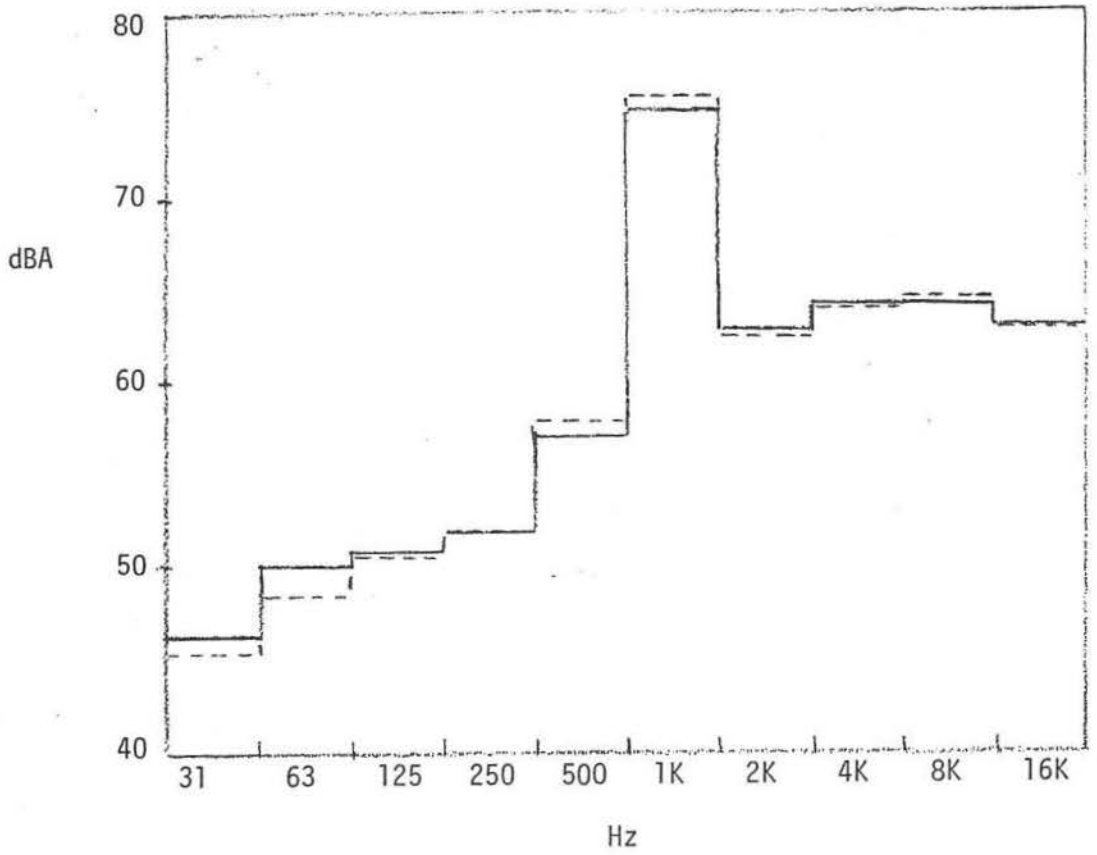
Hz	Windows Open dBA	Windows Closed dBA
31	47.0	46.2
63	49.2	49.2
125	50.9	51.5
250	52.4	52.2
500	68.2	59.9
1K	91.1	84.2
2K	76.2	71.1
4K	59.4	61.6
8K	66.3	67.6
16K	60.1	60.2
Overall	91.2	84.3

FIGURE 9. SPECTRAL DISTRIBUTION DATA
GRILLE SIREN - DRIVER COMPARTMENT



Hz	Windows Open dBA	Windows Closed dBA
31	48.7	49.6
63	55.4	53.9
125	57.0	55.5
250	56.8	54.9
500	67.2	61.9
1K	86.9	79.5
2K	76.2	66.7
4K	58.8	57.7
8K	65.1	64.5
16K	63.0	63.0
Overall	87.1	80.0

FIGURE 10. SPECTRAL DISTRIBUTION DATA
GRILLE SIREN - PATIENT COMPARTMENT



Hz	Windows Open dBA	Windows Closed dBA
31	46.2	45.2
63	50.0	48.2
125	50.9	50.6
250	51.9	52.2
500	57.2	58.2
1K	74.9	75.8
2K	62.7	62.4
4K	64.3	64.2
8K	64.4	64.9
16K	63.1	63.1
Overall	75.9	76.8