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Acoustic Directivity Patterns for Army Weapons: Supplement 3—The Bradley Fighting Vehicle

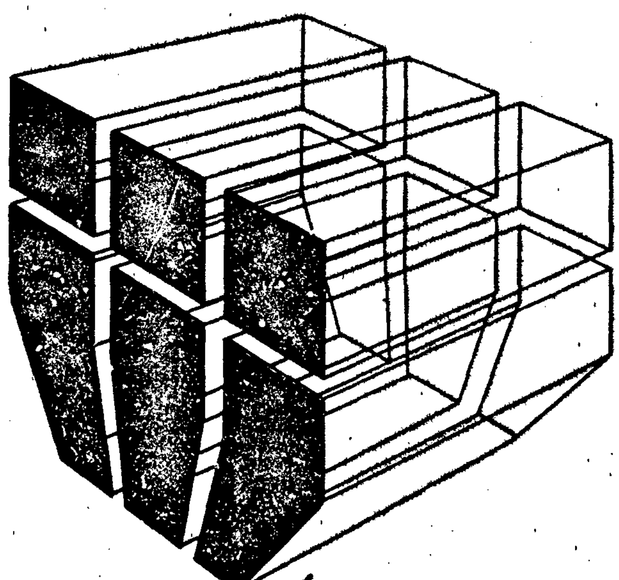
by
Paul D. Schomer
Steven G. Goebel

Environmental noise emissions of the Bradley Fighting Vehicle (BFV) main gun were measured in order to develop acoustic directivity patterns. Data were also gathered on the vehicle noise for future vehicle noise prediction.

The tests were made at Aberdeen Proving Ground, MD, on the M3 Cavalry Fighting Vehicle, CPT 406, and the following gun and ammunitions:

- 25 mm, M242 Main BFV weapon
- 25 mm, M791 APDS-T (Armor Piercing Discarding Sabot—Traced)
- 25 mm, M792, HEI-T (High Explosive Incendiary—Traced)
- 25 mm, M793, TP-T (Target Practice-Traced)

These data supplement the pattern data presented in USA-CERL Technical Report N-60. They have been included in the weapon directivity load module of BNOISE 3.2 and made available to users of the Integrated Noise Contour System (INCS).



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The tests were made at Aberdeen Proving Ground, MD, on the M3 Cavalry Fighting Vehicle, CPT 406, and the following gun and ammunitions:

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FOREWORD

This effort was initiated and funded by the Bradley Project Managers Office, the Tank Automotive Command (TACOM), Warren, Michigan, under Intra Army Order No. FVS 9-84, dated June 1984. The TACOM Technical Monitor was Jacques Pierre-Louis.

The work was performed by the Environmental Division (EN) of USA-CERL. The Principal Investigator was Paul D. Schomer, USA-CERL-EN.

Dr. R. K. Jain is Chief of USA-CERL-EN. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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ACOUSTIC DIRECTIVITY PATTERNS FOR ARMY WEAPONS: SUPPLEMENT 3—THE BRADLEY FIGHTING VEHICLE

1 INTRODUCTION

Background

On 20 May 1981, the Army instituted the Installation Compatible Use Zone program (ICUZ). Under ICUZ, an Army installation works with the local civilian community to find ways to prevent or lessen the encroachment of off-installation housing and other noise-sensitive land uses into areas that are, or are likely to be, impacted by Army training noise.[1]

Vital to the success of the ICUZ program is a noise-prediction computer tool developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL). The Integrated Noise Contour System (INCS) creates noise contours using data on the type, frequency, and time of training operations; weapon types and charge sizes; and target and firing point locations. These contours portray the yearly average total noise emissions of an installation. When overlayed on a map of an installation and its environs, these contours identify existing or potential conflicts between noise levels produced by training operations and noise-sensitive land uses on or near an installation. Using BNOISE 3.2, the blast noise prediction computer program associated with INCS, contours also can be created that predict how changes in training range operations, siting, use intensity, and weapon types will alter an installation's noise-impact profile.[2] The Army Environmental Hygiene Agency (AEHA) can make noise predictions for any Army installation using USA-CERL's INCS/BNOISE 3.2 program.

Contours predict tot yearly average noise emissions of an installation. Whether a noise problem exists, however, depends on numerous factors such as proximity of noise-sensitive land uses to range areas, weapon type, frequencies of operations, and time of day. For this reason, no "acceptable" or "excessive" levels have been defined for specific weapons. Nevertheless, one important data type needed for INCS/BNOISE 3.2 is the individual acoustic directivity pattern associated with each impulse-noise producing weapon in the Army inventory. These patterns form a standard module of data for the INCS/BNOISE 3.2 prediction program.

USA-CERL Technical Report (TR) N-60 lists directivity pattern data obtained during tests at Fort Sill, OK, for many weapons used routinely in Army training.[3] Supplements 1 and 2 to TR N-60 contain directivity pattern data for the LAW and TOW antitank weapons, three regularly used weapon simulators, and the proposed Abrams Tank (M1-E1) 120-mm main gun.

Purpose

The purpose of this study was to determine the acoustic directivity pattern of Bradley Fighting Vehicle 25-mm M242 main gun, and to measure the vehicle noise emissions.

Approach

Noise measurements were made on the 25-mm M242 gun at Aberdeen Proving Ground, MD. The measurement method was basically the same as that described in USA-CERL TR N-60. Weapon firings were interspersed with detonations of C-4 plastic explosive. The C-4 was used to "calibrate" the site and provide for correcting the data for wind and terrain effects.

Mode of Technology Transfer

The directivity patterns obtained from this study have been added to the INCS/BNOISE 3.2 input data bank and are available for use by AEHA and all Department of Defense activities.

2 DATA COLLECTION

Measurements were performed at Aberdeen Proving Ground (APG), MD as part of an ongoing test at that facility. The test site was in the

[1] Paul D. Schomer, "Noise Impact Prediction and Control," *Military Engineer*, Volume 74, Number 479 (April 1982).

[2] Paul D. Schomer, et al., *Blast Noise Prediction Volume I: Data Bases and Computational Procedures*, and Lincoln M. Little, et al., *Volume II: BNOISE 3.2 Computer Program Description and Program Listing*, Technical Report N-98/ADA099440 and ADA099335 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], 1981).

[3] P. D. Schomer, L. M. Little, and A. B. Hunt, *Acoustic Directivity Patterns for Army Weapons*, Technical Report N-60/ADA066223 (USA-CERL 1979).

Edgewood Area on an open, grassy field. Figure 1 shows the general test area and Figure 2 shows the detailed test site layout. There were two concentric rings of sensors; the inner ring had a radius of 250 yards (228.6 m) and the outer ring (except for stations 8 and 12 as noted on Figure 2) had a radius of 500 yards (457.2 m). The inner ring was entirely on the grassy field with no nearby reflecting objects. On the outer ring, sites 11 and 12 were adjacent to a tree line. The measurements were made early July 1984 when there was full foliage.

The microphones on the inner ring were Endevco piezoresistive tranducers close-coupled to USA-CERL-built preamplifiers and line drivers. (Appendix B of Supplement 1 describes the Endevco device and the USA-CERL preamplifiers.) Each microphone was wired to the USA-CERL mobile field acoustics laboratory, where the signal was recorded on an Ampex PR2230 14-channel FM recorder.

The outer ring consisted of a variety of equipment. Sites 8 through 12 each had a B&K 4921 outdoor microphone, a USA-CERL "Blue-Box" noise monitor,[4] and a Nagra DJ tape recorder. Sites 8 and 12 were operated over a long cable by personnel at sites 9 and 11, respectively. USA-CERL line drivers were used to vary amplifier gain for these two remote stations. Site 7 had a B&K 4921 microphone system connected over a long line to the van and its PR2230 FM tape recorder. USA-

[4] Aaron Averbuch, et al., *True-Integrating Environmental Noise Monitor and Sound-Exposure Level Meter*, Volumes I through IV, Technical report N-41, ADA050958, ADA072002, ADA083320, and ADA083321 (USA-CERL, 1978, 1979, and 1980).

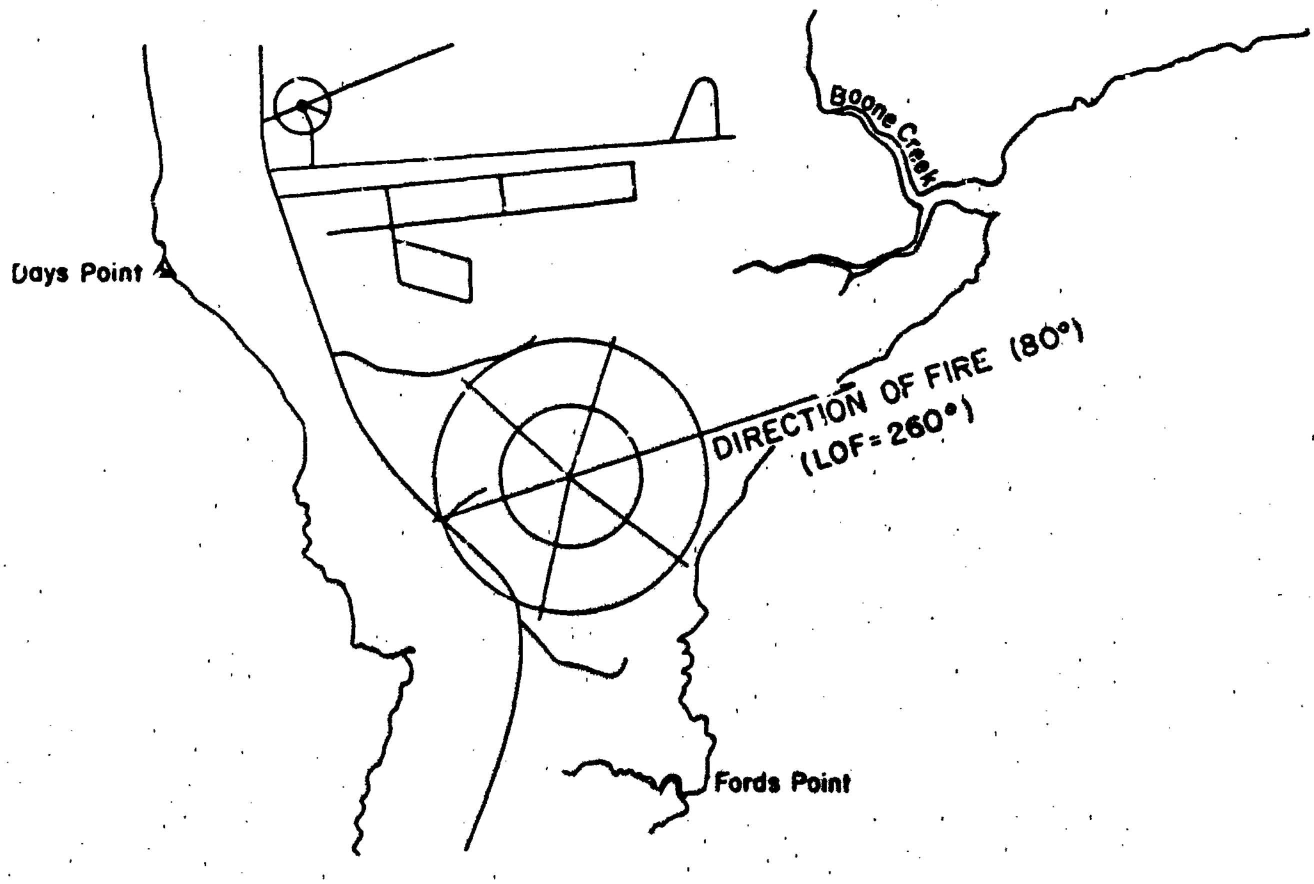

Figure 1. General site layout for noise measurements of the Bradley Fighting Vehicle 25-mm M242 main gun, Edgewood Area, APG, MD, July 1984.

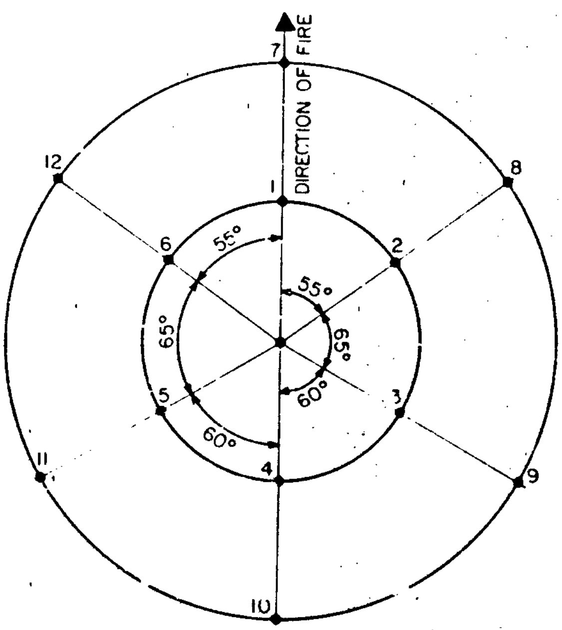

Figure 2. Microphone layout, Edgewood Area, APG, MD, July 1984.

CERL Blue-Box noise monitors were also used in the van for immediate data checking and readout.

Calibration

Calibration was done (1) at the beginning and end of each tape and/or testing period, (2) when the equipment or equipment placement was changed, and (3) when any equipment malfunction was suspected. The six Endevco stations were calibrated with a B&K 4420 pistonphone. USA-CERL constructed special housings for the Endevco microphones so calibration could be performed using standard laboratory and field devices. At the beginning of each FM tape, the calibration tone was recorded for about 15 seconds at the measurement tape speed of 30 in./second (762 mm/second). The B&K 4921 microphone system was calibrated initially using the B&K-type 4220 pistonphone. Subsequent calibrations were performed using its internal 1000-Hz electrostatic actuator.

Test Sequence

Three types of ammunition for the 25-mm gun were measured:

- Cartridge, 25 mm Armor Piercing Discarding Sabot-Traced (APDS-T), M791
- Cartridge, 25 mm High Explosive Incendiary-Traced (HEI-T), M792
- Cartridge, 25 mm Target Practice-Traced (TP-T), M793.

Table 1 lists the test sequence for these rounds and the C-4 calibration shots. The test sequence generally consisted of two or more C-4 shots followed by two or more rounds of the shell under test. This is essentially the same procedure used during the original Fort Sill measurements and the measurements described in Supplements 1 and 2.

3 DATA REDUCTION

Primary data reduction was done using the USA-CERL-developed True-Integrating Environmental Noise Monitor and Sound-Exposure Level Meter. This data reduction resulted in a measure of the C-weighted sound exposure level (CSEL). The Data 6000 computing oscilloscope was used to remeasure C-weighted data for each gun round at sites 1, 2, 6, 7, and 11. These were the sites that also received a shell-generated ballistic wave. The Data 6000 was used to separate muzzle blast data from the ballistic wave data. Background noise was also measured to

Table 1
Firing Sequence at Edgewood Area, APG, July 1984

Event(s)	Type
1,2	C-4
3 9	TP-T
10,11	C-4
12 21	TP-T
22,23	C-4
24 33	TP-T
34 36	C-4
37 47	HEI-T
48	C-4
49 58	HEI-T
59,60	C-4
61	APDS-T
62,63	C-4
64-77	APDS-T
78,79	C-4

ensure that the recorded data were far enough above the noise level to be valid. Appendix A lists analyzed data by event.

Each series of shell data was first corrected by the adjacent (in-time) C-4 calibration events. A set of numbers was found for the C-4 events just before and after the shell events. The C-4 data were corrected to data for an omnidirectional hemispherical (actually circular in the ground plane) radiating source. The shell data were averaged by microphone and corrected by the set of numbers found to convert the C-4 to a perfect, circular source. These averages are listed in Appendix B. Similar shells (after correction by adjacent C-4 calibration) were then combined (energy-averaged by microphone) to form the overall weapon/device directivity pattern. Corrections were made to form a symmetrical pattern. Appendix B lists the resultant data by weapon/device.

Table 2, which is based on the data given in Appendix B, lists the data as they are included in the BNOISE 3.2 weapons input table. In the table, the reference distance is 250 m (rather than 250 yards). At this distance, 1¼ lb (0.57 kg) of C-4 exploded on the ground typically produces a CSEL of 115 dB.

4 VEHICLE NOISE MEASUREMENTS

Currently, AEHA can include vehicle noise assessments as a part of a general noise assessment as required on a case-by-case basis; the computerized INCS does not include a module for vehicles. In the future a module in INCS will handle vehicle passby noise. With this case-by-case application of AEHA and the future INCS module in mind, passby noise emission data were gathered for the M3 Bradley Cavalry Fighting Vehicle (M3 CFV). Although this was a cavalry fighting vehicle, the infantry fighting vehicle has the same engine and track; differences are in space for personnel and materials. Thus the noise produced by either is about the same and can be thought of as interchangeable for environmental noise purposes.

The test site was an open, grassy field bisected by an approximately straight tar and gravel road (Figure 3). Four microphones were located in a line perpendicular to the road, two on each side at distances of 50 and 100 ft (15.2 and 30.5 m). The test zone was a straight line segment of the road extending 900 ft (274.3 m) to either side of the line of microphones. The Bradley Fighting Vehicle maintained one of three constant speeds within this zone: low, medium, and high speed (approximately 15, 25, and 35 miles per hour, respectively). As shown in Figure 3, an additional half mile of road was used beyond either end of the test zone for the vehicle to decelerate, turn around and accelerate for the next test. These long stretches for deceleration and acceleration assured constant speed during the vehicle's passby in the test zone.

Two USA-CERL operators ran the measurement equipment; one near each of the 100 ft (30.5 m) microphones. Cables connected their equipment to

Table 2
Report Data for BNOISE 3.2

		Position (degrees)												
		0	30	60*	90	120	150	180	210	240	270	300	330	AVE
TP-T	Value	103.8	102.2	100.6	98.4	96.3	96.6	96.7	96.6	96.3	98.4	100.6	192.2	99.9
	Value re rear of gun	7.1	5.5	3.9	1.7	−0.4	−0.1	0.0	−0.1	−0.4	1.7	3.9	5.5	3.2
HEI-T	Value	104.2	102.4	100.5	98.6	97.0	96.7	96.3	96.7	97.0	98.6	100.5	102.4	100.1
	Value re rear of gun	7.9	6.1	4.2	2.3	0.7	0.4	0.0	0.4	0.7	2.3	4.2	6.1	3.8
APDS-T	Value	104.1	102.8	101.5	99.5	97.9	97.7	97.5	97.7	97.9	99.5	101.5	102.8	100.7
	Value re rear of gun	6.6	5.3	4.0	2.0	0.4	0.2	0.0	0.2	0.4	2.0	4.0	5.3	3.2

* Value altered from the 55° measurement position to the 60° standard position.

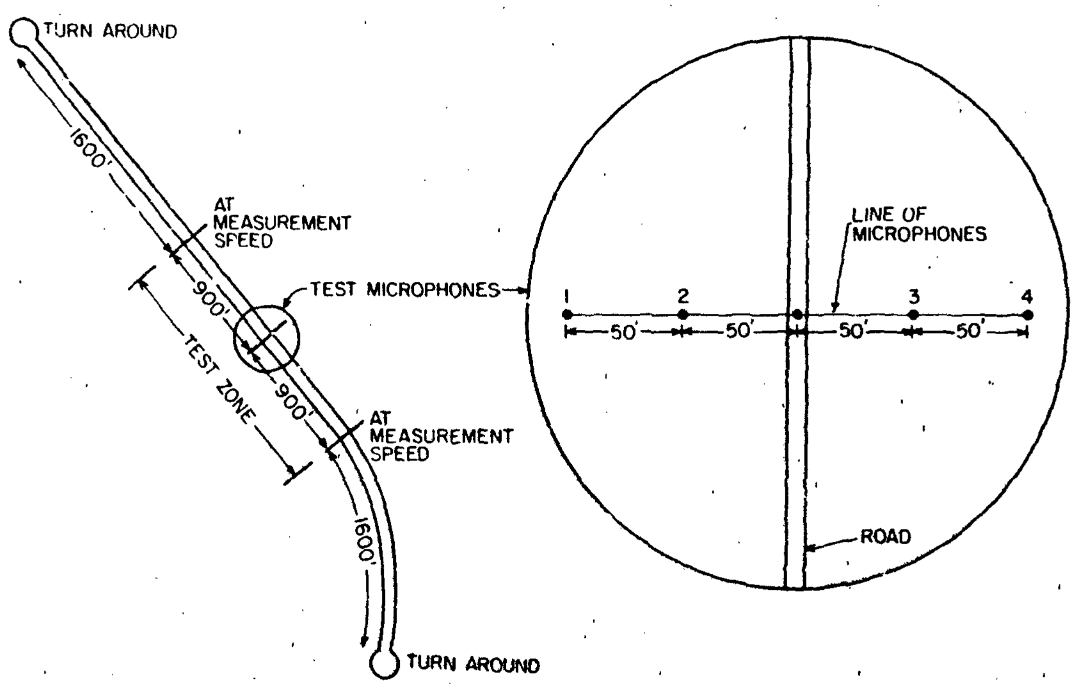

Figure 3. General site and microphone layout for passby noise measurements of the M3/CFV, Edgewood Area, APG, MD, July 1984.

the adjacent 50 ft (15.2 m) microphones. The equipment for this measurement consisted of a USA-CERL "blue box" noise monitor and a Nagra DJ tape recorder, both connected to a B&K type 4921 outdoor microphone system. Calibration was performed (1) at the beginning and end of each tape and/or testing period, and (2) when the equipment was changed or equipment malfunction was suspected. The equipment was calibrated using the B&K outdoor microphone's internal 1000 Hz electrostatic actuator.

As indicated above, measurements were made with the vehicle travelling at low, medium and high speeds and with microphones at distances of 50 and 100 ft (15.2 and 30.5 m). Three analyses were performed on the data:

1. The maximum ½-second A-weighted sound level
2. The passby A-weighted sound exposure level (SEL)
3. The flat-weighted spectrum for the maximum ½-second A-weighted sound level.

The A-weighted SELs and maximum levels are shown in Table 3. Figures 4 through 9 show the average (energy) 1/3-octave spectrum at 50 and 100 ft (15.2 and 30.5 m), respectively, for the ½ second during which A-weighted maximum occurred. The field measurements with the "blue box" were performed for most of the time that the vehicle was at

Table 3
Measured Energy Average A-Weight Vehicle, Constant Speed, Passby SEL for the M3/CFV as a Function of Distance and Speed

Distance/Speed (ft)	Low	Moderate	High
50	95.3*	94.5**	97.1*
100	91.3*	90.5**	93.3*

* The average for 10 measurements.

** The average for 8 measurements.

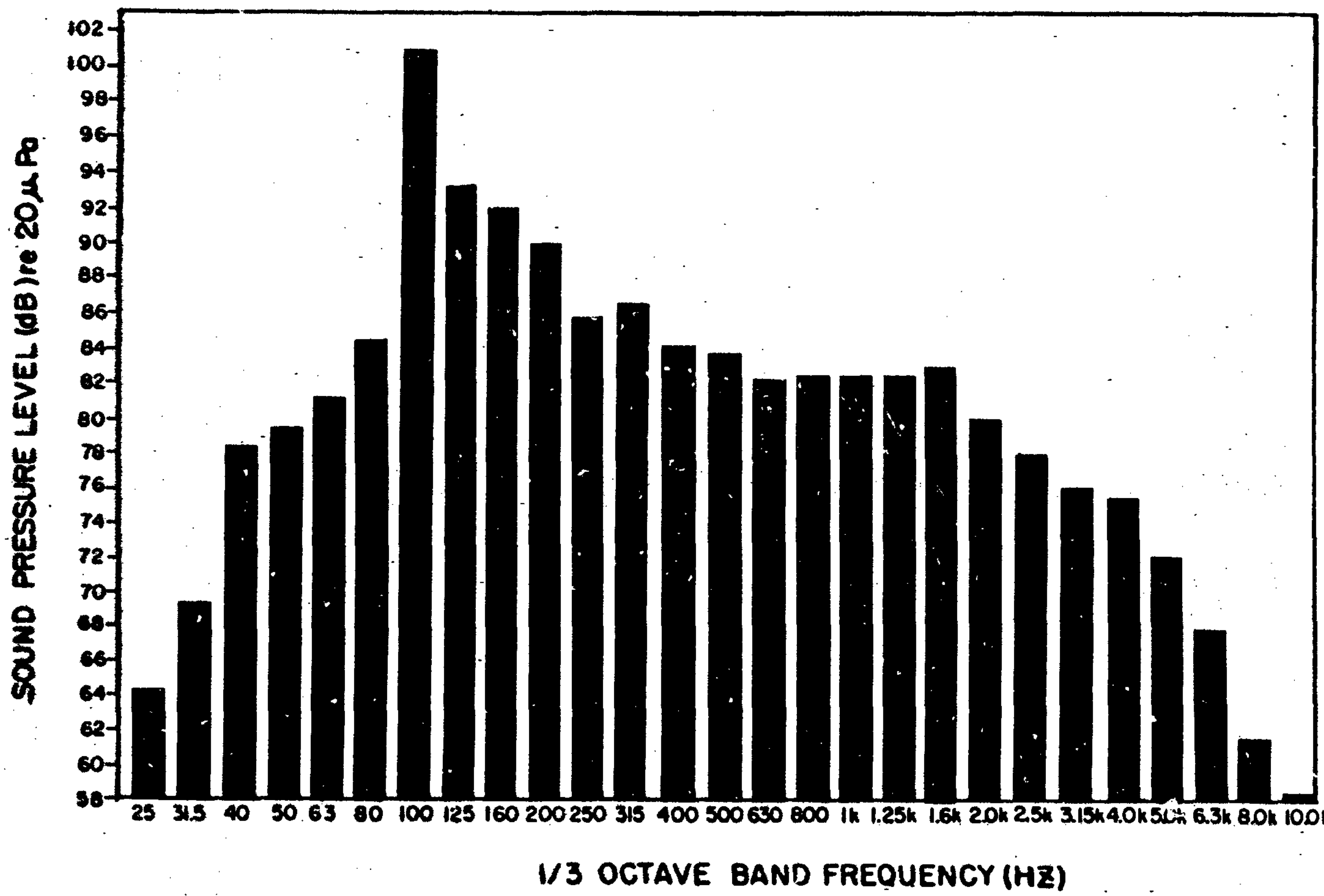

Figure 4. Measured energy—average maximum 1/2 sec, 1/3 octave spectrum for a constant high speed passby of the M3/CFV at 50 ft. The average is for 10 measurements.

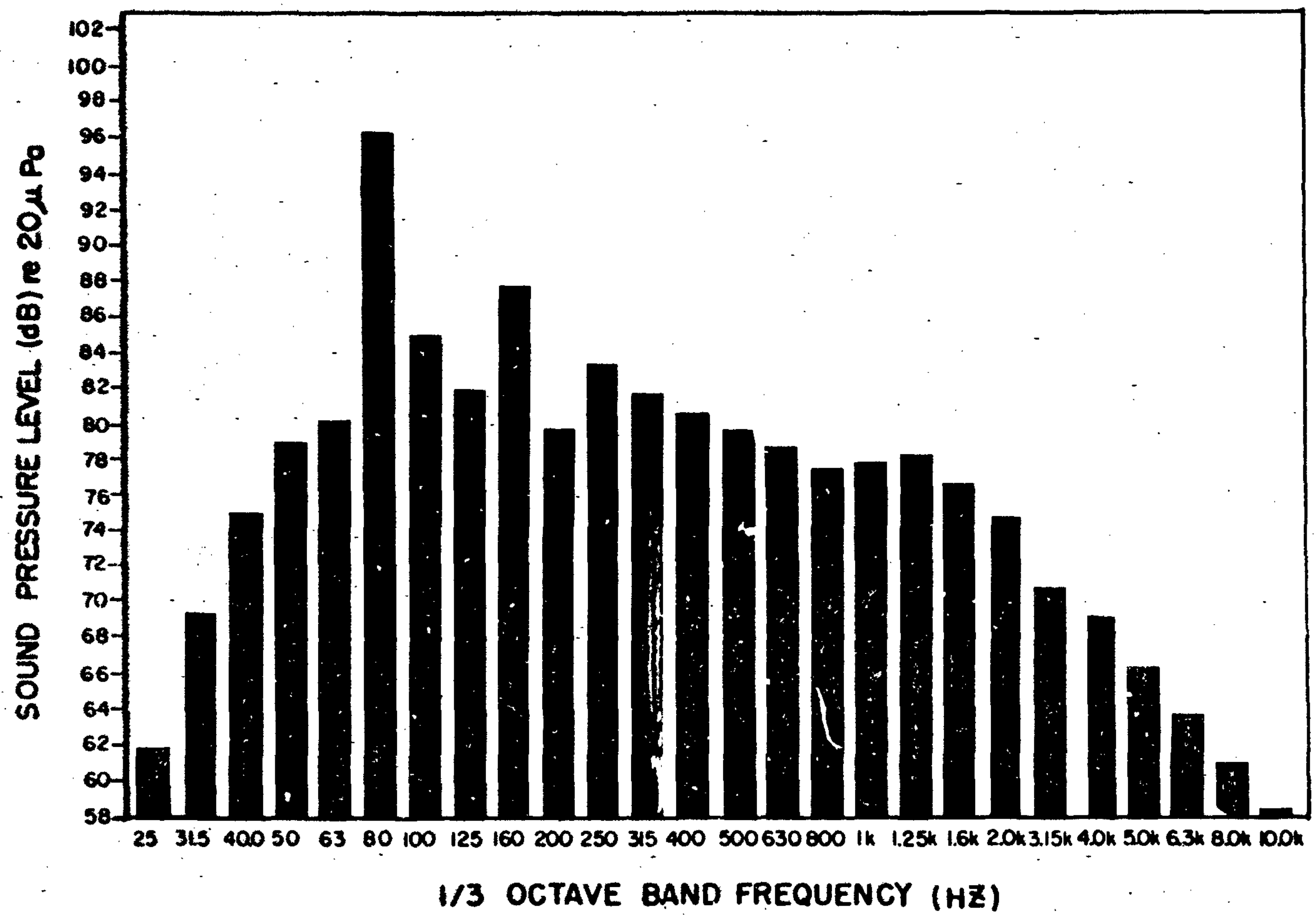

Figure 5. Measured energy—average maximum 1/2 sec, 1/3 octave spectrum for a constant medium speed passby of the M3/CFV at 50 ft. The average is for 8 measurements.

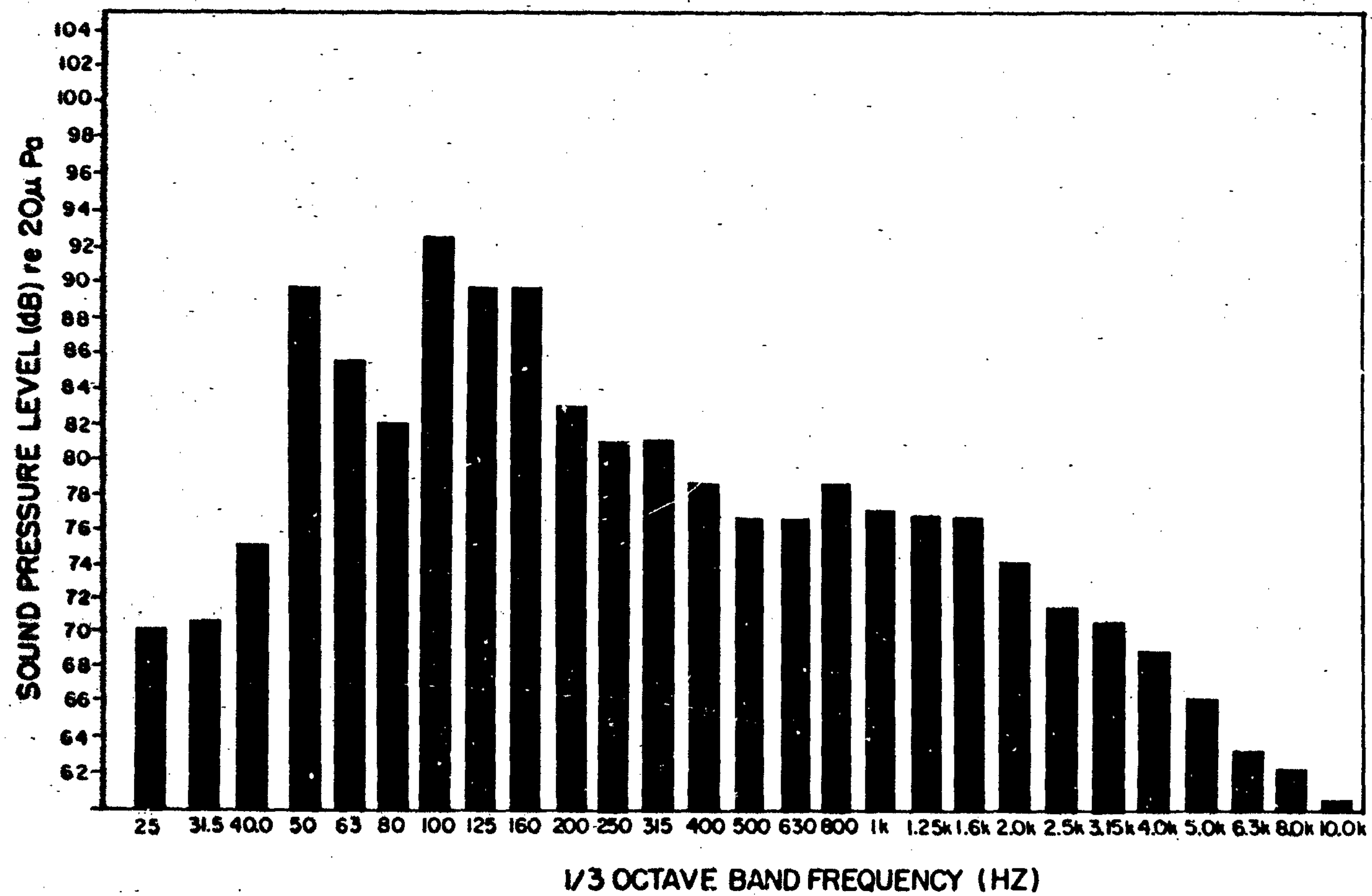

Figure 6. Measured energy—average maximum 1/2 sec, 1/3 octave spectrum for a constant low speed passby of the M3/CFV at 50 ft. The average is for 10 measurements.

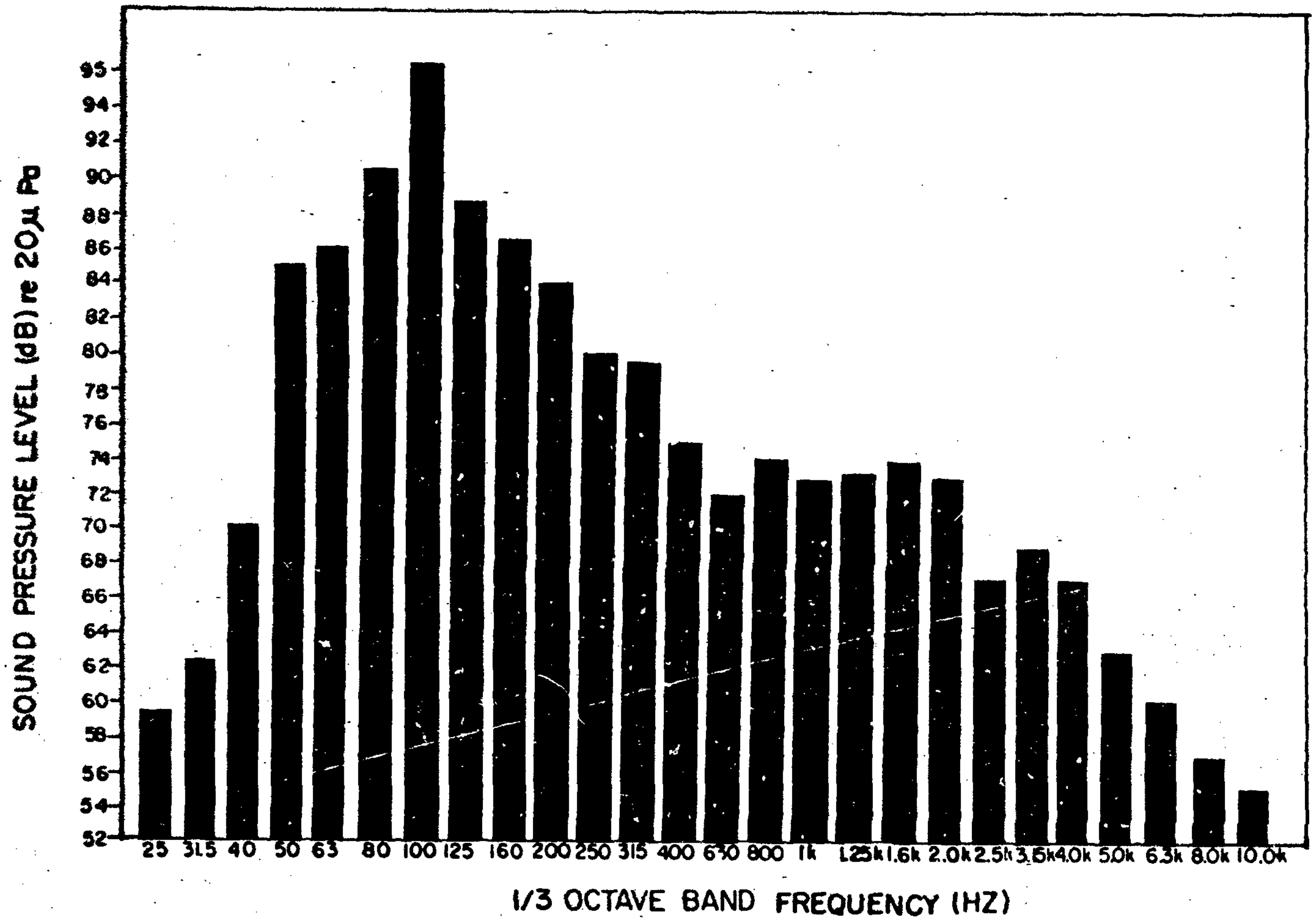

Figure 7. Measured energy—average maximum 1, 2 sec, 1/3 octave spectrum for a constant high speed passby of the M3, CFV at 100 ft. The average is for 10 measurements.

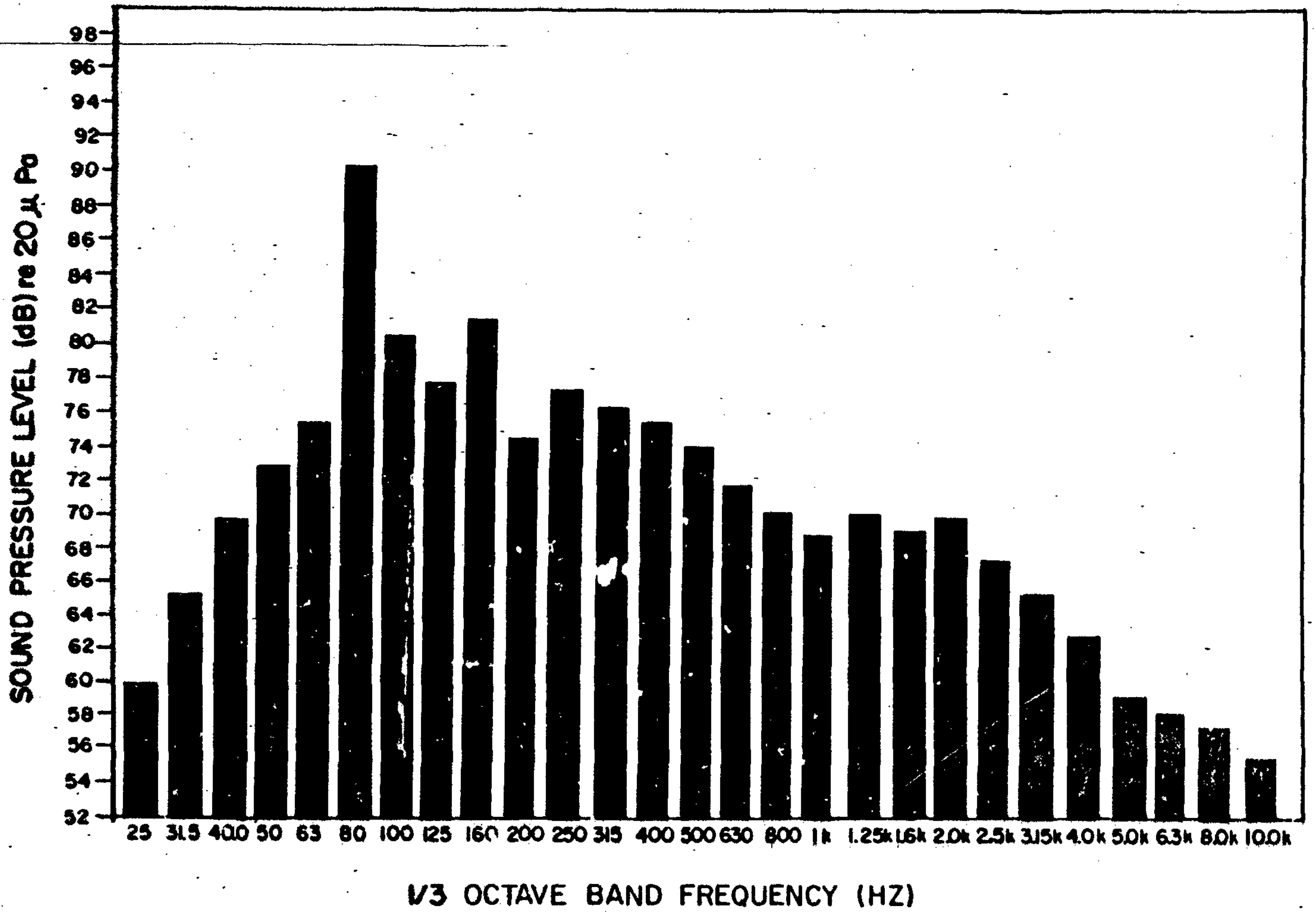

Figure 8. Measured energy—average maximum 1/2 sec, 1/3 octave spectrum for a constant medium speed passby of the M3/CFV at 100 ft. The average is for 8 measurements.

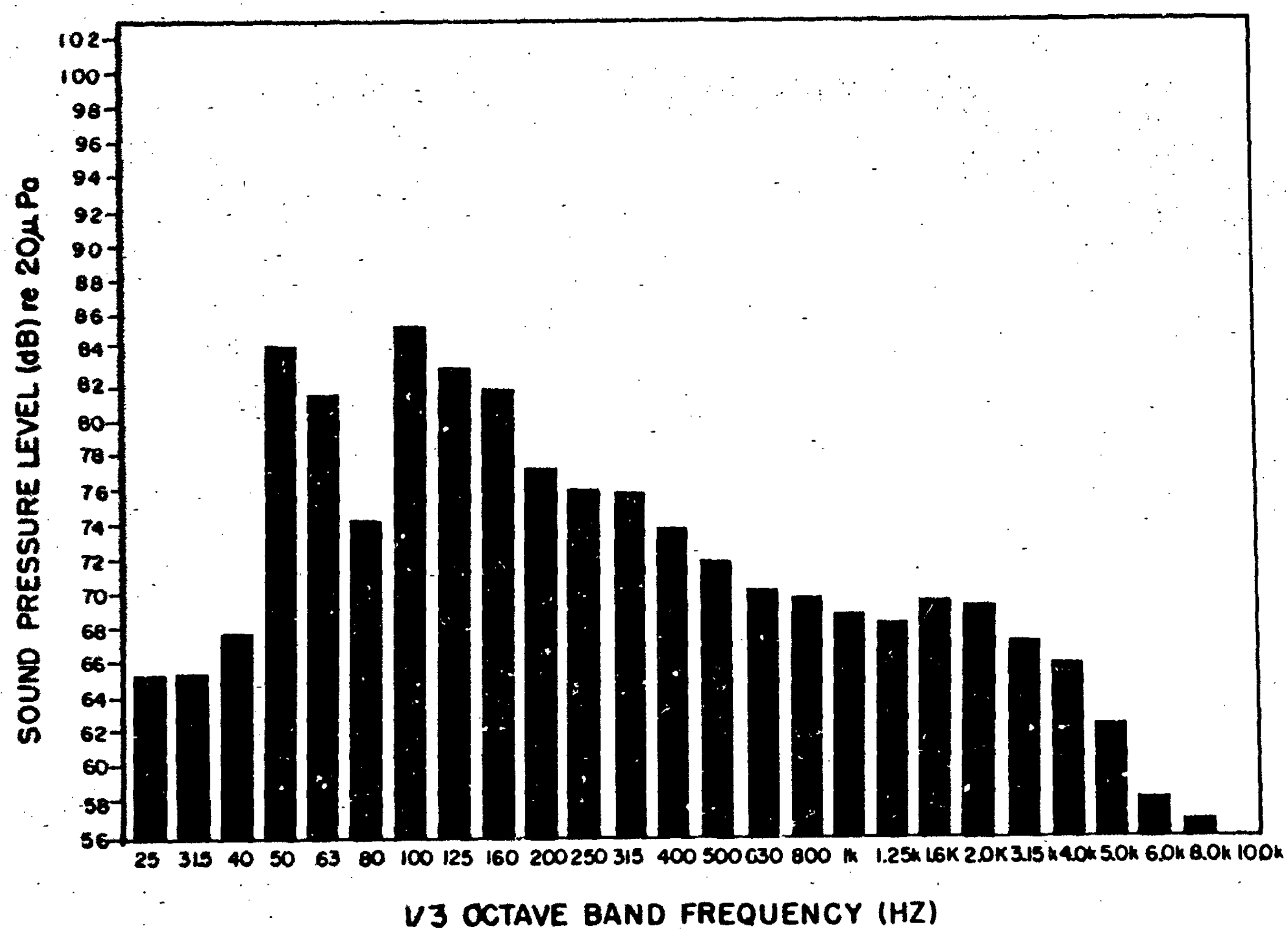

Figure 9. Measured energy—average maximum 1/2 sec, 1/3 octave spectrum for a constant low speed passby of the M3/CFV at 100 ft. The average is for 10 measurements.

constant speed in the measurement zone. Typically this was 10 to 20 seconds. Analysis of the tape recordings showed that the 10-dB-down interval was more like 5 seconds, so the "blue box" data encompass all of the energy of interest. Differences between the field readings and the readings taken from the tape recorders using just the 10-dB-down interval were very small: 0.1 to 0.2 dB.

In the future these data will be sufficient to predict SEL versus distance curves for the carrier as needed by AEHA or as part of a new noise assessment module in INCS.

5 CONCLUSIONS

This report gives the acoustic directivity patterns for the Bradley Fighting Vehicle 25-mm, M242 main gun. These data supplement the pattern data presented in USA-CERL Technical Report N-60. These supplemental pattern data have been included in the weapon directivity pattern load module of BNOISE 3.2 and made available to users of the Integrated Noise Contour System. The vehicle noise emissions were also gathered for future use.

APPENDIX A:

ANALYZED C-WEIGHTED SEL DATA BY EVENT

Bradley Fighting Vehicle 25-mm, M242 Main Gun, Aberdeen Proving Ground

Event		Station 1	Station 3	Station 4	Station 5	Station 6	Station 8	Station 9	Station 10	Station 11	Station 12
1.	C4	113.9			—		106.5	108.9	105.3	113.0	109.8
2.	C4	114.9	113.1	115.5	118.4	114.8	108.3	109.0	112.1	113.3	105.9
3.	TP-T	105.0	96.1	99.6	100.8	103.5	95.2	83.5	88.9	93.4	92.8
4.	TP-T	104.4	95.0	98.0	98.6	102.6	95.8	81.4	86.1	98.1	94.6
5.	TP-T	103.9	96.7	98.0	99.5	102.3	90.0	81.1	86.4	95.9	90.9
6.	TP-T	105.2	94.0	98.0	98.7	101.8	90.2	81.2	88.3	94.9	91.5
7.	TP-T	104.4	95.4	97.0	99.9	101.8	90.8	81.8	87.3	95.4	89.4
8.	TP-T	104.2	96.2	97.2	99.7	101.6	92.3	83.6	87.8	94.8	91.1
9.	TP-T	105.0	95.9	98.0	100.2	102.0	92.9	83.4	86.7	95.5	91.3
10.	C4	115.0	113.0	115.2	118.9	115.1	108.4	108.7	111.8	113.8	110.5
11.	C4	114.7	112.8	115.3	118.2	114.9	108.6	107.9	111.4	113.6	111.0
12.	TP-T	104.6	96.4	98.0	100.2	101.6	89.6	83.5	89.0	94.9	91.4
13.	TP-T	103.6	95.6	98.0	99.7	101.8	90.8	82.7	87.7	94.6	90.6
14.	TP-T	105.1	96.0	97.8	98.7	102.0	91.1	83.8	87.4	93.9	90.9
15.	TP-T	105.5	95.9	97.4	99.7	101.5	87.9	82.7	86.6	94.4	90.8
16.	TP-T	105.2	95.6	97.5	99.8	102.5	92.9	82.3	86.4	95.2	91.9
17.	TP-T	104.5	96.6	96.9	99.3	102.0	92.9	82.4	86.5	94.6	90.4
18.	TP-T	103.9	96.0	97.9	99.1	102.0	93.4	83.0	88.3	94.2	90.0
19.	TP-T	105.4	96.5	96.9	99.4	102.5	94.2	83.8	87.3	94.5	90.5
20.	TP-T	104.6	96.6	97.9	98.8	102.0	92.0	84.1	87.4	94.4	90.0
21.	TP-T	105.1	96.4	97.7	98.2	101.8	90.9	84.7	87.8	94.3	90.4
22.	C4	116.9	115.3	116.8	119.1	117.1	107.9	108.5	110.8	113.5	105.9
23.	C4	116.6	115.9	116.9	118.5	117.3	109.7	108.4	111.5	113.7	107.8
24.	TP-T	104.4	96.6	97.6	99.1	102.0	92.4	83.8	87.4	93.7	92.5
25.	TP-T	103.4	96.6	97.1	99.4	101.3	91.9	85.1	88.4	94.1	91.5
26	TP-T	104.8	97.2	98.0	99.2	101.1	90.8	85.1	88.2	94.2	91.1
27.	TP-T	104.4	97.5	97.3	99.3	101.7	92.5	85.8	88.7	93.8	89.8
28.	TP-T	104.0	97.4	98.1	99.1	101.1	93.4	85.6	88.0	93.8	90.6
29.	TP-T	105.2	97.6	98.1	98.6	101.3	95.0	[illegible]	88.5	93.3	90.5
30.	TP-T	104.4	97.7	98.6	98.7	101.2	93.0	84.3	89.0	94.6	91.1
31.	TP-T	103.8	97.1	98.1	98.9	101.1	92.7	84.3	90.0	93.8	90.9
32.	TP-T	104.1	97.4	97.6	98.7	100.5	93.0	85.3	88.7	93.7	90.7
33.	TP-T	104.1	97.2	98.0	98.7	101.3	91.7	84.7	88.0	93.7	90.4
34.	C4	116.6	116.0	117.1	118.8	118.4	110.4	108.9	111.3	113.5	--
35.	C4	117.4	116.1	117.1	118.5	117.4	109.7	108.5	111.7	113.8	110.0
36.	C4	117.1	116.2	117.1	118.5	115.8	109.5	108.9	112.2	113.6	109.2
37.	HEI-T	104.0	98.2	98.1	99.2	101.3	95.2		90.4	94.0	92.6
38.	HEI-T	105.5	96.7	98.0	99.8	102.4	93.9	84.5	90.0	94.2	90.4
39.	HEI-T	104.8	97.0	97.7	100.4	102.6	95.0	84.4	89.1	96.0	90.1
40.	HEI-T	105.5	96.4	97.8	100.1	102.4	95.6	84.3	88.2	95.0	89.4
41.	HEI-T	104.4	97.2	97.7	100.1	102.5	95.8	86.0	88.1	94.1	89.1
42.	HEI-T	104.8	97.8	97.7	99.2	101.2	92.4	85.7	88.6	94.0	89.6
43.	HEI-T	101.5	97.3	97.4	99.8	102.0	91.3	84.9	88.0	92.0	89.7
44.	HEI-T	104.8	97.8	97.7	98.9	101.7	93.7	85.1	89.6	94.5	90.6
45.	HEI-T	104.1	97.7	98.4	99.1	100.8	93.3	86.1	89.0	94.0	91.1
46.	HEI-T	104.1	97.7	97.6	100.3	102.7	92.9	86.2	89.5	94.6	93.7
47.	HEI-T	104.3	98.2	97.9	100.3	101.7	94.8	85.9	90.2	95.3	93.7
48.	C4	113.9	114.7	115.4	116.5	115.4	104.6	106.8	108.4	111.9	108.8
49.	HEI-T	104.7	97.0	97.8	99.5	102.2	93.8	84.5	90.7	93.9	94.6
50.	HEI-T	104.9	97.2	97.8	99.8	102.0	94.3	84.4	88.3	94.6	94.2
51.	HEI-T	104.4	97.0	97.9	99.3	102.4	93.9	85.2	89.0	93.9	94.4
52.	HEI-T	104.7	97.2	97.5	100.0	102.4	93.1	84.7	87.9	95.3	94.7
53.	HEI-T	104.5	97.0	97.5	99.7	102.2	95.1	85.0	88.4	94.5	94.2

Event		Station 1	Station 3	Station 4	Station 5	Station 6	Station 8	Station 9	Station 10	Station 11	Station 12
54.	HEI-T	105.3	97.2	97.6	100.2	102.6	93.8	85.2	88.2	95.8	94.5
55.	HEI-T	104.9	97.6	97.5	99.8	102.1	94.4	85.1	89.1	95.2	93.6
56.	HEI-T	105.5	96.5	97.8	99.6	102.9	95.6	84.6	88.5	95.1	94.8
57.	HEI-T	105.3	97.0	96.8	99.8	102.7	95.4	85.7	87.8	94.6	94.6
58.	HEI-T	104.8	97.1	97.9	99.5	102.8	95.0	85.1	89.7	94.9	95.4
59.	C4	116.6	116.9	117.5	118.5	117.0	108.5	109.6	111.9	113.5	110.0
60.	C4	116.6	116.6	117.2	118.2	116.8	108.7	109.3	112.7	113.7	110.1
61.	APDS-T	106.8	99.0	99.6	101.2	104.0	97.2	89.3	90.4	96.5	95.9
62.	C4	116.1	116.6	117.2	118.2	116.6	110.2	108.8	111.8	113.2	109.9
63.	C4	116.7	116.7	117.3	118.2	116.5	108.6	109.3	111.9	113.8	110.2
64.	APDS-T	106.0	99.0	99.9	101.6	104.3	95.8	88.2	90.9	96.7	96.6
65.	APDS-T	105.7	99.0	99.9	101.6	104.3	97.1	88.0	90.3	95.6	95.2
66.	APDS-T	105.7	99.2	99.0	101.3	103.3	96.7	87.4	92.0	95.8	95.2
67.	APDS-T	105.5	98.9	99.0	101.5	103.8	95.7	87.4	90.6	95.7	95.6
68.	APDS-T	106.4	99.3	99.6	100.4	103.6	95.3	89.5	91.2	95.9	95.8
69.	APDS-T	105.5	100.1	99.5	100.8	103.6	95.7	88.3	91.4	95.7	96.9
70.	APDS-T	105.9	99.3	99.3	100.9	103.6	95.5	89.0	91.6	96.5	95.3
71.	APDS-T	105.6	99.3	100.3	101.4	103.3	94.0	87.4	90.5	96.9	95.8
72.	APDS-T	105.2	99.3	99.5	101.3	103.4	93.9	87.1	90.9	96.1	95.8
73.	APDS-T	105.9	99.0	99.4	101.4	103.5	95.1	88.0	91.0	96.0	95.2
74.	APDS-T	104.9	98.8	99.2	101.1	103.4	97.1	86.8	91.9	97.0	96.6
75.	APDS-T	106.0	98.8	99.7	101.5	104.1	94.9	87.5	90.7	98.2	96.7
76.	APDS-T	105.7	98.9	100.1	102.2	104.0	96.1	87.3	90.1	97.1	96.8
77.	APDS-T	104.9	99.3	99.9	101.7	105.1	96.5	87.3	91.8	97.8	96.4
78.	C4	116.3	115.1	116.4	118.4	—	107.7	108.5	112.3	113.6	111.1
79.	C4	116.8	116.0	117.1	112.8	117.1	109.3	108.4	111.2	113.7	110.9

APPENDIX B: DATA CALCULATIONS

Table B1 contains energy averages by microphone of like sources. For example, C1 is for the first set of C-4 charges, events 1 and 2. Event 61, an AP round, was averaged with events 64-77 which were APDS-T rounds. The raw data are taken from Appendix A. Stations two and seven did not function properly so these data are omitted from Appendix A.

Table B2 contains the energy average of consecutive C-4 groups. For example, C12 is the average of groups C1 and C2 from Table B1. These data are used to form Table B3 and correct the data, S_i, for site factors such as wind which cause the sound propagation for a blast to depart from omnidirectional spherical spreading.

Table B3 contains the corrections to be subtracted from corresponding shell data. In each case, CR i, i+1 is used to correct S_i. For example CR 4,5 is used to correct S_4. For example, the first row, first column entry is —0.3 which is (114.7 — 115.0). Thus, in each case, the real entry is the difference between the data entry in Table B2 and 115.0 dB, where 115.0 dB is the standard value for 1¼ lb of C-4 set off on a 3-ft (0.9 m) post at a distance of 250 m.[5] Because of the small gun size, 1¼ lb of C-4 was used instead of the standard 5 lb.

Table B4 contains the S values from Table B1 corrected by the corresponding CR values in Table B3. This table also contains the energy average for all the ammunition rounds.

Table B5 contains the ammunition data, averaged to be symmetrical. That is, position 3 is averaged with position 5. (Positions 1, 4 and 6 have no counterparts.)

Table B6 contains the data for the BNOISE 3.2 input. First, the data from Table B5 are extrapolated to fill every 30 degree position (rows 1 and 3 in

[5] *Blast Noise Prediction Volume I: Data Bases and Computational Procedures*, p. 41, Figure 16.

Table B6). Second, the value for the rear of the gun (180 degrees) is subtracted from every value (rows 2 and 4 in Table 36). In Table B6, the AVE values come from the energy average of each row.

Tables B7 and B8 show calculated noise differences between the inner and outer rings of microphones and averages based on these values, respectively.

Table B1
Average of Events by Grouping and Position

		Measurement Position									
Event(s)		1	3	4	5	6	8*	9*	10*	11*	12*
1,2	C1	144.4	113.1	115.5	118.4	114.8	107.5	109.0	112.1	113.2	108.3
3 9	S1	104.6	95.7	98.0	99.7	102.3	93.0	82.4	87.5	95.6	91.9
10,11	C2	114.9	112.9	115.3	118.6	115.0	108.5	108.3	111.6	113.7	110.8
12 21	S2	104.8	96.2	97.6	99.3	102.0	91.9	83.4	87.5	94.5	90.7
22,23	C3	116.8	115.6	116.9	118.8	117.2	108.9	108.5	111.2	113.6	107.0
24 33	S3	104.3	97.2	97.9	99.0	101.3	92.8	85.1	88.5	93.9	91.0
34 36	C4	117.0	116.1	117.1	118.6	117.3	109.9	108.8	111.7	113.6	109.6
37 47	S4	104.5	97.5	97.8	99.8	102.0	94.2	85.4	89.2	94.4	91.2
48	C5	113.9	114.7	115.4	116.5	115.4	104.6	106.8	108.4	111.9	108.8
49 58	S5	104.9	97.1	97.6	99.7	102.4	94.5	85.0	88.9	94.8	94.5
59,60,62,63	C6	116.5	116.7	117.3	118.3	116.7	109.1	109.3	112.1	113.6	110.1
61,64 77	S6	105.7	99.2	99.6	101.3	103.8	95.9	88.0	91.1	96.6	96.0
78,79	C7	116.6	115.6	116.8	118.6	117.1	108.6	108.5	111.8	113.7	111.0

* Outer ring.

Table B2
Average of Consecutive Sets of C-4

	1	3	4	5	6
C12	114.7	113.0	115.4	118.5	114.9
C23	116.0	114.5	116.2	118.7	116.2
C34	116.9	115.9	117.0	118.7	117.3
C45	115.7	115.5	116.3	117.7	116.5
C56	115.4	115.8	116.5	117.5	116.1
C67	116.6	116.2	117.1	118.5	116.9

Table B3
Correction Table to Convert Measured Shell Data to Omnidirectional Site Independent Data re 1¼ lb of C-4 (115 dB at 250 m)

	1	3	4	5	6
CR 1,2	-0.3	-2.0	0.4	3.5	—0.1
CR 2,3	1.0	-0.5	1.2	3.7	1.2
CR 3,4	1.9	0.9	2.0	3.7	2.3
CR 4,5	0.7	0.5	1.3	2.7	1.5
CR 5,6	0.4	0.8	1.5	2.5	1.1
CR 6,7	1.6	1.2	2.1	3.5	1.9

Table B4
Corrected Shell Data by Group and Overall Average for the Ammunition re 1¼ lb of C-4 (115 dB at 250 m)

	1	3	4	5	6
S1	104.9	97.7	97.6	96.2	102.4
S2	103.8	96.7	96.4	95.6	100.8
S3	102.4	96.3	95.9	95.3	99.0
TP-T AVE.	103.3	96.9	96.7	95.7	101.0
S4	103.8	97.0	96.5	97.1	100.5
S5	104.5	96.3	96.1	97.2	101.3
HEI-T AVE.	104.2	96.7	96.3	97.2	100.9
S6	104.1	98.0	97.5	97.8	101.9
APDS-T AVE.	104.1	98.0	97.5	97.8	101.9

Table B5
Ammunition Data Averaged to be Symmetrical re 1¼ lb of C4 (115 dB at 250 m)

	1	2	3	4	5	6
TP-T	103.8	101.0	96.3	96.7	96.3	101.0
HEI-T	104.2	100.9	97.0	96.3	97.0	100.9
APDS-T	104.1	101.9	97.9	97.5	97.9	101.9

Table B6
Report Data for BNOISE 3.2

		Position (degrees)												
		0	30	60*	90	120	150	180	210	240	270	360	330	AVE
TP-T	Value	103.8	102.2	100.6	98.4	96.3	96.6	96.7	96.6	96.3	98.4	100.6	102.2	99.9
	Value re rear of gun	7.1	5.5	3.9	1.7	−0.4	−0.1	0.0	−0.1	−0.4	1.7	3.9	5.5	3.2
HEI-T	Value	104.2	102.4	100.5	98.6	97.0	96.7	96.3	96.7	97.0	98.6	100.5	102.4	100.1
	Value re rear of gun	7.9	6.1	4.2	2.3	0.7	0.4	0.0	0.4	0.7	2.3	4.2	6.1	3.8
APDS-T	Value	104.1	102.8	101.5	99.5	97.9	97.7	97.5	97.7	97.9	99.5	101.5	102.8	100.7
	Value re rear of gun	6.6	5.3	4.0	2.0	0.4	0.2	0.0	0.2	0.4	2.0	4.0	5.3	3.2

* Value altered from the 55° measurement position to the 60° standard position.

Table B7
Differences in dB Between the Inner and Outer Rings by Radial Position

	3–9	4–10	5–11	6–12
C1	4.1	3.4	5.2	6.5
S1	13.3	10.5	4.1	10.4
C2	4.6	3.7	4.9	4.2
S2	12.8	10.1	4.8	11.3
C3	7.1	5.7	5.2	10.2
S3	12.1	9.4	5.1	10.3
C4	7.3	5.4	5.0	7.7
S4	12.1	8.6	5.4	10.8
C5	7.9	7.0	4.6	6.6
S5	12.1	8.7	4.9	7.9
C6	7.4	5.2	4.7	6.6
S6	11.2	8.5	4.7	7.8
C7	7.1	5.0	4.9	6.1

Table B8
Selected Average Differences in dB Between the Inner and Outer Rings by Position

	3–9	4–10	5–11	6–12	AVE
TP-T	12.8	10.0	4.7	10.7	10.4
HEI-T	12.1	8.7	5.2	9.6	9.5
APDS-T	11.2	8.5	4.7	7.8	8.6
All Shells	12.1	9.1	4.9	9.5	9.6
All C-4	6.7	5.2	4.9	7.2	6.1

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