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PRELIMINARY VIBRATION SURVEY OF MOBILE ARCTIC SHELTER AND THE NORTRAC 'SNOTRUK'

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ABSTRACT

A preliminary vibration survey was carried out on the Mobile Arctic Shelter developed by DREO/DCIEM and on the Nortrac 'Snotruk' whose chassis is incorporated in the shelter.

Acceleration intensities were recorded in two axes (Y and Z) and a power spectral density analysis was carried out for twenty 1/3-octave bands covering the frequency spectrum from 1 to 100 Hz. Results indicate that the length of ride in these vehicles should be limited, depending on the terrain to be traversed, in accordance with I.S.O. Standards on Vibration Exposure. Poor terrain conditions and mechanical problems of the test vehicles prevented a thorough vibration study from being carried out. // (U)

PRELIMINARY VIBRATION SURVEY OF MOBILE ARCTIC SHELTER AND THE NORTRAC 'SNOTRUK'

INTRODUCTION

A small Mobile Arctic Shelter has been developed by Defence Research Establishment Ottawa in co-operation with the Defence and Civil Institute of Environmental Medicine to support the activities of two men on patrol in Arctic regions. The tracked vehicle utilizes the chassis of the NORTRAC 'Snotruk', with a specially designed shelter being attached to the main frame (1). The vibration environment was investigated to determine whether the vibration intensities were sufficiently severe to warrant further development of the seat, and if the length of ride in these vehicles should be limited in accordance with the International Standards Organisation proposed Vibration Exposure Criteria (2). This report describes the findings of a preliminary vibration study carried out at DREO in Ottawa in March 1973.

CONDUCT OF STUDY

Both the Mobile Arctic Shelter and the 'Snotruk' supply vehicle (Figures 1 and 3) were operated on hard-packed gravel roads and in a field covered with two inches of soft snow and slush. The terrain was far from ideal due to warm weather melting most of the snow cover.

With both vehicles measurements were made of the spectrum of vibration present at the base of the passenger seat and that encountered by a subject riding in the passenger seat. The vehicles were driven at operational speeds (approximately 10 - 20 mph) over both terrains and 5 - 10 minutes of vibration data were tape-recorded on each test. Measurements on the floor at the base of the passenger seat could not be completed for the Mobile Arctic Shelter because of a drive-train breakdown.

DETAILS OF VIBRATION MEASUREMENT AND ANALYSIS

Data Acquisition

The technique used was similar to that described previously (3). Acceleration was measured in two axes (y - lateral acceleration or sway and z - vertical acceleration or heave) using Statham accelerometers attached either to the floor of the vehicle under the passenger seat (Figures 2 and 4) or to the subject in the passenger seat by means of a special harness with fibreglass reinforcing. A tri-axial accelerometer was not available for these trials, restricting the measurement of acceleration to two axes using two single accelerometers mounted orthogonally. Care was taken to align the accelerometers with the axes of the body (3).

The accelerometers were excited by a precision direct-current source and accelerometer bridge imbalances, equivalent to accelerative loading, were amplified and tape-recorded on a TEAC R-70 Cassette Instrumentation Tape Recorder (4) (Figure 5). Calibration of the accelerometers was accomplished using a General Radio 1557-A Vibration Calibrator which excites the transducers with 1 g RMS at 100 Hz.

Analysis

The recorded vibration data were analyzed on a Federal Scientific UA-10 Ubiquitous Spectrum Analyzer using an analysis bandwidth from 1 to 100 Hz. Tape speed variation, caused by mechanical vibrations affecting the drive mechanism of the tape recorder, were electronically compensated. The constant bandwidth spectrum generated by the spectrum analyzer was averaged 64 times on a Fabritek Model 1070 Instrumentation Computer interfaced with a PDP-9T computer. The PDP-9T computer subsequently calculated the 1/3-octave power spectral density acceleration intensities using a weighting function. Twenty 1/3-octave band P.S.D. acceleration intensities were printed out and plotted with respect to the centre frequency of each band (see Appendix I for description of the bands). The appropriate ISO Decreased Proficiency Boundary and Exposure Limit (2) was then determined* (see Appendix II).

RESULTS

From Table 1 it can be seen that the Decreased Proficiency Boundaries (below which human working efficiency is preserved) for the Mobile Arctic Shelter lie at 3-1/2 and 5 hours, respectively, for gravel road and cross-country terrain. The Exposure Limit (below which human health and safety are preserved) is reached at 10 and 13 hours, respectively.

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*A detailed description of the data acquisition and analysis system will be published soon (4).

The Decreased Proficiency Boundaries for the 'Snotruk' lie at 7 and 4 hours for gravel road and cross-country terrain, respectively, with the Exposure Limit being reached at 16 and 10 hours. The spectra, given in Appendix II, show that the seat of the 'Snotruk' is effective in the Y-axis and very effective in the Z-axis (vertical vibrations) in reducing the intensities of vibration being transmitted from the chassis of the vehicle to the human occupant riding in the passenger seat. This is especially noticeable on hard, gravel roads for the lower frequencies of vibration (<5Hz).

The twenty 1/3-octave bands over which the power spectral density vibration intensity was calculated are shown at the top of the spectral plots (Appendix II). The intensity for each band is plotted at the centre frequency of each band and these points are joined for graphical clarity. It should be remembered, however, that the bandwidth (in Hz) of each 1/3-octave band varies, depending on the band number, and specific single frequencies may have much higher vibration intensities. This is especially true in the higher bands.

DISCUSSION

Spectral analysis clearly shows that for both vehicles the low-frequency components of vibration (<5Hz) in both axes are accentuated when travelling over rough and varied cross-country terrain. This increase in low-frequency vibrations is terrain-induced since the frequency range of tracked vehicle suspensions falls off below 4 Hz. This increase in heave and sway acceleration is primarily responsible in limiting the length of ride in these vehicles since humans are most susceptable to low frequency vibrations (1 - 2 Hz for the Y-axis, 4 - 8 Hz for the Z-axis). Longer exposure times could thus be obtained by the driver reducing the speed of the vehicles over this terrain to decrease these vibration intensities.

On gravel roads, on which these vehicles were not really designed to travel, the Snotruk produced accentuated higher frequency vibrations, especially in the Y-axis. Although the seat was effective in decreasing the transmission of vibrations to the occupant, quite annoying vibrations could be felt on the back of the seat, especially if the spine came in contact with any part of the metal frame of the seat where padding was insufficient.

Both vehicles had distinctive vibration peaks around 50 Hz. Since this was present regardless of the terrain it is probably produced by the engine.

The somewhat higher intensity of the low-frequency Az vibration found in the Mobile Shelter, as compared to the Snotruk, is perhaps due to the more springy seat and is probably also a function of the greater mass and weight of this vehicle with the shelter attached to the chassis. The moment of inertia of the Mobile Arctic Shelter should also be considered as a factor leading to increased low-frequency vibrations, especially roll, with a component in the Az direction. Subjectively it was found that the Shelter rolls more, and with less of a returning moment, than the Snotruk.

The test conditions for this trial, notably the weather and the resulting terrain, were far from ideal. In cold weather the seat of the Snotruk is known to get much harder due to the exposure of the cab. This would increase the transmission of vibrations to the rider and possibly further limit the acceptable length of ride. Other limitations included the poor mechanical condition of the vehicles, especially the drive train, and the availability of only two axes for the sensing of acceleration. It should also be kept in mind that the exact applicability of the ISO Proposed Vibration Exposure Standards to these type of vehicles has not been determined, but in the absence of any better criteria they were chosen to be the most suitable.

CONCLUSIONS

The Mobile Arctic Shelter and Snotruk vibration environment was partially studied. The length of ride should be limited to about 3-1/2 and 5 hours for the Mobile Arctic Shelter travelling over gravel road and cross-country, respectively, and to 7 and 4 hours for the Snotruk travelling over the same respective terrains. These ride limitations should be considered tentative, however, due to the limited data obtained in this study.

RECOMMENDATIONS

It is recommended that:

a. the tests be repeated measuring tri-axial accelrations;

b. the vehicles be tested over more characteristic terrain ie, tundra, ice, snow covered roads;

c. the vibration environment of the vehicles be studied at different controlled speeds; and

d. stationary vehicles be studied as a crew may occupy the shelter with the motor running and be exposed to vibrations.

REFERENCES

1. Beevis, D. and McCann, C.: Human Engineering aspects of a Small Self-contained Mobile Shelter System. DCIEM Technical Memorandum No. 875, July 1972.

2. International Organization for Standardisation, "Guide for the Evaluation of Human Exposure to Whole-body Vibrations." I.S.O./TC 108/WG7 (Secr. -17), December 1968.

3. Maret, K. and Winship J.: Vibration Measurement in Selected Armoured Vehicles. DCIEM Report No. 897.

4. Maret, K. An Automated Vibration Measurement System. DCIEM Technical Report. In preparation.

APPENDIX 1

STANDARD 1/3-OCTAVE BANDS FOR VIBRATION ANALYSIS

BAND NO.	CENTRE FREQUENCY OF 1/3-OCTAVE BAND Hz	BANDWIDTH OF 1/3-OCTAVE BAND Hz
1	1.00	0.23
2	1.25	0.29
3	1.58	0.37
4	2.00	0.46
5	2.51	0.58
6	3.16	0.73
7	3.98	0.92
8	5.01	1.16
9	6.31	1.46
10	7.94	1.84
11	10.00	2.31
12	12.59	2.91
13	15.85	3.67
14	19.95	4.62
15	25.12	5.81
16	31.62	7.33
17	39.81	9.22
18	50.12	11.61
19	63.09	14.61
20	79.43	18.39

The Centre Frequency is given by: $f_c = 10^{n/10}$

where N = Band No. -1

The Bandwidth is given by: $BW = (2^{-1/6} - 2^{1/6})\ f_c$

TABLE I

VEHICLE AND TERRAIN	AXIS	BOUNDARY DETERMINING ACCELERATION		DECREASED PROFFICIENCY BOUNDARY † (HRS)	MAXIMUM EXPOSURE LIMIT FOR HEALTH & SAFETY † (HRS)
		Amplitude (m-Sec-2)	Frequency (Hz)		
Mobile Arctic Shelter Passenger seat					
Gravel road	Y	.365	1.6	3½*	10
	Z	.188	2.5	20	>24
Cross-country	Y	.28	1.6	6	14
	Z	.60	2	5*	13
SNOTRUK Passenger seat					
Gravel road	Y	.25	2	7*	16
	Z	.20	6	14	>24
Cross-country	Y	.37	2	4*	10
	Z	.47	2.5	6	15

* Indicates maximum length of ride for preservation of operator efficiency.

† Derived from I.S.O. Standards on Vibration Exposure.

APPENDIX I

FIGURES 1 to 5

Figure 1. Mobile Arctic Shelter.

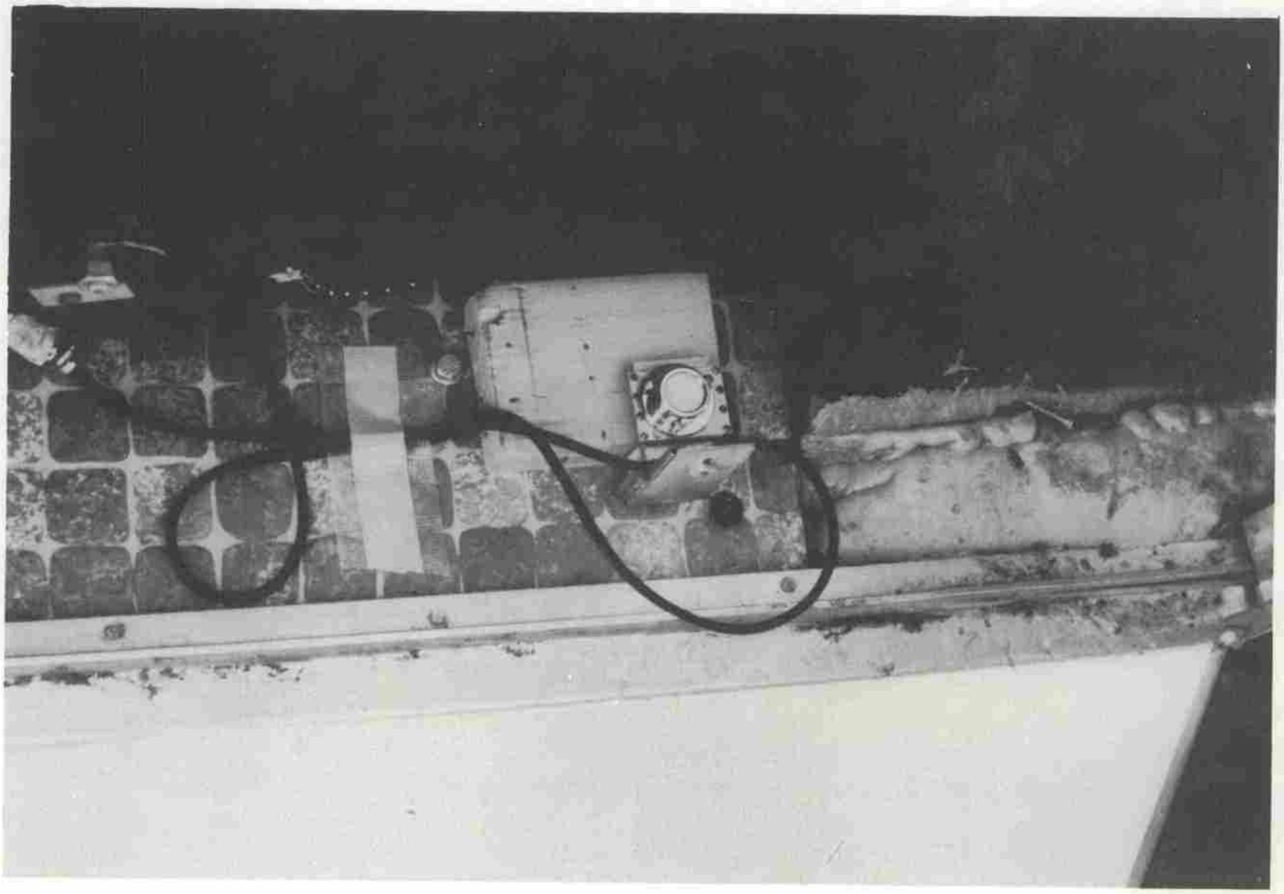


Figure 2. Accelerometers Mounted at Base of Passenger Seat in Mobile Arctic Shelter.

Figure 3. Snowtruck - Supply Vehicle

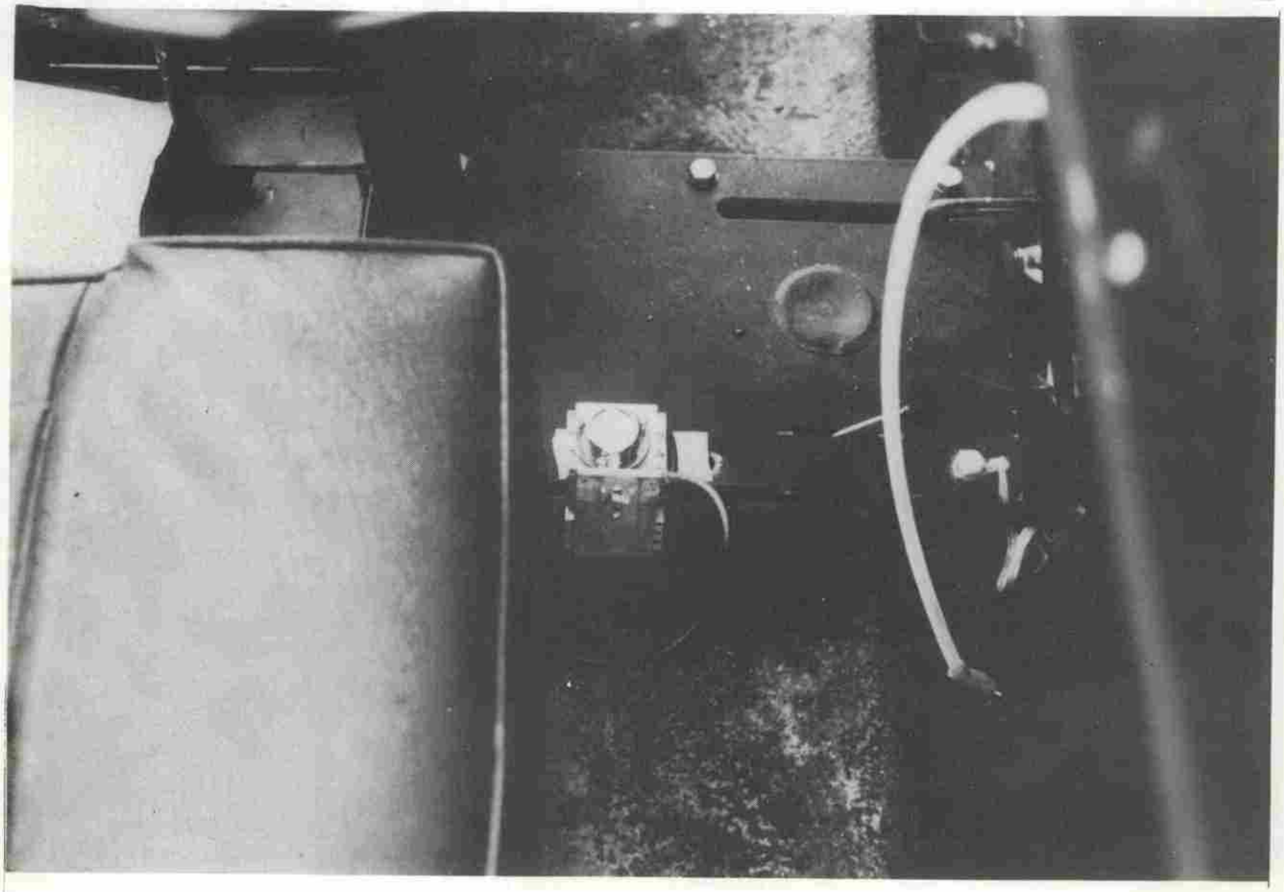


Figure 4. Accelerometers Mounted at Base of Passenger Seat in Supply Vehicle.

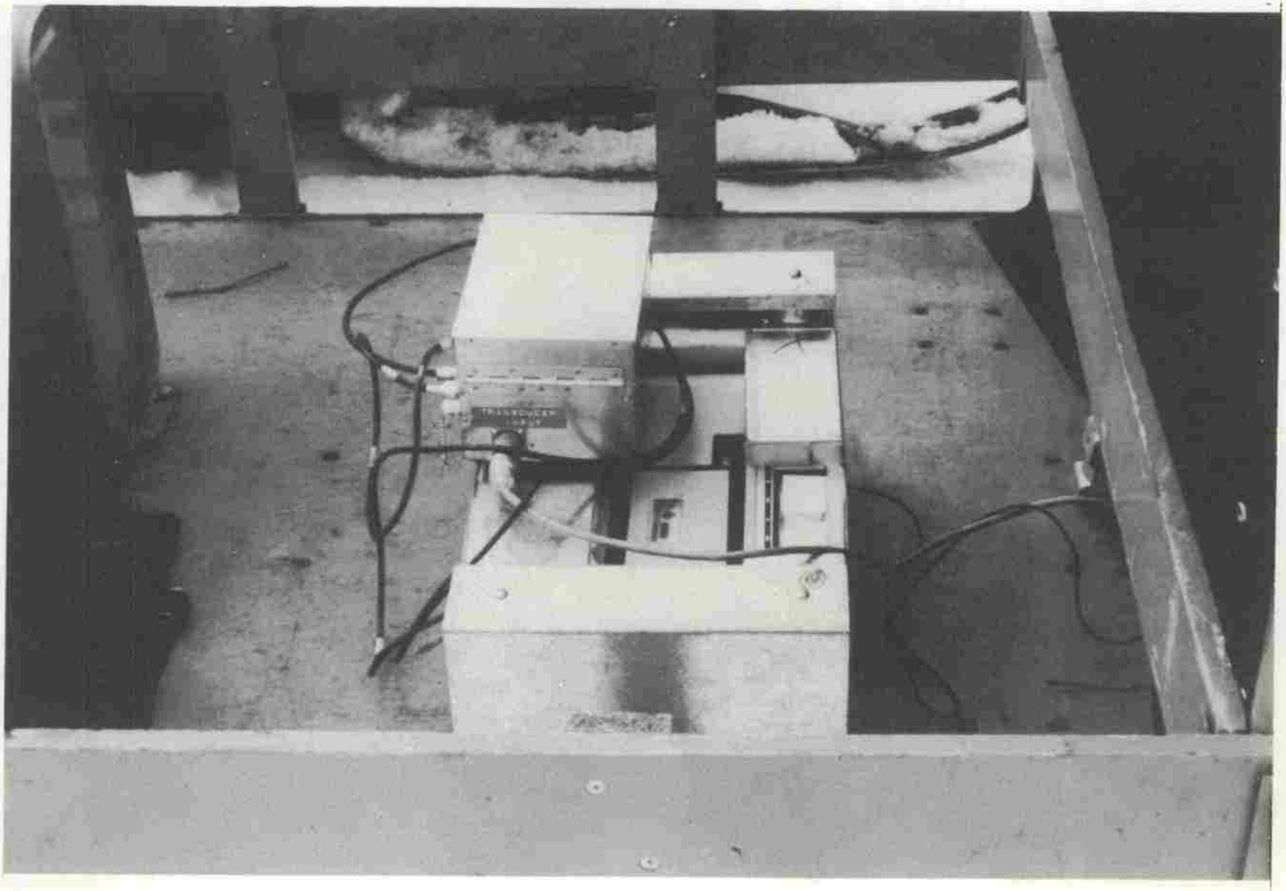


Figure 5. Shock-Mounted Tape Recorder and Electronics Package Mounted on Rear Platform of Supply Vehicle.

APPENDIX II

VIBRATION SPECTRA OBTAINED (POWER SPECTRAL DENSITY ANALYSIS)

FIGURES 2.1 to 2.4

Figure 2.1

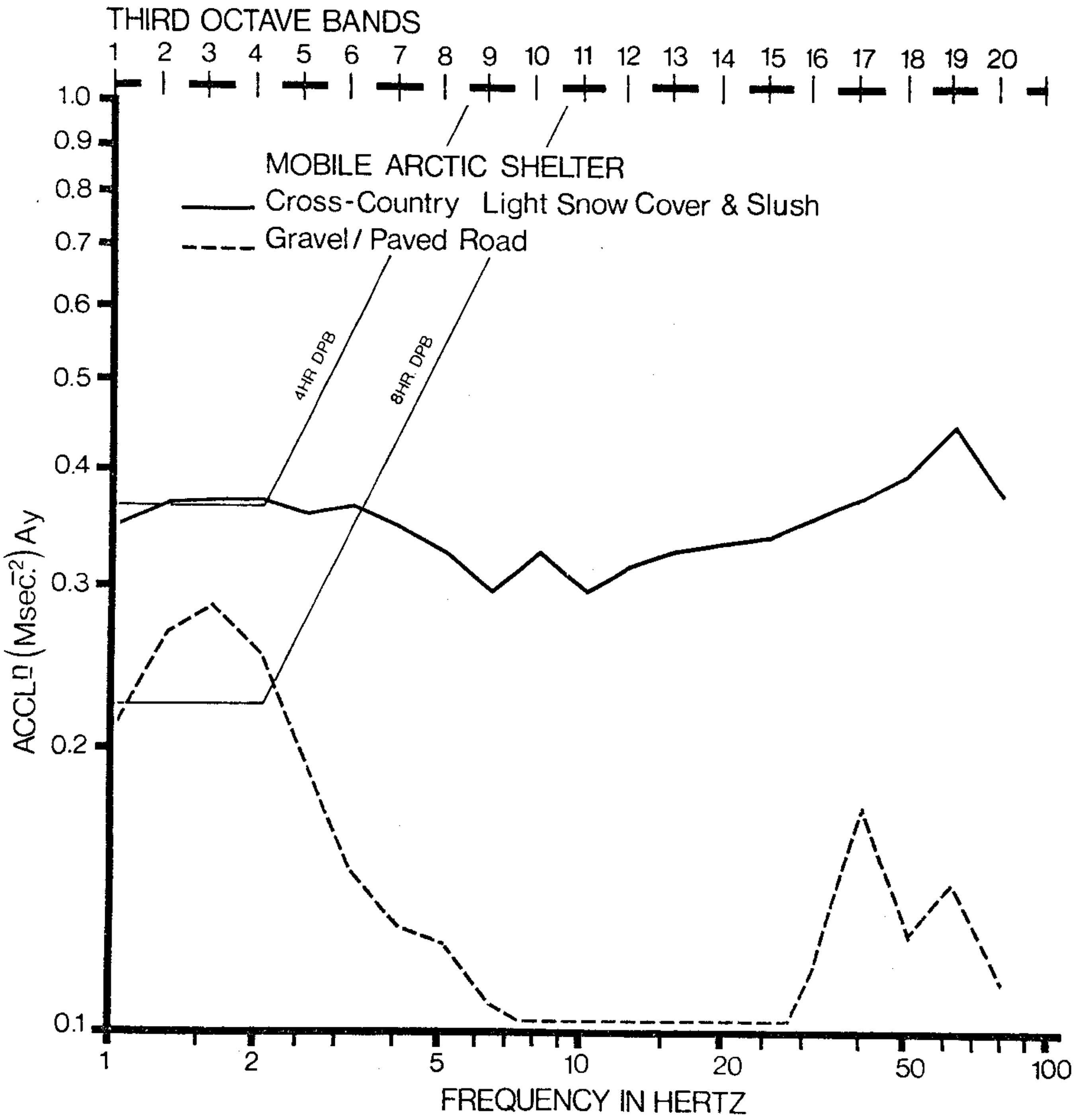
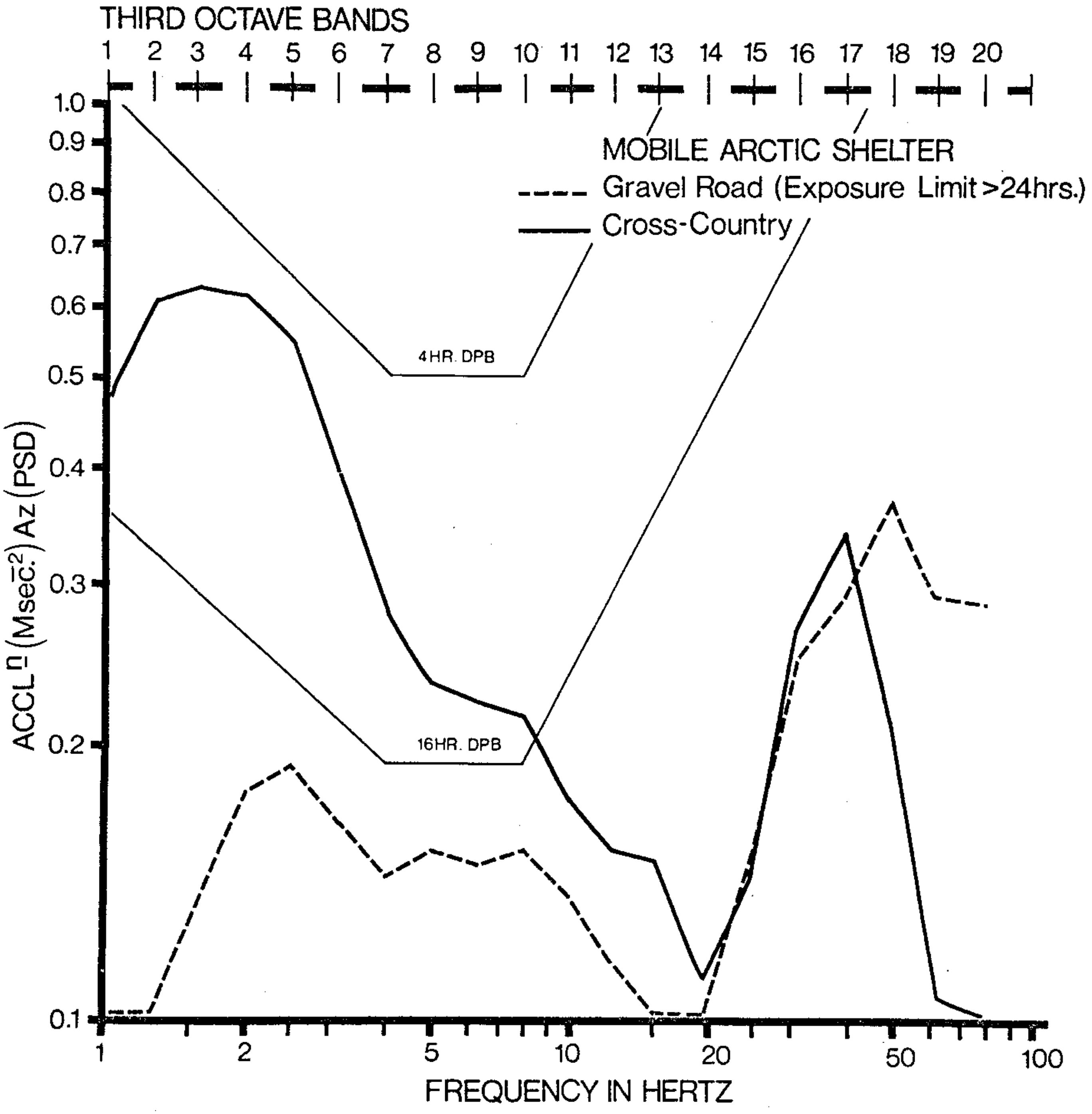

THIRD OCTAVE BANDS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
MOBILE ARCTIC SHELTER
Cross-Country Light Snow Cover & Slush
Gravel / Paved Road
4HR DPB
8HR. DPB
ACCLⁿ (Msec.⁻²) Ay
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
5
10
20
50
100
FREQUENCY IN HERTZ

Figure 2.2


THIRD OCTAVE BANDS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
MOBILE ARCTIC SHELTER
Gravel Road (Exposure Limit >24hrs.)
Cross-Country
4HR. DPB
16HR. DPB
ACCL^n (Msec^{-2}) Az (PSD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
5
10
20
50
100
FREQUENCY IN HERTZ

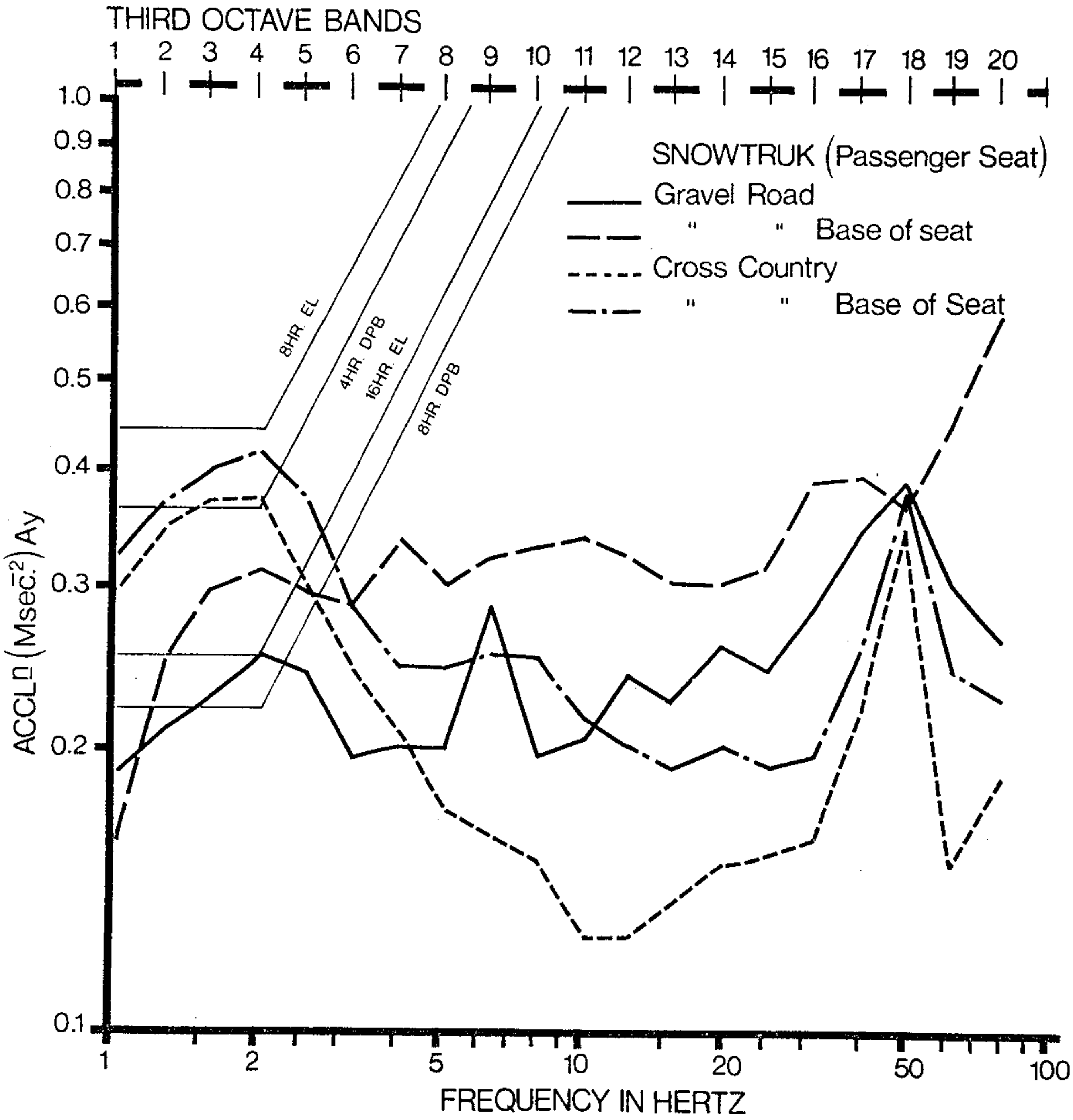
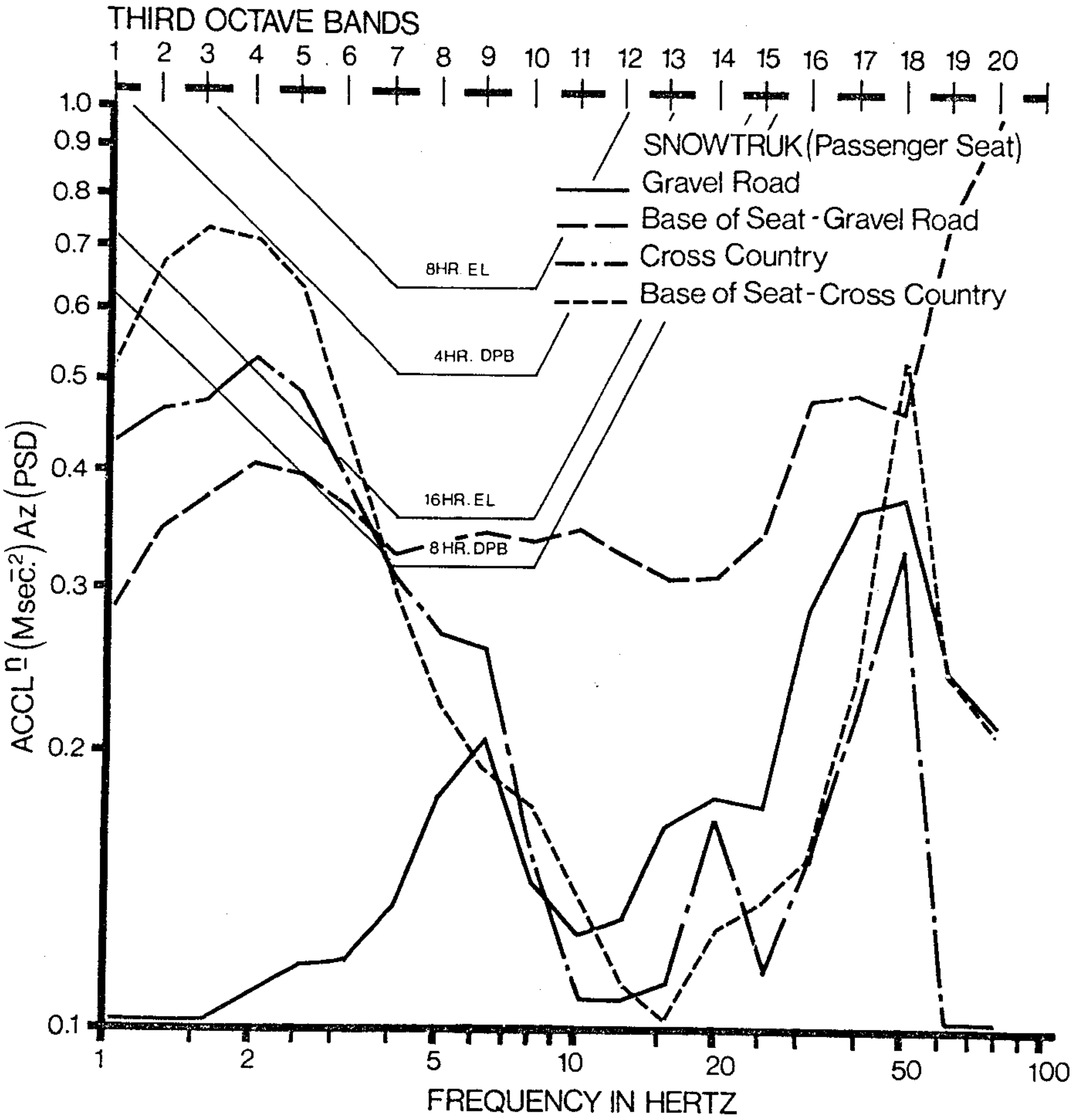

THIRD OCTAVE BANDS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
8HR. EL
4HR. DPB
16HR. EL
8HR. DPB
SNOWTRUK (Passenger Seat)
Gravel Road
" " Base of seat
Cross Country
" " Base of Seat
ACCL^n (Msec.$^{-2}$) Ay
1
2
5
10
20
50
100
FREQUENCY IN HERTZ

Figure 2.3

Figure 2.4


THIRD OCTAVE BANDS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
SNOWTRUK (Passenger Seat)
Gravel Road
Base of Seat - Gravel Road
Cross Country
Base of Seat - Cross Country
8HR. EL
4HR. DPB
16HR. EL
8 HR. DPB
ACCL^{n} (Msec^{-2}) Az (PSD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
5
10
20
50
100
FREQUENCY IN HERTZ