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COMPARATIVE NOISE LEVELS PRODUCED BY SELECTED ULTRA-LOW VOLUME INSECTICIDE DISPERSAL MACHINES [1]

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ABSTRACT. Noise measurements were made on seven ultra-low volume (ULV) insecticide dispersal machines in order to identify noise hazardous conditions. With the exception of the Northeastern Associates Cardinal ULV Sprayer (which was operationally unacceptable for ULV insecticides dispersal), all of the machines were gasoline-driven and the predominant source of noise from them was identified as the engine exhausts. All of the gasoline-driven ULV machines, by US Army standards, constituted a hearing hazard to personnel in close proximity such as the jeep driver or operator and maintenance personnel. With the exception of the Buffalo Turbine Sonic ULV machine, all the gasoline-driven machines constituted a hearing hazard to personnel in the cab of a ¾-ton truck with a canvas top. The Micro-Gen MS2W–15 did not constitute a hearing hazard to the driver in the cab of a ½-ton pickup truck with windows either up or down. The converted standard military cold fogger did constitute a hearing hazard to the driver in the cab of a ½-ton pickup truck if windows were open. The Cardinal ULV machine did not constitute a hearing hazard. Tests with the LECO Model HD designed to suggest possible noise reduction measures were inconclusive.

INTRODUCTION. The literature pertaining to equipment used in the ultra-low volume (ULV) dispersal of insecticides has dealt primarily with biological effectiveness (Mount et al. 1972; Coombes et al. 1973; Mount et al. 1974); droplet sizes (Mount and Pierce 1972a, 1972b; Mount 1970); and capabilities (Linkfield 1972; Mount et al. 1970); however, no data have been developed concerning the comparative noise levels of the various ULV machines.

As part of an extensive evaluation of seven ULV machines by the US Army Environmental Hygiene Agency, it was deemed necessary to include noise measurements to insure that military pest control operators be made aware of any unprotected noise hazards associated with their use.

MATERIALS AND METHODS. The following ULV sprayers were evaluated: (1) The standard military, 40 GPH, skid-mounted, gasoline-engine driven, fog-type, insecticide sprayer (used as a standard); (2) The standard military sprayer equipped with a LECO ULV conversion unit; (3) The LECO Cold Aerosol Generator, Model HD; (4) The Micro-Gen ULV Liquid Chemical Dispersal Unit, Model MS2W–15; (5) The Buffalo Turbine Sonic ULV Sprayer; (6) The Northeastern Associates Cardinal ULV Sprayer, Model 150; and (7) The US Army LWL Rotary Tube Sprayer prototype.

It should be noted that the machines used for noise measurements were either on loan from the manufacturer or secured from Army inventory. Although the equipment was new at the beginning of these evaluations, no attempt was made to ascertain the state of repair or the state of assembly of the equipment at the time

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noise measurements were taken. For this reason the noise levels measured may or may not reflect those actual noise levels produced by the equipment upon delivery from the manufacturer.

Noise measurements for each of the seven ULV machines were made with the machine placed on the back of a ¾-ton truck and the nozzle facing the rear, this being one of the standard methods of operation. The other methods included mounting the machines on the back of a ½-ton pickup truck or on a jeep. The jeep mounted condition was simulated and limited measurements were made utilizing the ½-ton pickup truck.

In each case, the truck carrying the ULV machine was parked in a clear area, with motor off, a minimum of 100 ft from the nearest building and noise measurements were made at the ear of the driver in the cab of the vehicle. The ¾-ton truck's canvas top was up and the side windows were rolled down. Measurements were made in the pickup truck cab with windows rolled up and again with the windows rolled down. Measurements were also made on the back of the ¾-ton truck at a location which would approximately correspond to the ear of the driver if the equipment had been mounted on the back of a jeep. In addition, measurements were made at various other locations with some of the machines in an attempt to determine predominant noise sources. The operating settings were normal except no liquids were sprayed.

The LECO Model HD was subjected to detailed acoustical measurements in various operating conditions and muffler configurations. For these measurements the machine was mounted on a dolly and positioned on the ground about 40 ft from the nearest building. Noise measurements were made at a position about 3 ft forward of the machine. The instrumentation used for all noise measurements was a Bruel & Kjaer (B&K) model 2204 Sound Level Meter, a B&K model 4134 Microphone, a B&K model 4220 Pistonphone, and a B&K 1613 Octave Filter Set.

RESULTS AND DISCUSSION. Noise levels, at positions corresponding to the driver's ears of the ¾-ton truck and the jeep are listed in Table 1. The Cardinal ULV Sprayer is a battery-driven machine and produced very low noise levels, being below 72dB(A) at all personnel locations. All of the other machines are powered by gasoline engines and noise levels produced by these in the ¾-ton truck cab varied from 83 to 95dB(A). The noise levels measured at the jeep driver location were 100 to 108dB(A), the levels which would also be experienced by a machine operator during normal machine starting and adjustment operations.

The noise levels recorded at the driver's ear in the cab and at the control panel in the ½-ton pickup truck are shown in Table 2 for two ULV machines. These data indicate that noise levels inside the cab of the ½-ton pickup truck, with windows closed, are below the US Army's hearing hazard criteria (The US Army hearing conservation criteria are more stringent than OSHA criteria. For Army hearing conversation purposes, hearing hazardous conditions exist whenever steady state noise levels exceed 85dB(A) regardless of duration of exposure). With the windows rolled down, the noise level for the Micro-Gen was below the hearing hazard criteria while the noise level for the LECO converted standard military cold fogger was above the hearing hazard criteria. A comparison of results measured using the ½-ton and ¾-ton trucks shows some trends with respect to the noise attenuation provided by the cabs. The canvas cab of a ¾-ton truck, with windows rolled down, provides 13 to 17 dB(A) of noise reduction between levels at the driver's ear and levels at some location near a ULV machine. The metal and glass cab of a ½-ton pickup truck provides 16 to 20 dB(A) of attenuation with the windows open and 25 to 26 dB(A) of attenuation with the windows closed. Of course these results are approximations because they were arrived at without taking into account the varia-

Table 1. Noise levels in dB re 0.0002 dyne/cm² at ¾-ton truck and Jeep driver's ear for various ULV machines.

Machine	At driver's ear of:	Measured overall, a weighted	Octave band center frequency, Hz							
			63	125	250	500	1000	2000	4000	8000
Cardinal ULV Model 150	Truck	..	..	..	..	..	..	..	..	..
	Jeep	72	68	64	63	66	66	65	56	54
Micro-Gen Corp CDU Model MS2W–15	Truck	87	88	95	88	87	82	75	76	72
	Jeep	103	98	99	94	94	93	94	99	97
LECO ULV Model HD	Truck	89	91	96	90	86	86	79	79	74
	Jeep	105	98	101	98	98	95	98	100	98
Buffalo Turbine Model Sonic ULV	Truck	83	88	95	83	79	75	69	69	65
	Jeep	100	90	100	95	91	90	91	94	93
USA Sprayer, Insecticide, Skid Mounted, NSN 3740–00–930–9384	Truck	95	101	101	100	93	89	87	84	80
	Jeep	108	104	107	107	102	99	103	100	104
USA Sprayer with LECO ULV Conversion Unit	Truck	91	90	97	96	87	85	81	79	72
	Jeep	108	103	90	107	101	100	100	101	103
U.S. Army LWL Rotary Tube Sprayer (Prototype)	Truck	90	82	91	93	83	80	74	79	88
	Jeep	106	94	101	101	98	93	95	96	105

Table 2. Noise levels in dB re 0.0002 dyne/cm² at ½-ton truck driver's car and at the control panel for two ULV machines.

Machine	Location/ position	Measured overall, a weighted	Octave band center frequency, Hz							
			63	125	250	500	1000	2000	4000	8000
Micro-Gen Corp. CDU Model MS2W-15	Control Panel	98	97	96	92	94	92	90	92	92
	Inside Cab Windows Open	78	90	87	81	71	66	64	70	70
	Inside Cab Windows Closed	73	87	86	76	65	57	52	50	50
USA Sprayer with LECO ULV Conversion Unit	Control Panel	104	102	106	101	94	94	98	98	98
	Inside Cab Windows Open	88	92	94	88	80	75	81	80	79
	Inside Cab Windows Closed	78	90	90	80	74	65	62	59	55

tions in the distance and the shadowing effects between the actual noise source and the driver among the different machines.

The predominant source of noise for the gasoline-driven machines was the engine exhausts. These produced a fairly flat, broad band spectrum. The noise produced by the jet (spray nozzle) tended to peak at high frequencies, as indicated by measurements taken in back of the nozzle. Other noise sources normally expected on this type of equipment are radiation from the engine surfaces, and noise from the compressor and engine intakes. The magnitude of these suspected sources could not be determined because of the masking effect of the high exhaust noise.

The LECO Model HD was arbitrarily selected for possible engineering noise reduction measures for the exhaust and jet noise. It should be noted that the material used for noise reduction represented materials on hand at the time, and the data obtained should be used only as an indication of trends.

The muffler on the LECO HD was removed and an automobile muffler was installed. Table 3 lists the noise reduction provided by the two types of mufflers. Also listed are the noise reductions required from a muffler in order for the LECO Model HD to comply with Army noise level requirements at the ¾-ton truck driver's position and at the jeep driver's position. The required noise reduction was calculated using the measured data and assumes that all the noise is generated by the exhaust.

The automobile muffler used for experimentation provided enough noise reduction to meet the Army noise criteria in the ¾-ton truck cab for all octaves except 1000 Hz where an additional 3dB reduction is required. This could possibly be obtained by providing a better seal at the muffler to manifold joint and by directing the exhaust pipe toward the rear of the truck.

The automobile test muffler would not provide enough noise reduction to elimi-

Table 3. Noise reduction provided by two types of mufflers on LECO Model HD, and exhaust noise reductions required to meet military standard, noise limits for army material.

Noise reduction in dB re 0.0002 dyne/cm² for:	A weighted overall	Octave band center frequency, Hz							
		63	125	250	500	1000	2000	4000	8000
Original Muffler	8	1	2	3	1	4	8	12	11
Automotive Muffler[1]	12	7	9	6	3	7	8	17	18
Required with ¾-Ton[2] Truck Cab to Meet Military Standard	NA[3]	—14[4]	2	4	4	10	8	12	4
Required with Jeep[2] to Meet Military Standard	NA[3]	—7[4]	7	12	16	19	27	33	28

[1] Could probably be improved by better seal at the muffler to exhaust manifold input.

[2] Exhaust noise reduction required to meet requirements of military standard, noise limits for army materiel.

[3] Not applicable. Military standard, noise limits for army materiel, does not define requirements for the overall A-weighted level.

[4] Negative sign indicates that the level without any muffler is below the military standard limit and further noise reduction is not required in this octave band.

nate hearing hazards in the immediate vicinity of the LECO HD where a high degree of silencing, in excess of 30 dB at high frequencies, is required (Table 3). A cardboard box measuring approximately 1.5 x 1.5 x 2 ft, with one end open was placed around the LECO HD spray jet in an attempt to block the direct path of the high frequency jet noise. The overall effect was a 1 dB reduction in the A-weighted noise level. The 8000 Hz octave band was reduced 2 dB; however, the 250 Hz band was increased. These changes were very small compared to those changes resulting from the use of the automobile muffler. This could have resulted from the ineffectiveness of the box or because the exhaust noise was masking the effects of the box.

Other techniques were tried in order to measure the engine noise without any masking effects of jet or compressor noise. To this end, the nozzle was disconnected and later the compressor was disconnected with noise measurements being made in each case. These data were judged inconclusive because the engine seemed to run differently in each case due probably to the changes in load conditions when the nozzle or compressor was removed.

CONCLUSIONS. By U.S. Army standards, all of the 6 gasoline-driven ULV machines constitute a hearing hazard to personnel in close proximity such as the jeep driver or operator and maintenance personnel. With the exception of the Buffalo Turbine Sonic ULV machine, all of the gasoline-driven ULV machines constitute a hearing hazard to personnel in the cab of a ¾-ton truck with canvas top.

The Micro-Gen MS2W–15 does not constitute a hearing hazard to the driver in the cab of a ½-ton pickup truck with windows either up or down. The LECO converted standard military cold fogger does constitute a hearing hazard to the driver in the cab of a ½-ton pickup truck if the windows are open. The metal cab of the ½-ton truck provides a greater amount of noise attenuation than does the canvas top of ¾-ton truck. The former vehicle from this standpoint is preferable to a jeep or a ¾-ton truck with canvas top.

The Cardinal ULV machine does not produce hearing hazardous noise levels. Based on the results of these tests, it was recommended that military pest control operators utilize hearing protective devices during operation of any of the gasoline-driven test machines.

Additional studies aimed at the reduction of noise levels from these machines are clearly desirable.

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