

Report No. 71

Introducing the National Physical Laboratory Report

on the Measurements of the Noise from Small Power Operated Chain Saws

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Origin

The noise created by power saw engines has been a subject of criticism not only by people unconnected with forestry who may be in the neighbourhood but also by forest workers themselves. No measurement of this noise has ever been made in this country so no comparison with noise levels created by other machinery could be made. The co-operation of the National Physical Laboratory was therefore obtained in completing a series of tests on three different power saws and a small brush cutter.

Observations

1. The complete N.P.L. report is attached at Appendix A with some further observations given at Appendix B. The measurement figures and calculations are in the field of the physicist rather than the mechanical engineer so little comment on these figures can be made here.
2. It was confidently expected that the noise when working under a tree canopy would be much greater than when working in the open. This was not substantiated by the tests and the reason may be that virtually all the noise is reflected from the ground and the expected overhead "soundboard" effect of the tree is of no importance. It must however be noted that the hardwoods were not in leaf.

Conclusions

All these saws make a noise which is in the range which can be described as offensive to the ear. Although there was some variation in the noise given by the standard chain saws on the various tests there was little overall nett difference. The standard Jo Bu Junior and Danarm Fury were identical when cross cutting but the Danarm was the noisier of the two when felling.

The benefit that can be obtained from a silencer was demonstrated particularly the experimental Danarm Silencer.

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R. G. SHAW

Machinery Research Officer

March, 1958

NATIONAL PHYSICAL LABORATORY

Report

on

Measurements of the Noise from small power operated Chain Saws

For:- The Forestry Commission,
25, Savile Row,
London, W.1.

Site and Date of Measurements: Effingham Forest. January 7th 1958.

Types of Saws concerned. The types of saws concerned in the measurements were (1) Jo-Bu Junior, (2) Danarm Fury, (3) Danarm DD8F and (4) Jo-Bu Brush Cutter, all being one-man operated machines driven by a small two-stroke petrol engine. The engine exhaust is fitted with a very small lightweight expansion type silencer only to save weight. In all cases except for the Brush Cutter, the noise heard when wood cutting is taking place is due entirely to the exhaust noise. In the case of the Brush Cutter the noise at high frequencies is due to the saw blade.

Method of Noise Measurement. Measurements of the noise were made directly by means of a calibrated microphone and Sound Level Meter, and simultaneously the noise under measurement was recorded on magnetic tape for subsequent analysis in the Laboratory into a series of eight octave bands, having centres at approximately octave intervals from 53 to 6800 c/s, i.e. covering the frequency range from about 35-9000 c/s. These measurements are expressed in terms of the Sound Pressure Level per octave in decibels above a zero of 0.0002 dyn/cm^2 , which is near the threshold of audibility at 1000 c/s.

The Sound Level is defined as the reading given by a Sound Level Meter (American Standards Association Z24.3, 1944) which, in effect measures the value of the overall sound pressure either unweighted (Flat response), or weighted to reduce the low frequencies in approximate accordance with the lower sensitivity of the ear at the 70 and 40 phon contours. The contour (Flat, 70 or 40 phon) used for measurement is determined by the level of the noise. At the high levels Flat response is specified, and accordingly this setting was used in the measurements.

By these means, the noise was measured at a point about 6 ins. from the operators right ear, and at a point 4 ft to the side of the saw (to the operators right hand). In this series of measurements, cross cutting was being made on a large elm stump some 2 ft. 6 ins. in diameter located in a clearing. For a second series of measurements simulated felling was made on a beech stump some 9 ins. in diameter, and here the operator was surrounded by overhanging trees.

Results of the Measurements. The results of the measurements are given in the Table, which also gives calculated values for Loudness Level in Phons, derived from the octave band measurements by a procedure given by S. S. Stevens. (Journal Acoust. Soc. Amer. 28, 1956. p.807).

The measurements show that the noise levels near the operator are high, with the highest sound pressure levels in the middle frequency octaves. The experimental silencer fitted to the Danarm Fury saw effects a useful reduction of the noise from the standard silencer of about 6 phons (about 35 per cent reduction in the loudness sensation). Runs 1 and 2 show that the effect of the silencer on the Jo-Bu Junior saw noise is small. No significant change in the loudness levels was observed when a saw was operated in the open or under trees.

DATE 28th January, 1958

G. B. B. M. SUTHERLAND
Director

REFERENCE S.1403

PASSED BY W. C. C.

B. Wheeler Robinson

C.S.2.

Superintendent
Physics Division

NATIONAL PHYSICAL LABORATORY

CONTINUATION
of Report on

Measurements of the Noise from small power operated Chain Saws

Table I
Results of Noise Measurements

Run No.	Saw	Sound Pressure level (db re 0.0002 dyn/cm ²) in octave bands centred at frequency (c/s)								Measured Sound Level (Flat) (dB)	Calculated Loudness Level (Phons)
		53	105	210	425	850	1700	3400	6800		
1a	Jo-Bu Junior Standard silencer	88	92	101	104	104	108	98	94	111	121
1b	"	86	94	95	103	104	100	95	92	108	117
2a	As above. No silencer	90	92	96	107	108	109	102	100	113	122
2b	"	87	92	102	108	109	105	100	99	114	122
3a	Danarm Fury Standard silencer	85	95	103	109	108	101	102	95	113	121
3b	"	87	98	100	107	106	103	104	98	111	122
4a	Danarm DD8F Standard Silencer	88	97	101	105	104	104	102	96	110	121
4b	"	91	97	96	105	105	102	103	98	110	121
5a	Danarm Fury Experl. Silencer	85	92	96	99	98	96	93	90	104	114
5b	"	90	98	93	97	99	97	98	94	104	117
6a	Jo-Bu Junior Standard Silencer	86	94	96	103	102	99	95	91	107	116
7a	Danarm Fury Standard Silencer	86	94	103	108	109	102	101	97	112	122
8a	As 6.	86	95	98	105	101	98	92	91	107	118
9a	Jo-Bu Brush Cutter	84	89	89	96	97	97	97	98	103	117
10a	Danarm DD8F Standard Silencer	95	101	102	108	105	102	102	98	111	122

(a) 6 ins. from operators right ear.

(b) 4 ft. to side of saw

Runs 1a - 5b. Cross cutting in open

Runs 6 - 10. Felling under trees.

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Physics Division

G. B. B. M. SUTHERLAND
Director

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PHYSICS DIVISION

Observations on Measurements given in Report S.1403

The results are given in several forms to facilitate comparison with other noises, or with saw noise measurements made elsewhere.

1. The Octave Band analyses, presenting the sound pressure in each of eight successive octave bands, give the most detailed information on the noises. (Sound pressure level is defined as $20 \log_{10} P/P_0$ dB, where P is the sound pressure in dyn/cm², and P_0 is a reference value of 0.0002 dyn/cm²). From these analyses can be calculated single figure (but less fully descriptive) characteristics of the noise e.g. Sound Level, and Loudness Level.

(a) Sound Level

This is defined in the Report. In the present case, where the "Flat" response of the Sound Level Meter was used, it is merely the overall sound pressure level in the frequency band from about 35 - 9000 c/s, instead of in each octave separately as in the analyses. It was measured directly, but it is readily calculable from the analyses by summing the corresponding mean square sound pressures in each band.

$$\text{i.e. Sound Level (Flat)} = 10 \log_{10} \sum_{r=1}^8 \text{antilog} \left(\frac{L_r}{10} \right)$$

where L_r is the sound pressure level in the r^{th} band.

The sound level however, which takes the response of the ear into account only to a very minor degree, is not generally a good single figure characteristic of a noise, and a better characteristic is the Loudness Level.

(b) Loudness Level

Fundamentally loudness is measured by aural comparison, under prescribed conditions, between the noise measured and a standard tone of 1000 c/s, to the levels of which a scale of loudness is ascribed. On the Phon scale, the scale is one of dB steps of sound pressure level starting at zero at a sound pressure level of 0.0002 dyn/cm². The loudness level of the 1000 c/s tone is thus defined as being "n" phons when its sound pressure level is "n" dB, and the loudness of the noise is "n" phons when it is judged, as the average of the observations of a group of observers, to be equally loud to this level of the standard tone. The measurement is a difficult one to make, and no reliable instrument exists to measure it directly, therefore means of calculating the loudness level from octave band data have been developed. Various methods have been advanced, and the one used is that given by Stevens (J.A.S.A., 28, 807, 1956).

The Phon scale is difficult to interpret without experience, and another scale (the Sone scale) based upon practical judgments of loudness has been devised. Hence the aim is that the number defining the loudness should be proportional to the loudness sensation, e.g. doubling the scale number corresponds to doubling the loudness sensation.

(c) Loudness (Sone scale)

The sone scale is defined precisely by its relation to the phon scale, the relation adopted internationally being

$$S = 2^{(P-40)/10}$$

where S is the loudness in sones, and P is the loudness level in phons. Thus, 1, 2 and 4 sones etc. correspond respectively to 40, 50 and 60 phons etc. The formula expresses the fact that halving or doubling the loudness corresponds to a change in loudness level of 10 phons.

The phon/sone relations for the various runs given in Table I of the Report are as below. Since a change of 1 phon corresponds to a change of about 7 per cent in the sone value, sones values are not normally quoted to more than two significant figures.

Run	Phons	Sones
1a	121	270
b	117	210
2a	122	290
b	122	290
3a	121	270
b	122	290
4a	121	270
b	121	270
5a	114	170
b	117	210
6a	116	190
7a	122	290
8a	118	220
9a	117	210
10a	122	290

The mean sone values for runs 3a/b, 5a/b, are 280 and 190, the latter figure being about 65 per cent of the former, i.e. as stated in the Report, a loudness reduction of about 35 per cent on fitting the experimental silencer to the Danarm Fury saw. Even so, the loudness is still high.

A Table of the Loudness Levels of various noises is given below to afford some comparison with the saw noise,

Noise	Phons	Sones
Approx. threshold of pain	130	510
Rivetting on a large steel plate (operators position)	130	510
18 ft. from exhaust of stationary unsilenced 35 cc., OHV, m/cycle	125	360
100 yds. from a jet engine	125	360
Twin engined aircraft (overhead 125 ft.)	115	180
Loud motor horn at 20 ft.	110	130
Weaving shed	100	64
Stationary m/cycle as above with silencer	100	64
In tube train	100	64
Kerbside traffic (busy road)	90	32
Normal conversation	70	8

2. Hearing Impairment

No reliable data exist to estimate the extent by which hearing may be damaged by the present levels of saw noise. Tentative American data give sound pressure levels of 110, 102, 97, 95, 95, 95, 95 and 95 dB in the eight octave bands from 53 c/s to 6800 c/s respectively, as values which should not be exceeded for reasonable assurance that no permanent damage will occur even after years of exposure. These values apply moreover for continuous exposure throughout the normal working day, and (to quote) "the numbers are not to be taken too literally - figures 10 dB lower would involve negligible risks indeed, whilst levels 10 dB higher would result in significant hearing loss". Some English work suggests that the figures given above may be too high. From the Report, it is seen that the American figures are significantly exceeded in the middle frequency bands, but on the other hand, the saw noise is very intermittent - a very pertinent fact which would greatly decrease risk of hearing impairment.

On the whole perhaps, it is likely that after some years of exposure, day after day, to these levels of saw noise, some hearing impairment could result.