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THE USE OF SEL'S IN THE PREDICTION OF MOTOR RACING NOISE IMPACT

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INTRODUCTION

The control of the noise impact of Motor Sport has traditionally been by the use of maximum levels for exhaust noise for individual vehicles. This is monitored by a close proximity test carried out with the vehicle stationary and the engine running at a proscribed speed. The maximum level allowed and the proscribed engine speed are different for each class of motor sport and type of event with the exact regulations being set by the governing bodies of the sport [1] [2]. Whilst this method is simple and can be carried out as part of the normal scrutineering of vehicle before events the static close proximity test is not a reliable way of controlling noise emissions from moving vehicles[3] [4].

Increasingly local authorities, under community pressure, are requiring motor sports organisers to control the noise impact from their events. This can be approached in a number of ways. If the disturbance of motor sport is viewed as an 'acoustic feature' process i.e. the disturbance is related to the individual noise events of vehicles on a track, then one would seek to control the noise emissions from each vehicle, either by a static test as above or by monitoring drive-by levels during the event. An alternative approach would be to control the increase in the overall noise level during the period of the event. This would require the operator to keep the event $L_{eq,T}$ below a set limit.

The first approach has been developed at Donington Park Motor Sports circuit in Derbyshire. A track side maximum level is set with regard to an agreed maximum level in the nearby residential areas and is monitored by an automatic on-line system. The development of this system has been reported in an earlier paper [5] and over the 1995 season proved more effective than the static test that it replaced.

Not all situations will be suitable for control by limiting drive pass maximum and some operators and local authorities will wish to utilise

the greater flexibility that comes from time averaging of the noise increase over the whole period of the event. However time averaging of the noise increase does present problems in that the expected increase in noise level will have to be accurately predicted before the event is held. As yet there are no accepted methods for such predictions and very little published data on motor sport vehicle emissions.
This paper reports measurements made of drive-by noise levels for a range of motor sports cars and the correlation between the drive-by maximum levels and the SEL values. This correlation provides the basis for the first stages of a means of predicting an event $L_{eq,T}$ from simple track side measurements.

MEASUREMENTS

All measurements were carried out at Donington Park Race Circuit and the results described herein only relate to motor cars.
Two measurement positions were used. The first position was on the top of the pit lane wall in line with the track control room, approximately one third of the distance along the Pit Straight at the Finish line. Vehicles passing this position consistently follow a straight racing line that is 13m +/- 2m from the measurement position.
The second position was located on the infield at the exit to Coppice Corner; this is a wide radius curve leading onto the main Dunlop Straight. The curve is on a rising gradient and the vehicles are accelerating a full power as they leave the corner. Previous work had established that maximum noise output per vehicle occurs at Coppice Corner[3]. The distance from the measurement position to the racing line was 12m +/- 2m.

Drive-by L_{Max} measurements

Drive-by measurements of L_{Max} were taken using a type 1 meter for each vehicle type. Measurements were taken both in practise sessions and during racing whenever the spacing between vehicles allowed.
Measurements were disregarded if there was any significant interference from other sources such as the PA system or aircraft overflights. The measurements from individual vehicles were logarithmically averaged and the averaged result for each type of vehicle is shown in Table 1.

SEL measurements

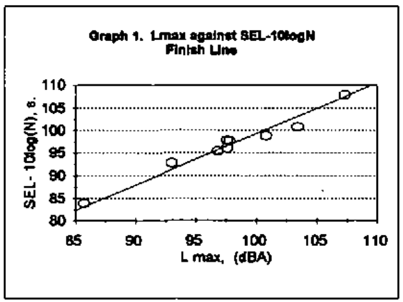
SEL measurements were taken during the start of a race. The measurement period was commenced just before the leading cars reached the measurement postion and measurement was stopped when the last vehicle had passed. The number of vehicles, N that passed by was recorded. In this way the noise emission of each vehicle in the race was measured once in a short time period. If the race vehicles remained close together it was possible to repeat the measurement on the second and third laps. The averaged values are shown in Table 1

RESULTS

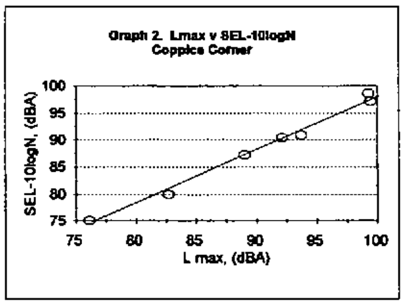
The results are summarised in Table 1. Graphical plots of the comparison of drive-by L_{max} with the individual vehicle SEL, D are shown for both measurement positions.
The number of drive-bys for the SEL measurement is N and the individual drive-by SEL, D is calculated as SEL-10logN.

Table 1 **Track Side Measurements of Vehicle Drive-by Levels.**

Racing Category	Pit Straight Lmax dBA	Pit Straight SEL Group dBA	Pit Straight N	Pit Straight D dBA	Pit Straight Lmax-D dBA	Coppice Corner Lmax dBA	Coppice Corner SEL Group dBA	Coppice Corner N	Coppice Corner D dBA	Coppice Corner Lmax-D dBA
VW Ventos/Polos						82.7	93.4	22	80	2.7
Historic Cars						99.4	109.2	16	97.2	2.2
Alpha Romeo	85.7	95.7	15	83.9	1.8	76.1	94.8	94	75.1	1
Mini Sevens	93	107.3	28	92.8	0.2					
Ford Fiesta	96.8	108.6	21	95.4	1.4	91.2				
Rover GTI	97.6	109.3	21	96.1	1.5	89	100.4	21	87.2	1.8
Formula Vauxhall	97.6	111.5	23	97.9	-0.3					
Formula Ford 1800cc	97.8	110.8	21	97.6	0.2	92.1	108.6	66	90.4	1.7
Vauxhall Supersport	100.8	111.8	20	98.8	2					
Vauxhall Caterham	103.4	114.8	25	100.8	2.6	93.7	105.5	29	90.9	2.8
Formula 3	107.3	121.9	25	107.9	-0.6	99.2	112.5	24	98.7	0.5
	mean (arithmetic)				1	mean (arithmetic)				1.8
	Standard Deviation				1	Standard Deviation				0.7
	Standard error (Lmax v D)				1.133	Standard error (Lmax v D)				1.009



Graph 1. Lmax against SEL-10logN Finish Line



Graph 2. Lmax v SEL-10logN Coppice Corner

DISCUSSION

The measured SEL is the sum of a number of drive-bys. Dividing this SEL logarithmically by N gives the average SEL per drive-by, D; this is calculated in Table 1 as SEL -10log N where N is the number of drive-bys. It is expected that this quantity should be related to the Lmax of the drive-by event with the exact relationship depending upon the time history of the drive-by. Graphs 1 and 2 clearly show a linear relationship between L_{Max} and drive-by SEL, D for all racing categories.

Graph 1 for the Finish Line shows that $L_{max} - D = 1$

Graph 2 for Coppice Corner shows that $L_{max} - D = 1.9$

From the drive-by SEL of individual vehicles,D it should prove possible to estimate either

a) the Race L_{eq} Race $L_{eq} = n \times D$ where n = no. of vehicle drive-bys in the race

or b) the event L_{eq} Event $L_{eq} = \Sigma$ Race L_{eq}.

Alternatively it should be possible to determine the possible L_{max} limit for individual vehicle drive-by levels for a given race or event L_{eq}. Monitoring the SEL at the start of a race for the complete race field will also provide a quick and simple method of measuring the mean L_{Max} of the race vehicles

These type of relationships for track side monitoring provides means of linking the monitored noise event of the vehicle (the L_{max}) with the noise impact of the race (the race L_{eq}). The measurements reported here were taken in the 1994 season. It is hoped to continue this work throughout the 1996 season.

REFERENCES

[1] R.A.C. Motor Sports Association Ltd, General Regulations, 1996.
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