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AUDIENCE EXPOSURE TO SOUND AT POP CONCERTS AND THE IMPACT OF PROPOSED GUIDELINES

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1. INTRODUCTION

The most widely adopted criteria for the control of noise at pop concerts is contained in the GLC Code of Practice for Pop Concerts (CPPC)(1). The CPPC contains criteria on minimising both environmental annoyance and the risk of hearing damage to the audience. However, experience has shown that the guidelines dealing with the risk of hearing damage to the audience is rarely enforced providing environmental annoyance is adequately controlled. This may be a case of 'so long as they don't bother us let them do what they want to themselves' or resources simply do not permit enforcement. Also by its very nature the music at pop concerts is perceived by the audience not as noise but as wanted sound and they expect and often demand very high noise levels.

The Health and Safety Executive (HSE) are currently preparing guidance notes which will cover all the health, safety and welfare aspects associated with holding pop concerts. One section within the notes deals with the problems of noise and again covers both environmental disturbance and hearing damage. Travers Morgan Environment were commissioned to provide advice on the drafting of the guidelines and the need to acquire base data on audience exposure was established. This paper presents the results of a survey into audience exposure at pop concerts and how they relate to the CPPC and the proposed HSE guidelines.

2. MEASUREMENT SURVEY

Concert and Venue Selection

The results of the survey were required relatively quickly in order for the findings to be considered during the drafting stages of the HSE guidance notes(2). Given this requirement, ten concerts were chosen to provide a representative database.

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The monitoring survey was carried out over ten weeks from June to August 1991. A range of artistes were selected for the survey although the final choice was obviously limited by the performers on tour at that time and their permission being granted to carry out the survey.

The names of the artistes and venues of the concerts monitored have not been included in this paper, as a prerequisite to the agreement to the survey was complete anonymity. However the concerts were classified into five music categories with advice being obtained from promoters(3) and event managers(4) as to the most appropriate classification for each artiste. The music categories are:

Rock, Pop, Middle of the Road (MOR), Rap and House

The majority of concerts on tour fell into the Rock, Pop and MOR classification, and this gave a fair representation of the relative number of concerts per music type. Surveys were also undertaken at venues where bands performed the latest trends in music described by the Rap and House definitions.

To assess sound levels in the widest possible range of venues, site visits varied from club venues with an audience of 1000 to large open air concerts attracting some 80,000 spectators. Each venue has been defined as either Small, Medium or Large as indicated in Table 6.

In order to provide a larger sample of concerts and venues, data recorded at eight events in the course of other Travers Morgan commissions (following client approval) have been included within the databank for analysis. These data are mainly for the barrier location as additional data for the mixer were not readily available in the required format. A summary of the sample size for each concert is given in Table 5.

Monitoring

At each concert, continuous measurements were made at two positions:

i. the nearest position to an operational loudspeaker that the audience were allowed to approach, from hereonin called the barrier location.

ii. At the Sound mixer console from hereonin called the mixer position.

The measurements were made at head height which in essence meant that two monitoring heights were used dependant upon whether the audience were seated or standing. The distance of the barrier location from the loudspeakers varied from 0.25 metres (typically at the smaller venues with no barrier) to 4.5 metres at the larger outdoor venues. Likewise, the distance of the mixer console location from the loudspeakers varied from 15 metres at small venues to 50 metres at large outdoor stadia.

The continuous monitoring at these two positions was made using data logging dose meters (Larson Davis Model 710). These instruments were calibrated prior to each measurement and were fitted with a $^3/_8$ inch microphone and windshield. Parallel processing of the data is carried out by these instruments so that both the Unweighted Peak Level (Lp) and short term Equivalent Continuous Sound Level (L_{Aeq}) can be recorded simultaneously.

To be compatible with our existing data the instruments were set to record the maximum peak level (Lp) and L_{Aeq} over one minute time periods throughout the duration of the concert. Short term L_{Aeq} measurements (typically 5 minutes in duration) were also made at various locations in most venues and compared with the results obtained from the data loggers. These measurements were carried out to establish whether higher sound levels were recorded at other positions in the audience by virtue of loudspeaker focusing, multiple reflections etc.

3. RESULTS AND DISCUSSION

An example of the output obtained from the data loggers in terms of a time-level history is shown in Figure 1. The maximum unweighted peak levels within each minute are displayed as well as 1 minute L_{Aeq} values. The Leq figure given above the graph in Figure 1 is the L_{Aeq} from the start to the end of recording and not the start and finish of the concert. The data for all events have been reprocessed for the duration of the concert defined as from the start of the first to the finish of the last performer.

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Each concert has been coded by an identification number, the type of music and whether the concert was indoors or outdoor (eg 1RI = concert No 1, Rock Music, Indoor). A summary of the results re-processed for the defined duration of each event are shown in Table 1 along with the type of concert, audience capacity and concert duration.

The arithmetic mean and standard deviation for the L_{Aeq} and Lp data recorded at the barrier location are given in Table 2. The results are presented in terms of all concerts and also by music type. The arithmetic mean L_{Aeq} and Lp for all the concerts is 104.7dB(A) and 135.7dB(A) respectively.

As the L_{Aeq} results show the Rock, Pop, Rap and House categories have very similar mean values (L_{Aeq} range from 105.9dB(A) to 107.4dB(A)) with the Middle of the Road type music having a much lower value of 97.2dB(A). The mean peak levels also indicate the same trend as given above with the Middle of the Road music again being some 11 to 16dB(A) lower in level compared with the other music classifications.

The summary results in Table 3 relate to the measurements at the mixer location. Due to the lower number of samples compared with the barrier position only the mean and standard deviation have been calculated for all the concerts and not by music classification. The mean L_{Aeq} and Lp values are 99.6dB(A) and 128.3dB respectively.

Comparison with guidelines

At present, it is understood that the HSE guidance will include several suggested criteria relating to audience noise exposure guidelines:

i. the L_{Aeq} in any public area shall not exceed 104dB(A) over the duration of the concert.

ii. the unweighted Peak Sound Pressure Levels shall not exceed 140dB in any public area in line with preventing acoustic trauma.

iii. Members of the attending public shall not be allowed within 3 metres of an operational loudspeaker.

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For assessing these suggested guidelines against the recorded data, the maximum levels have been assumed to be those collected at the barrier position. This assumption is enforced by the short term measurements which when compared with the results at the barrier (recorded over the corresponding time period) were lower in all cases apart from one concert. The exception was at a small venue exhibiting a high reverberant field with the stage mid to high frequency loudspeakers focused towards the mixer position which was located only 15 metres from the stage. Some short term results were marginally higher nearer the mixer, typically 1dB(A) above the barrier L_{Aeq} levels.

Table 2 gives the percentage of concerts assessed in the study which exceed the proposed guidance of an L_{Aeq} of 104dB(A). As can be seen, over 60% of all the concerts exceeded this guideline with only the MOR music category proving to be below the suggested limit. In terms of the Lp results a lower percentage of concerts breached the guideline. Some 4 out of 18 (22%) of the concerts in the study exceeded 140dB. Both the Rap music concerts were above the Lp limit which is likely due to the high impulse sound levels generated at low frequency.

The audience noise exposure guideline recommended in the GLC Code of Practice for Pop Concerts(1), is 93dB(A) for an 8 hour event with the equal energy principle applying for varying concert lengths. Table 4 compares the L_{Aeq} results recorded during the survey with the GLC recommended levels. For comparison purposes the GLC L_{Aeq} limits have been calculated with reference to the concert duration and the equal energy principle. The results show that only 1 out of 18 samples met the recommended guideline.

Short Measurement Method

As mentioned earlier, a possible explanation for the non-enforcement of audience exposure criteria may be a lack of resources. Therefore the results were analysed to determine if a short measurement period could be used to represent the overall L_{Aeq} for the event. The results of this analysis showed that 5 minute samples are likely to be within -4 to +2dB(A) of the overall L_{Aeq} of the concert, whereas 10 minute and 15 minute measurement periods provide overall L_{Aeq}'s to within ±1dB(A). Thus, it would be possible for the overall L_{Aeq} of the concert to be estimated with 10 minute samples for each artiste.

4. CONCLUSIONS

1. In general the Rock, Pop, Rap and House music categories produced similar mean L_{Aeq} and L_{p} levels. The Middle of the Road music produced significantly lower values.

2. 61% of the concerts in the study exceeded the proposed HSE L_{Aeq} guideline of 104dB(A) over the period of the concert. 22% of the concerts exceeded the unweighted peak sound pressure limit of 140dB. Only 1 out of the 18 concerts met the guidance given in the GLC Code of Practice

3. The enforcement of the proposed guidelines would mean that a reduction in sound level would be required for a majority of Rock, Pop, Rap and House music concerts. The magnitude of the reduction is dependent upon the performer but the proposed guideline was achieved by one or more artistes during the survey in each music category. A significant reduction in sound levels would be required for the GLC audience exposure guidelines to be met.

4. A short measurement method described in the report can be used to provide a reliable estimate of the L_{Aeq} sound level over the duration of the concert.

5. Generally the highest levels were recorded in the smaller venues. This may be a feature of the type of music being played in the venues at the time of the survey. It is also likely to be due to the very close access given to the public to operational loudspeakers, and the high powered systems used on tour at larger indoor venues being used at much small venues with little consideration to the reduced energy required to cover the smaller area.

6. With regard to enforcement of present GLC guidelines, this was only evident at the outdoor concerts and only in terms of environmental annoyance. None of the concerts surveyed had any form of active control on audience exposure levels.

5. REFERENCES

1) Code of Practice for Pop Concerts, GLC, 1985.
2) Guidelines for environmental noise control and exposure of an audience to pop concert music; Travers Morgan Environment, May 1991.
3) Private Communication with Harvey Goldsmith Promotions, 1991.
4) Private Communication with Wembley Stadium Ltd, 1991.

6. ACKNOWLEDGEMENTS

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Table 1 - Summary of the Sound Levels Measured at the Concerts

Concert ID*	Audience Capacity	Concert Duration (mins)	L_{Aeq} Barrier	L_{Aeq} Mixer	L_p Barrier	L_p Mixer
1RI	Small	159	104.6	94.4	132.3	123.5
2RO	Large	306	102.9	99.8	137.8	127.8
3RI	Small	195	105.2	101.7	141.1	133.1
4RO	Large	465	107.0	102.0	140.0	132.0
5RO	Large	591	108.9	94.0	140.3	126.5
6RI	Medium	141	109.9	-	136.0	-
7RI	Medium	202	104.3	-	137.3	-
8PO	Large	374	106.9	97.5	136.6	124.1
9PI	Small	184	105.0	102.0	135.6	126.5
10PI	Small	160	113.0	101.0	146.0	134.0
11PI	Medium	160	102.8	-	131.3	-
12PI	Medium	126	101.6	-	133.6	-
13MI	Medium	186	98.5	-	126.6	-
14MI	Medium	140	98.8	-	124.5	-
15MI	Small	170	94.4	92.1	122.9	117.8
16AI	Small	121	112.0	104.0	142.5	133.0
17AI	Medium	180	102.8	-	141.1	-
18HI	Small	190	106.0	107.0	137.0	133.0

* Concert ID: R-Rock, P-Pop, M-Middle of the road,
A-Rap, H-House
: O-outdoor, I-indoor

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Concert Type	Sample Size	L_{Aeq}				L_p			
		mean	range	SD	% above 104dBA	mean	range	SD	% above 140dB
All Concerts	18	104.7	94.4 - 113.0	4.7	61	135.7	122.9 - 146.0	6.3	22
Rock	7	106.1	102.9 - 109.9	2.6	86	137.8	132.3 - 141.1	3.0	14
Pop	5	105.9	101.6 - 113.0	4.5	60	136.6	131.3 - 146.0	5.6	20
MOR	3	97.2	94.4 - 98.8	2.5	0	124.7	122.9 - 126.6	1.9	0
Rap	2	107.4	102.8 - 112.0	6.5	50	141.8	141.1 - 142.5	1.0	100
House	1	106.0	-		above	137	-	-	below

Table 3 - Statistical Analysis of Results at the Mixer

	Sample Size	L_{Aeq}			L_p		
		mean	range	SD	mean	range	SD
All concerts	11	99.6	92.1 - 107.0	4.6	128.3	117.8 - 134.0	5.2

TABLE 2 - Statistical Analysis of Results at the barrier

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TABLE 4 - Comparison of Concert L_{Aeq} with GLC Guidelines

Concert ID	GLC L_{Aeq} Limit*	Concert L_{Aeq}#	Comments	Conclusions
1RI	97.8	104.6	exceeded	17 out of 18 concerts (94%) exceeded the GLC guideline limit
2RO	95.0	99.8	exceeded	
3RI	96.9	105.2	exceeded	
4RO	93.1	102.0	exceeded	
5RO	92.1	94.0	exceeded	
6RI	98.3	109.9	exceeded	
7RI	96.8	104.3	exceeded	
8PO	94.1	97.5	exceeded	
9RI	97.2	105.0	exceeded	
10PI	97.8	113.0	exceeded	
11PI	97.8	102.8	exceeded	
12PI	98.8	101.6	exceeded	
13MI	97.1	98.5	exceeded	
14MI	98.4	98.8	exceeded	
15MI	97.5	94.4	limit met	
16AI	99.0	112.0	exceeded	
17AI	97.3	102.8	exceeded	
18HI	97.0	106.0	exceeded	

* Permissible concert L_{Aeq} for compliance with the GLC limit of an L_{Aeq} of 93dB(A) for an 8 hour concert

\# For outdoor concerts the mixer L_{Aeq} has been used, for indoor events the barrier L_{Aeq} is used for the comparison

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TABLE 5 - Sample Size by Music Classification

Concert Type	Number of Samples
Rock Music (R)	7
Pop Music (P)	5
MOR Music (M)	3
Rap Music (A)	2
House Music (H)	1

TABLE 6 - Venue Size

Venue Category	Audience Capacity
Small	1,000 - 5,000
Medium	5,000 - 13,000
Large	40,000 - 80,000

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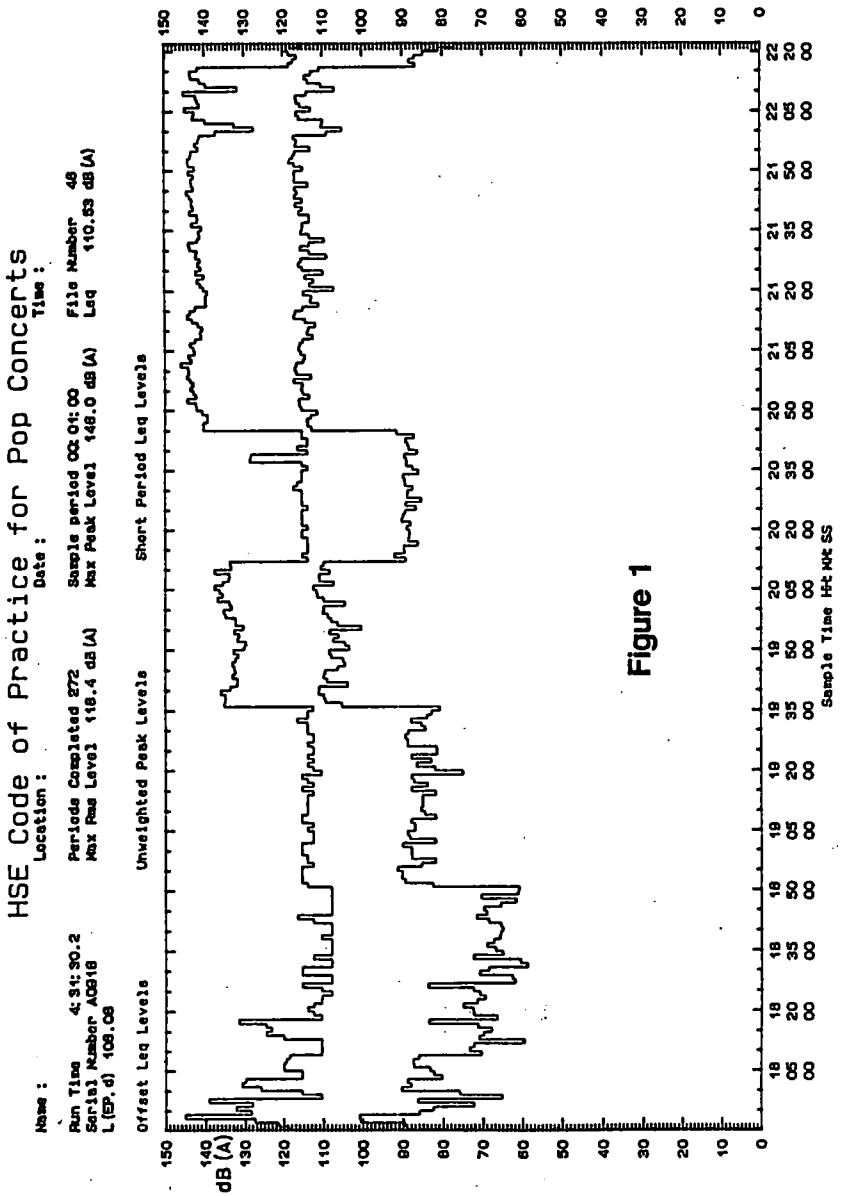

Figure 1