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HSE CONTRACT RESEARCH REPORT No. 35/1991

**A SURVEY OF SOUND LEVELS AT POP CONCERTS**

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***J E T Griffiths MIOA, MISPP***

Acoustics Group, Travers Morgan  
Environment, East Grinstead, West Sussex

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£20.00 net



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This report contains the results of a survey of sound levels in audience areas at a range of indoor and outdoor pop concerts. The events were chosen as representative of types promoted in the UK.

The results are compared with a proposed guideline included in a consultative document on safety at pop concerts and similar events issued by the Health and Safety Executive (HSE) in 1991; and with criteria in a Code of Practice on pop concerts published by the former Greater London Council (GLC). Sixty-one per cent of the concerts exceeded HSE's draft guideline; only one met the level in the GLC Code.

The report also considers the reliability of short term measurement of sound levels at concerts and the level of protection that should be provided by ear protectors.

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Technical Report  
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1.       **INTRODUCTION**

**Background**

1.01       The Health and Safety Executive 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 potential problem of the high intensity of sound produced during a concert performance.

1.02       This potential problem was discussed with Travers Morgan Environment who were commissioned to help give advice on noise guidelines in relation to:

- i.       Environmental Noise
- ii.       Audience Noise Exposure
- iii.       Employees Noise Exposure

1.03       In the course of preparing noise guidance, it was agreed that base data on audience noise exposure needed to be established in order to assess the present situation and the impact of the proposed guidance. The objective of the survey was defined and the results and conclusions of the study are presented in this report.

**Objective**

1.04       The objective of the survey was to measure sound levels within the audience at a variety of pop concerts and to compare the results with the guidelines<sup>[1]</sup> likely to be included in the HSE guidance notes and the criteria given in the GLC Code of Practice<sup>[2]</sup>.

2. **MEASUREMENT SURVEY**

**Concert and Venue Selection**

- 2.01 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. Given this requirement, it was considered that a sample of ten concerts would be required to provide a representative database.
- 2.02 The monitoring of ten concerts 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 original programme which was agreed with the HSE was successfully undertaken with the exception of two concerts where the artistes refused to let the monitoring take place. Two further concerts were arranged and in general the Promoters and Production Companies were helpful with the arrangements.
- 2.03 The names of the artistes and venues of the concerts monitored have not been included in this report, 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<sup>[3,5]</sup> and event managers<sup>[4]</sup> 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. Several surveys were however undertaken at venues where bands performed the latest trends in music described by the Rap and House definitions.

2.04 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 80,000 spectators. Each venue has been defined as either Small, Medium or Large as indicated in Table 2.

2.05 In order to provide a larger sample of concerts and venues, data recorded at eight events in the course of other 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 Tables 1.

#### Monitoring

2.06 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 called the mixer position.

- 2.07 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.
- 2.08 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 indoor venues to 50 metres at large outdoor stadia.
- 2.09 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  $\frac{3}{8}$  inch microphone and windshield. Parallel processing of the data is carried out by these instruments so that both the Unweighted Peak Level ( $L_p$ ) and short term Equivalent Continuous Sound Level ( $L_{Aeq}$ ) can be recorded simultaneously.
- 2.10 To be compatible with our existing data the instruments were set to record the maximum peak level ( $L_p$ ) and  $L_{Aeq}$  over one minute time periods throughout the duration of the concert. The specification of the data logger is given in Appendix A.
- 2.11 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 focussing, multiple reflections etc.

2.12 Sample octave band frequency measurements were made at the barrier location at a number of the concerts. This was carried out to establish the maximum sound levels in each octave band and thus determine the necessary attenuation requirements of ear protectors to meet the Noise at Work Regulations<sup>(6)</sup> for employees working by the barrier.

2.13 The octave band measurements and short-term  $L_{Aeq}$  recordings were made using a Type 1 Integrating Sound Level Meter (CEL 393B) fitted with a  $\frac{1}{2}$  inch microphone. This instrument was calibrated using a CEL calibrator (CEL 284/2).



3.           **RESULTS**

- 3.01           The sound levels recorded by the data loggers are displayed as a time-level history and are shown in figures 1 to 28 for each concert and each location. Each figure has been coded by the concert identification number, the type of music and whether the concert was indoor or outdoor (eg. 1RI = concert No.1, Rock Music, Indoor).
- 3.02           The  $L_{eq}$  figure given above each graph is the  $L_{Aeq}$  computed from the start to the end of the recording and not the start and finish of the concert. The data for all events have been re-processed for the duration of the concert defined as from the start of the first to the finish of the last performer.
- 3.03           The maximum peak sound levels recorded each minute are also shown in figures 1 to 28 with the maximum peak level printed above each graph. On some occasions maximum peak levels occurred outside the duration of the concert (ie. when the microphone was knocked during installation or removal) and on these occasions the data have been interrogated to determine the maximum peak value during the concert.
- 3.04           A summary of the results re-processed for the duration of each event are shown in table 3 along with the type of concert, audience capacity and concert length.
- 3.05           The mean and maximum sound levels recorded at preferred octave frequency bands, at the barrier, are shown in Table 7.

## 4. DISCUSSION OF RESULTS

### General Statistical Analysis

4.01 The arithmetic mean and standard deviation for the  $L_{Aeq}$  and  $L_p$  data recorded at the barrier location are given in table 4. The results are presented in terms of all concerts and also by music type. The arithmetic mean  $L_{Aeq}$  and  $L_p$  for all the concerts is 104.7dB(A) and 135.7dB(A) respectively.

4.02 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).

4.03 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.

4.04 The summary results in table 5 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  $L_p$  values are 99.6dB(A) and 128.3dB respectively.

### Comparison with guidelines

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

- i. the  $L_{Aeq}$  at any location where the public can circulate, 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.

4.06 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 supported 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 focussed 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.

4.07 Table 4 gives the percentage of concerts assessed in the study which exceed the proposed HSE guidance of an  $L_{Aeq}$  of 104dB(A). As can be seen, over 60% of all the concerts exceeded this proposed guideline with the Rock music category proving to be worst offender as six out of the seven samples breached the suggested limit. Conversely, MOR music samples were all within the  $L_{Aeq}$  guideline.

4.08 In terms of the  $L_p$  results a lower percentage of concerts breached the proposed guideline. Some 4 out of 18 (22%) of the concerts in the study

exceeded 140dB. Both the Rap music concerts were above the  $L_p$  limit which is likely due to the high sound levels generated at low frequency and the impulsive nature of this type of music.

4.09 The audience noise exposure guidelines recommended in the GLC Code of Practice for Pop Concerts<sup>[2]</sup>, is 93dB(A) for an 8 hour event with the equal energy principle apply for varying concert lengths. For outdoor venues, the guideline is set at 50 metres from the speakers and for indoor events the guideline applies to any member of the audience.

4.10 Table 6 compares the event  $L_{Aeq}$  levels with the GLC recommended limits which have been adjusted with reference to the duration of each concert. To enable a fair comparison for outdoor events, the mixer  $L_{Aeq}$  results have been used (the mixer position varied between 40 and 50 metres from the speakers at outdoor shows). In contrast for indoor events the barrier  $L_{Aeq}$  results have been used for the comparison to assess the guideline at the highest audience noise exposure. The results show that only 1 out of the 18 concerts under investigation met the GLC guidelines.

#### Short Measurement Method

4.11 As it has been discussed, the maximum  $L_{Aeq}$  sound levels are most likely to occur by the front barrier position. Making practical measurements at this position throughout the duration of the event can be difficult and the reliability of shorter measurement periods to represent the overall  $L_{Aeq}$  have been assessed. The results show that 5 minute samples are likely to be within -4 to +2dB(A) of the overall  $L_{Aeq}$  of the performance, whereas 10 minute

and 15 minute measurement periods provide  $L_{Aeq}$  results to within  $\pm 1dB(A)$ .

4.12

Given these results the overall  $L_{Aeq}$  of the concert can be estimated and assessed during an event knowing:

i. the 10 minute  $L_{Aeq}$  of each performer (dBA)  
=  $L_n$

ii. the duration of each performance  
(minutes) =  $t_n$

iii. the duration of the concert (minutes)  
=  $T$

$$L_{Aeq} (\text{Concert}) = 10 \log \frac{1}{T} \left[ t_1 10^{\frac{L_1}{10}} + t_2 10^{\frac{L_2}{10}} \dots t_n 10^{\frac{L_n}{10}} \right]$$

#### Octave Band Sound Pressure Levels

4.13

Table 7 shows the maximum and mean sound pressure levels recorded in each octave band at the barrier position. Assuming a worst case scenario, the maximum levels have been used to give a guide to the assumed protection (mean attenuation minus standard deviation) that has to be provided by ear protectors to achieve 'A' weighted sound levels of below 90dB. The assumed protection figures are given in Table 8 and give suggested guidance as to the level of protection required for employees who have to work by the front barrier.

5. **CONCLUSIONS**

- 5.01 The arithmetic mean  $L_{Aeq}$  sound level over the duration of all the concerts in the survey was 104.7dB(A) at the barrier location and 99.6dB(A) at the mixer position. The respective mean peak sound pressure levels ( $L_p$ ) were 135.7dB and 128.3dB.
- 5.02 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.
- 5.03 The maximum levels in all but one concert were recorded at the barrier position. The one exception produced marginally higher  $L_{Aeq}$  levels (typically 1dB(A)) near the mixer position due to loudspeaker focussing and the high reverberant sound field exacerbated by the acoustics of the venue.
- 5.04 61% of the concerts in the study exceeded the suggested  $L_{Aeq}$  guideline of 104dB(A) over the period of the concert. 22% of the concerts exceeded the unweighted peak sound pressure limit of 140dB.
- 5.05 Almost no compliance was evident in terms of attempting to meet the guidelines for minimising the audience exposure given in the GLC Code of Practice. Only 1 out of the 18 concerts met the guideline recommendations.
- 5.06 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.

5.07

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 but it is likely to be due to:

- i. the very close access given to the public to operational loudspeakers
- ii. the high powered systems used on tour at larger indoor venues being used at much smaller venues with little consideration to the reduced energy required to cover the smaller area.

5.08

A larger sample of sound levels in the smaller clubs would be useful to establish whether these levels are typical of the audience exposure received at these types of venues.

6.

**REFERENCES**

- 1) Guidelines for environmental noise control and exposure of an audience to pop concert music; Travers Morgan Environment, May 1991.
- 2) Code of Practice for Pop Concerts, GLC, 1985.
- 3) Private Communication with Harvey Goldsmith Promotions, 1991.
- 4) Private Communication with Wembley Stadium Ltd, 1991.
- 5) Private communications with MCP Ltd, 1991
- 6) Noise at Work Regulations, HSE, 1989.



**TABLE 1 - Sample Size by Music Classification**

Concert Type	Number of Samples
Rock Music	7
Pop Music	5
MOR Music	3
Rap Music	2
House Music	1

**TABLE 2 - Venue Size**

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

**Table 3 - Summary of the Sound Levels Measured at the Concerts**

Concert ID*	Audience+ Capacity	Concert Duration (mins)	L <sub>Aeq</sub> Barr-ier	L <sub>Aeq</sub> Mix-er	L <sub>p</sub> Barr-ier	L <sub>p</sub> Mix-er
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 No/Concert Type/Outdoor or Indoor (O or I)

Concert Types:

- R - Rock music
- P - Popular music
- M - Middle of the road music
- A - Rap music
- H - House music

+ Audience capacity:      Small venue- 1000-5000  
    Medium venue- 5000-13,000  
    Large venue- 40,000-80,000

**TABLE 4 - Statistical Analysis of Results at the barrier**

Concert Type	Sample Size	L <sub>Aeq</sub>				L <sub>p</sub>			
		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 5 - Statistical Analysis of Results at the mixer**

	Sample Size	L <sub>Aeq</sub>			L <sub>p</sub>		
		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 6 - 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

**Table 7 - Mean and Maximum Sound Pressure Levels Recorded at Preferred Octave Band Frequencies at the Barrier Position**

Frequency Hz	31.5	63	125	250	500	1K	2K	4K	8K
Mean/dB	111	115	114	103	100	98	96	90	82
Maximum/ dB	116	120	118	107	103	100	100	93	88

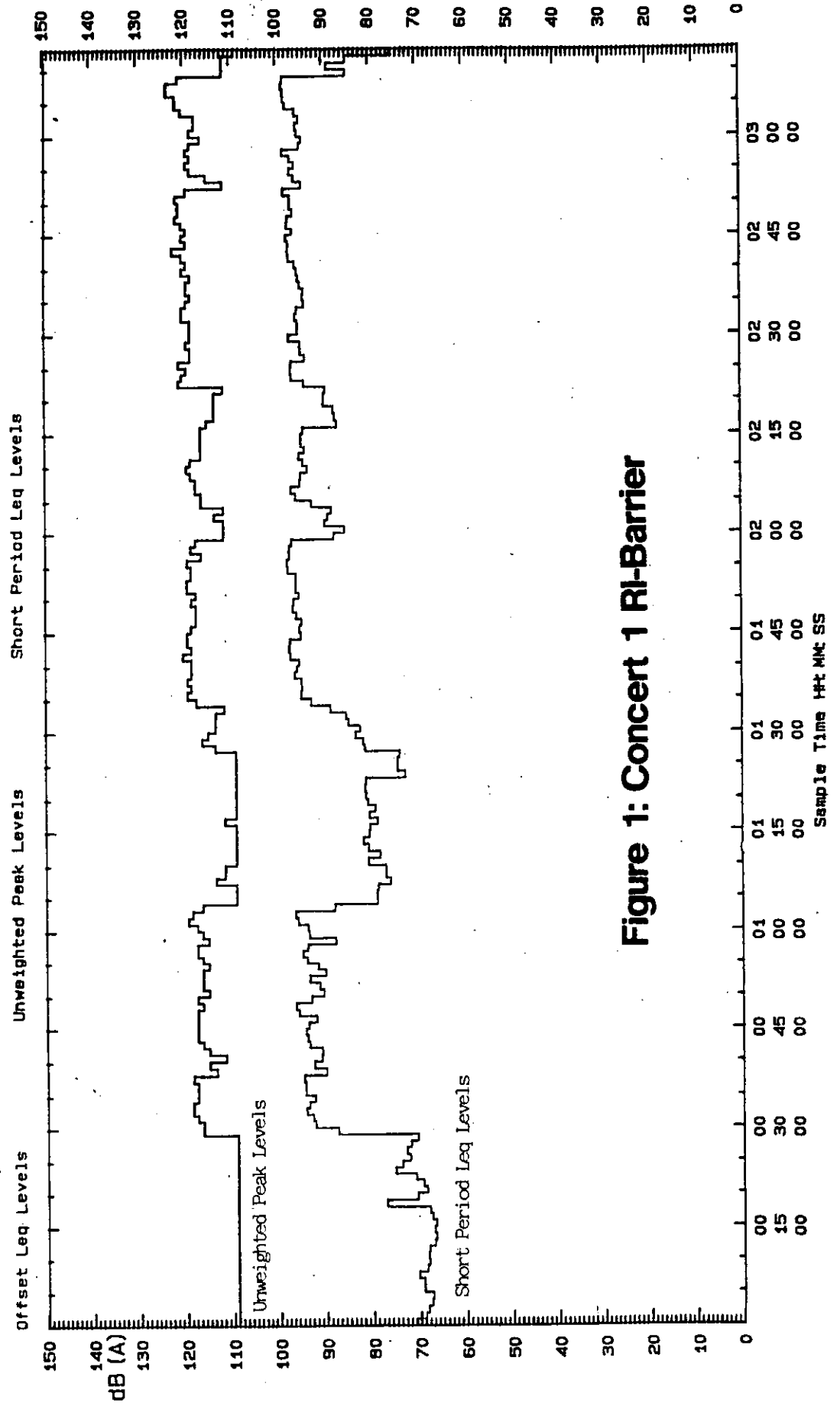
**Table 8 - Assumed Protection Required for Employees working in Areas Near Sound Systems**

Frequency - Hz	63	125	250	500	1K	2k upwards
Assumed Protection /dB	14	17	16	17	18	>25

**Time - Level Histories**

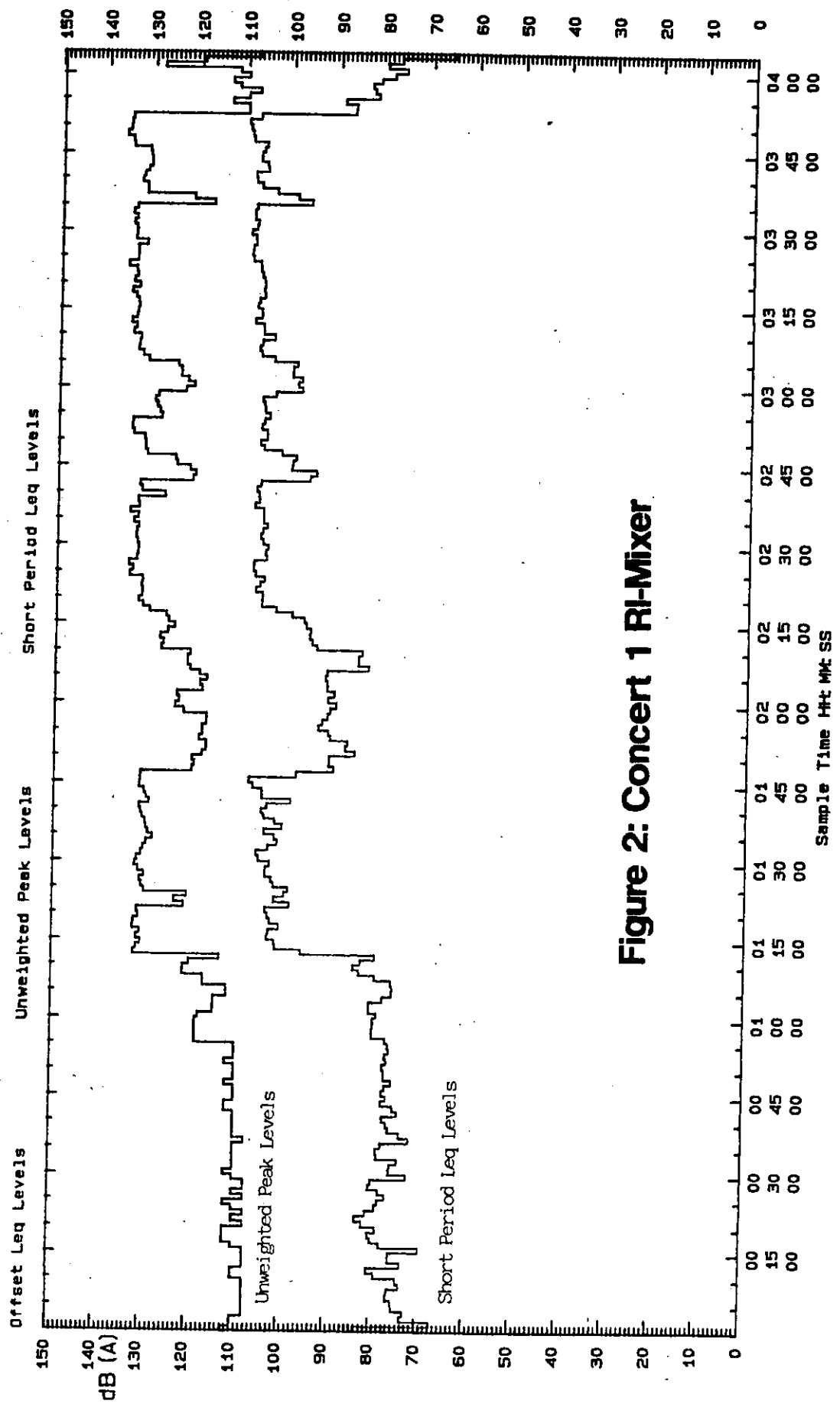
**Figures 1 to 28**

Run Time 3:12:01.5      Periods Completed 193      Sample period 00:01:00      File Number 28  
 Serial Number A1108      Max Rms Level 98.9 dB(A)      Max Peak Level 123.5 dB(A)      Leq 93.61 dB(A)  
 L(EP,d) 89.63



**Figure 1: Concert 1 RI-Barrier**

Run Time 4:03:01.0      Periods Completed 244      Sample period 00:01:00      File Number 27  
 Serial Number A0915      Max Rms Level 109.8 dB (A)      Max Peak Level 136.1 dB (A)      Leq 102.77 dB (A)  
 L (EP, d) 99.92

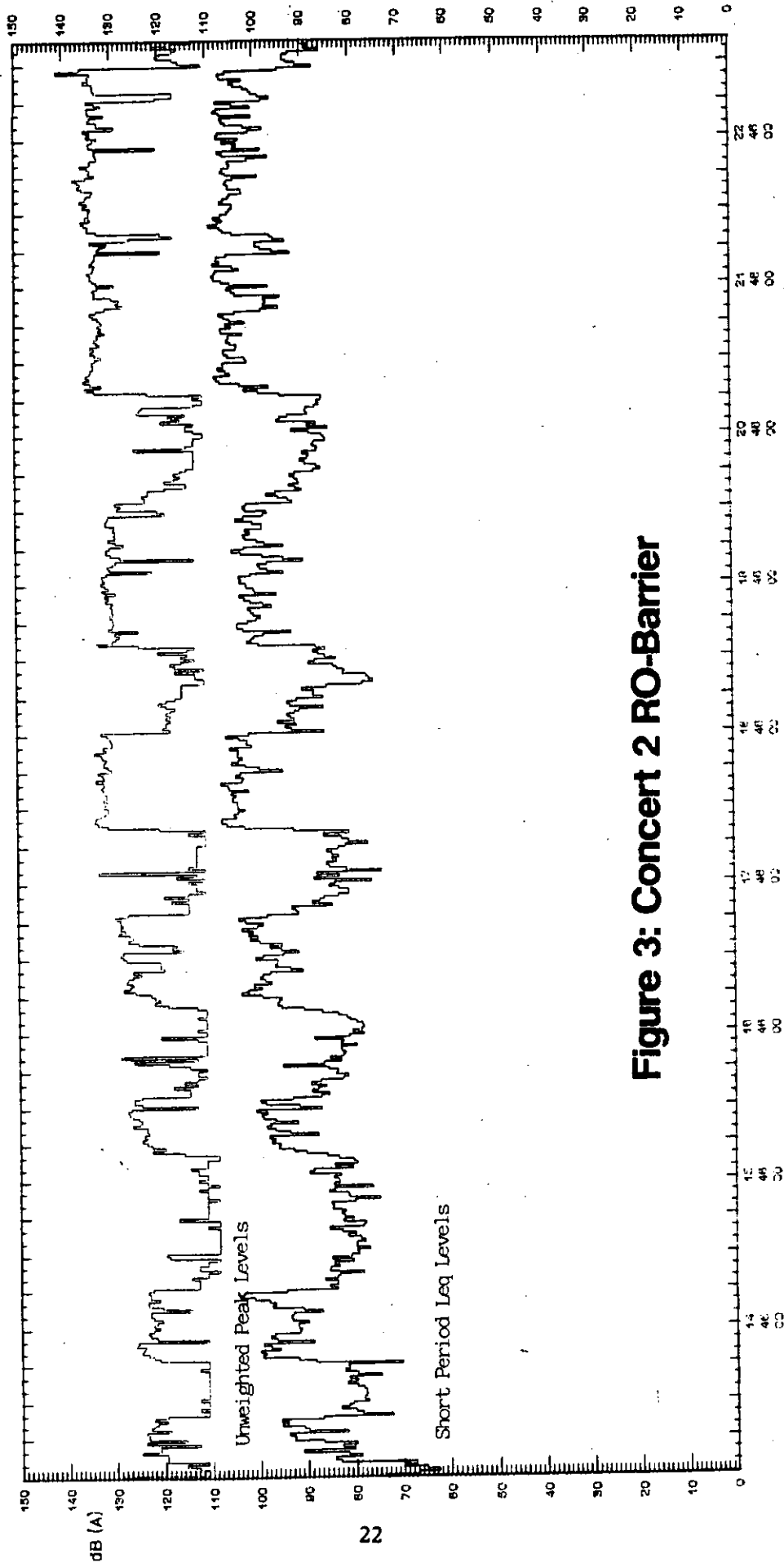


**Figure 2: Concert 1 RI-Mixer**



# HSE Code of Practice for Pop Concerts

Run Time 02:58:29.0      Periods Completed 679      Sample Period 00:01:00      File Number 38  
 Ser-13] Number: A0910      Max Peak Level 109.4 dB(A)      Max Peak Level 141.3 dB(A)      Leq 100.05 dB(A)  
 L (EP, d) 101.45      Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels

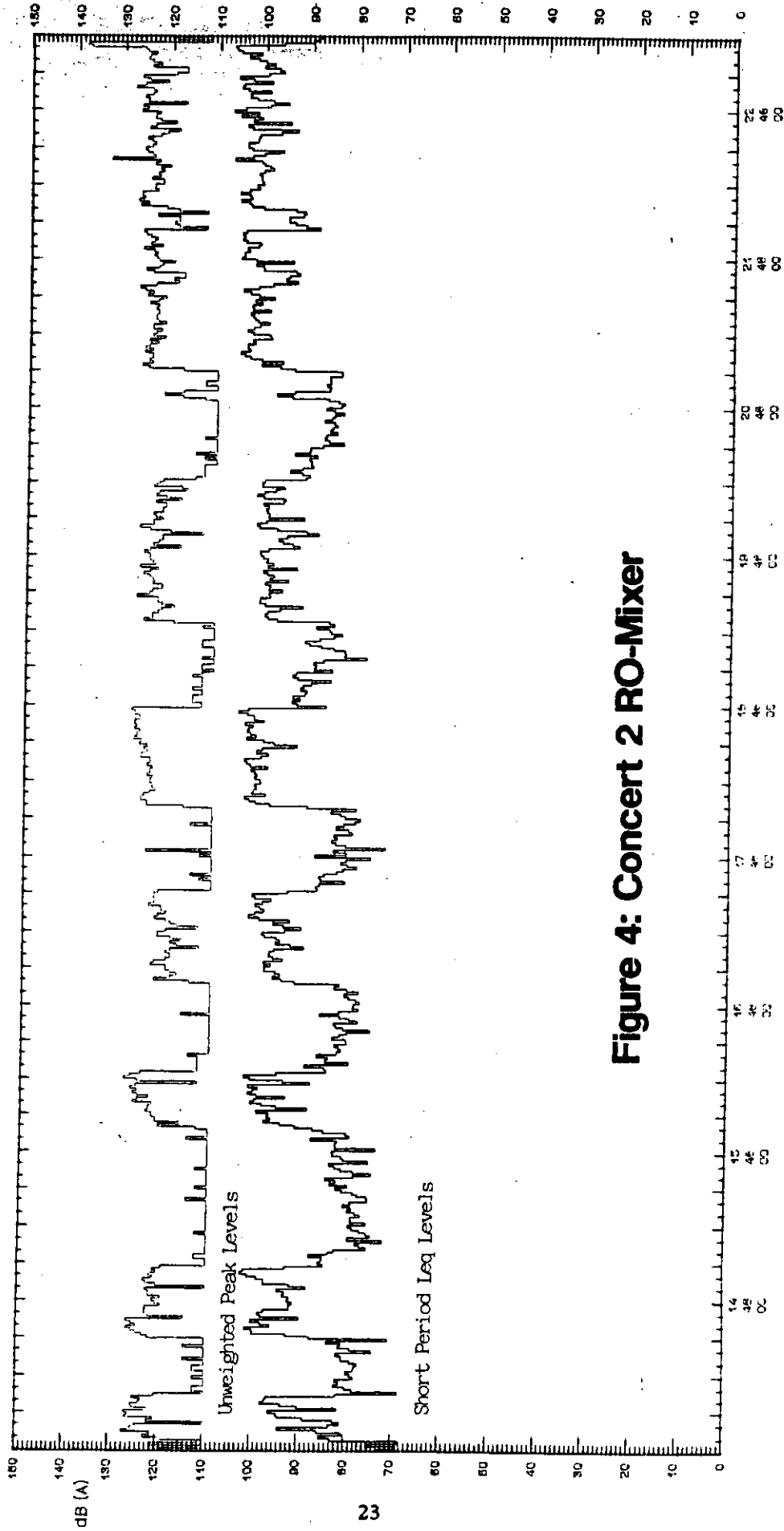


**Figure 3: Concert 2 RO-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time 02:28:13.0      Periods Completed 570      Sample period 02:01:00      File Number 57  
 Serial Number A1100      Max Run Level 107.0 dB(A)      Max Peak Level 136.5 dB(A)      Leq 96.07 dB(A)  
 L (EP, d) 06.61

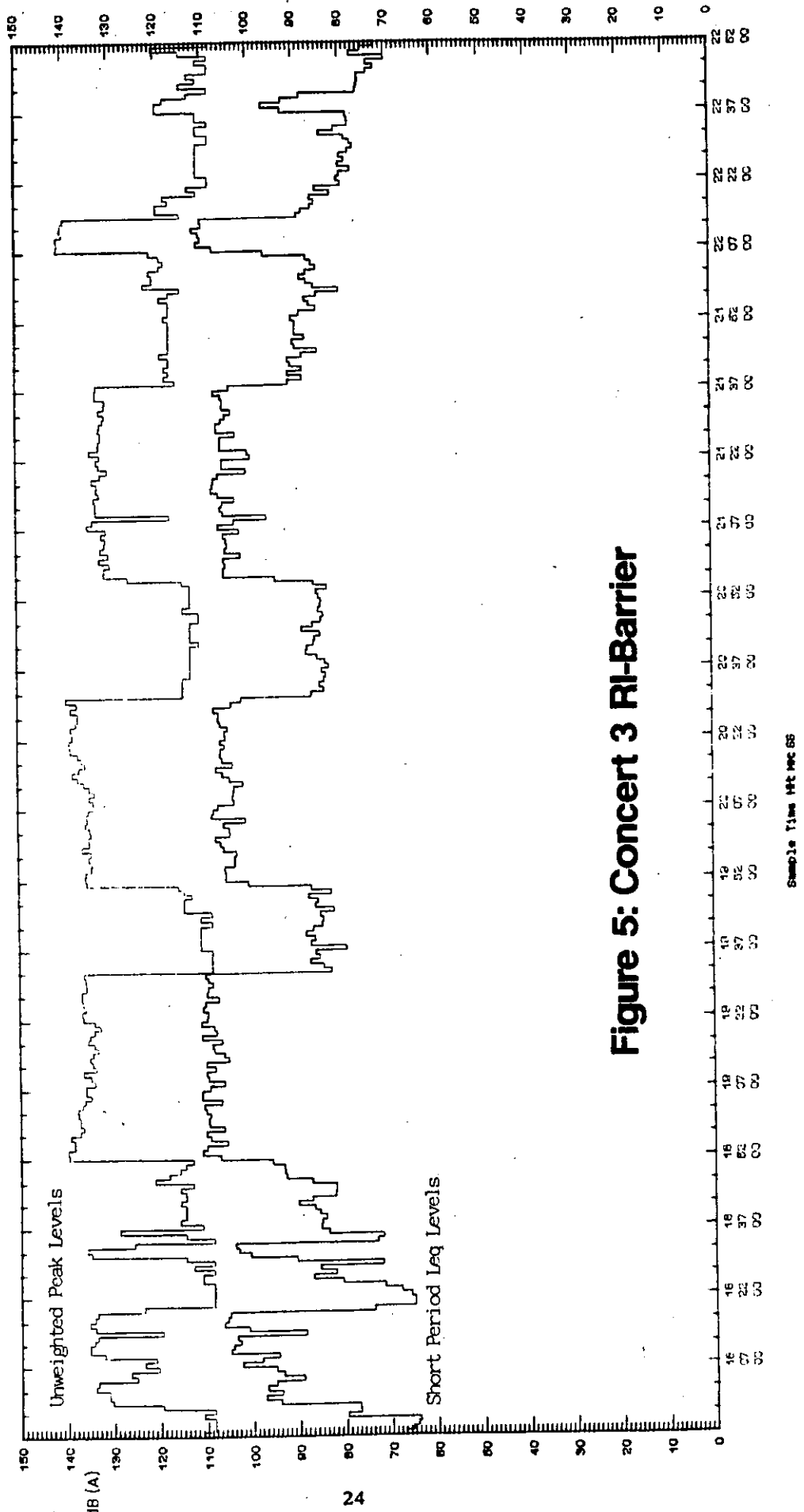
Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



**Figure 4: Concert 2 RO-Mixer**

# HSE Code of Practice for Pop Concerts

Run Time 4:02:32.9      Periods Completed 300      Sample Period 03:01:00      File Number 36  
 Serial Number A0816      Max Res Level 111.0 dB(A)      Max Peak Level 141.1 dB(A)      Leq 103.76 dB(A)  
 L (EP, d) 04.74      Orient Leq Levels      Unweighted Peak Levels      Short Period Leq Levels

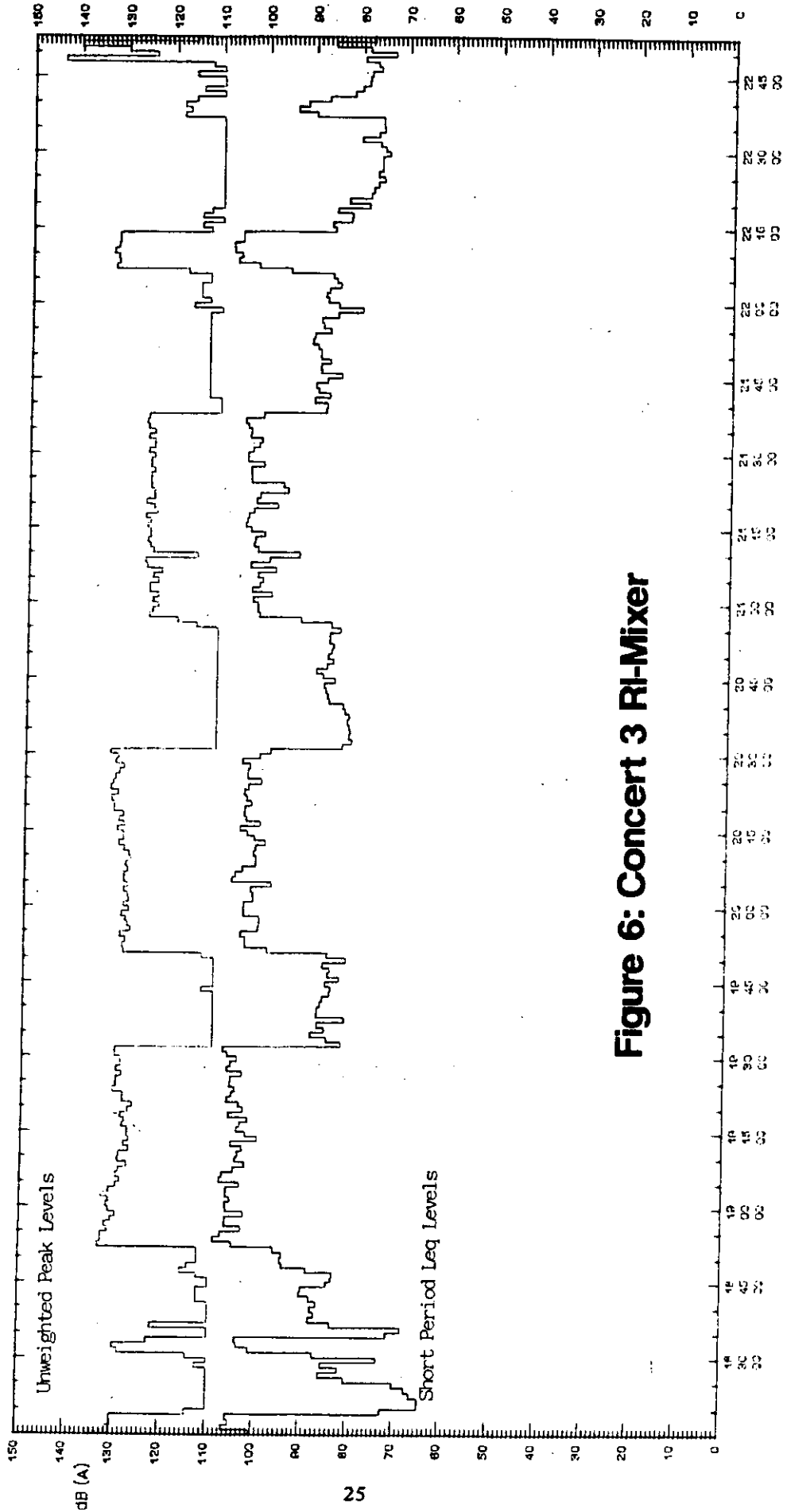


**Figure 5: Concert 3 RI-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time 4:37:45.9      Periods Completed 279      Sample Period 00:01:00      File Number 38  
 Serial Number A1106      Max Pms Level 100.0 dB(A)      Max Peak Level 143.5 dB(A)      Leq 100.87 dB(A)

Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels

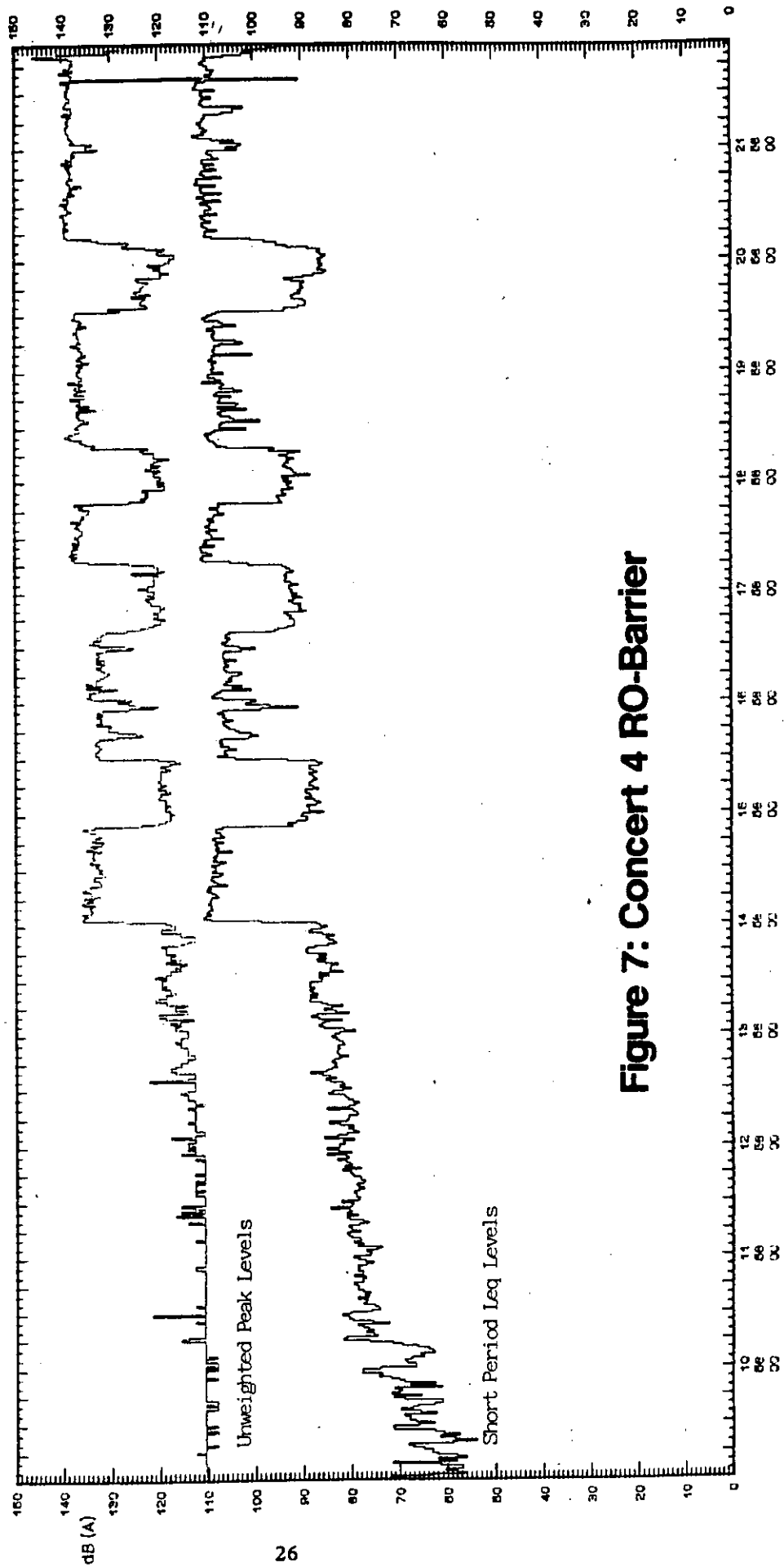


**Figure 6: Concert 3 RI-Mixer**

# HSE Code of Practice for Pop Concerts

Run Time 12:00:48.8      Periods Completed 777      Sample Period 00:01:00      File Number 43  
 Series Number A0818      Max Peak Level 112.5 dB(A)      Max Peak Level 146.0 dB(A)      Leq 104.44 dB(A)

L (EP, d) 108.86      Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



**Figure 7: Concert 4 RO-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time 13:22:43.8  
 Serial Number A1108  
 L (EP, d) 101.01

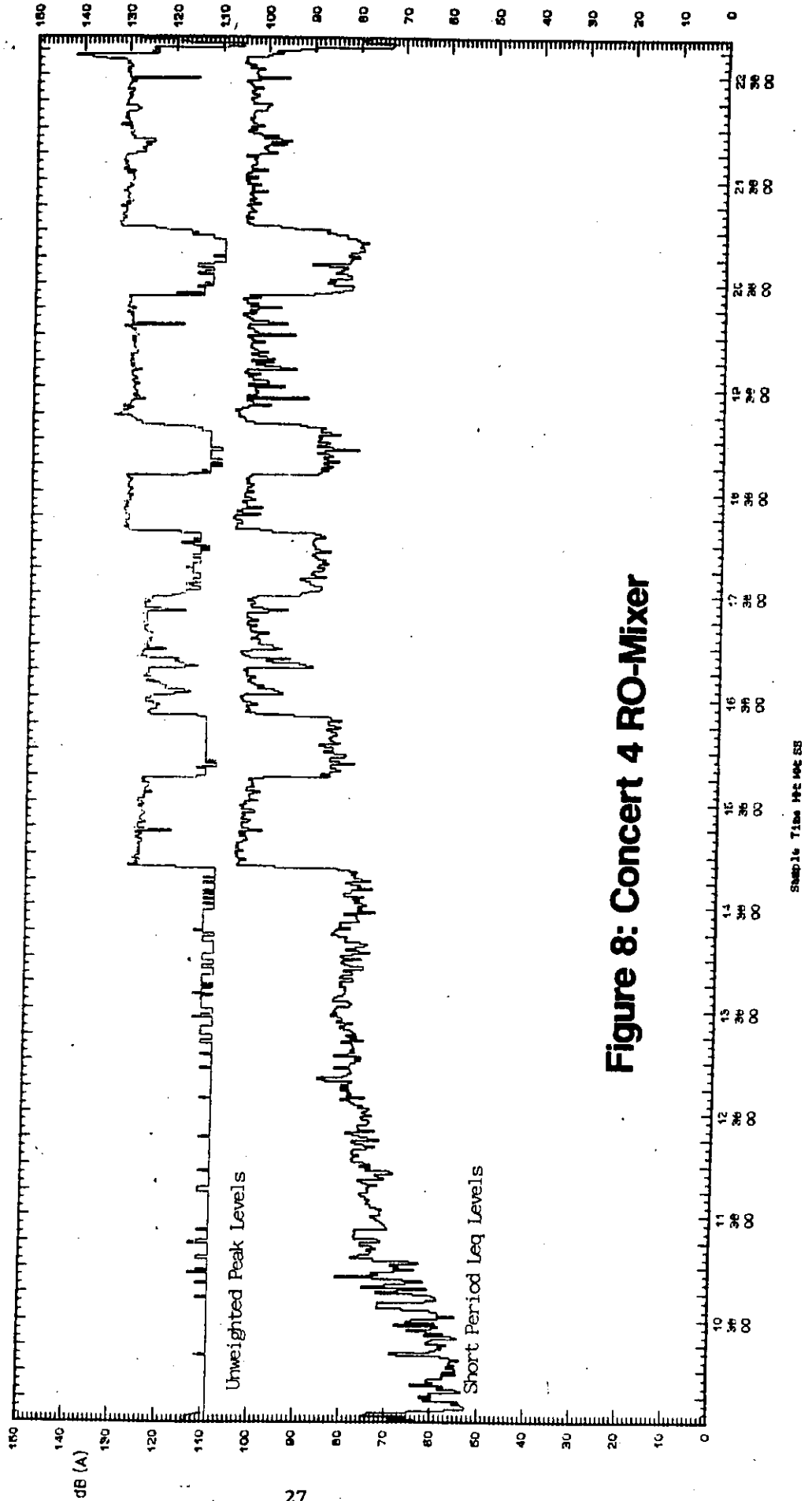
Periods Completed 803  
 Max Peak Level 100.4 dB(A)

Sample Period 02:04:00  
 File Number 44  
 Max Peak Level 141.6 dB(A)  
 Leq 90.76 dB(A)

Offset Leq Levels

Unweighted Peak Levels

Short Period Leq Levels



**Figure 8: Concert 4 RO-Mixer**

Sample Time 13:22:43.8

Travers Morgan

Run Time 10:30:10.3      Periods Completed 640      Sample Period 00:01:00      File Number 1  
 Serial Number A0916      Max Peak Level 115.3 dB(A)      Max Peak Level 140.3 dB(A)      Leq 108.78 dB(A)

Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels

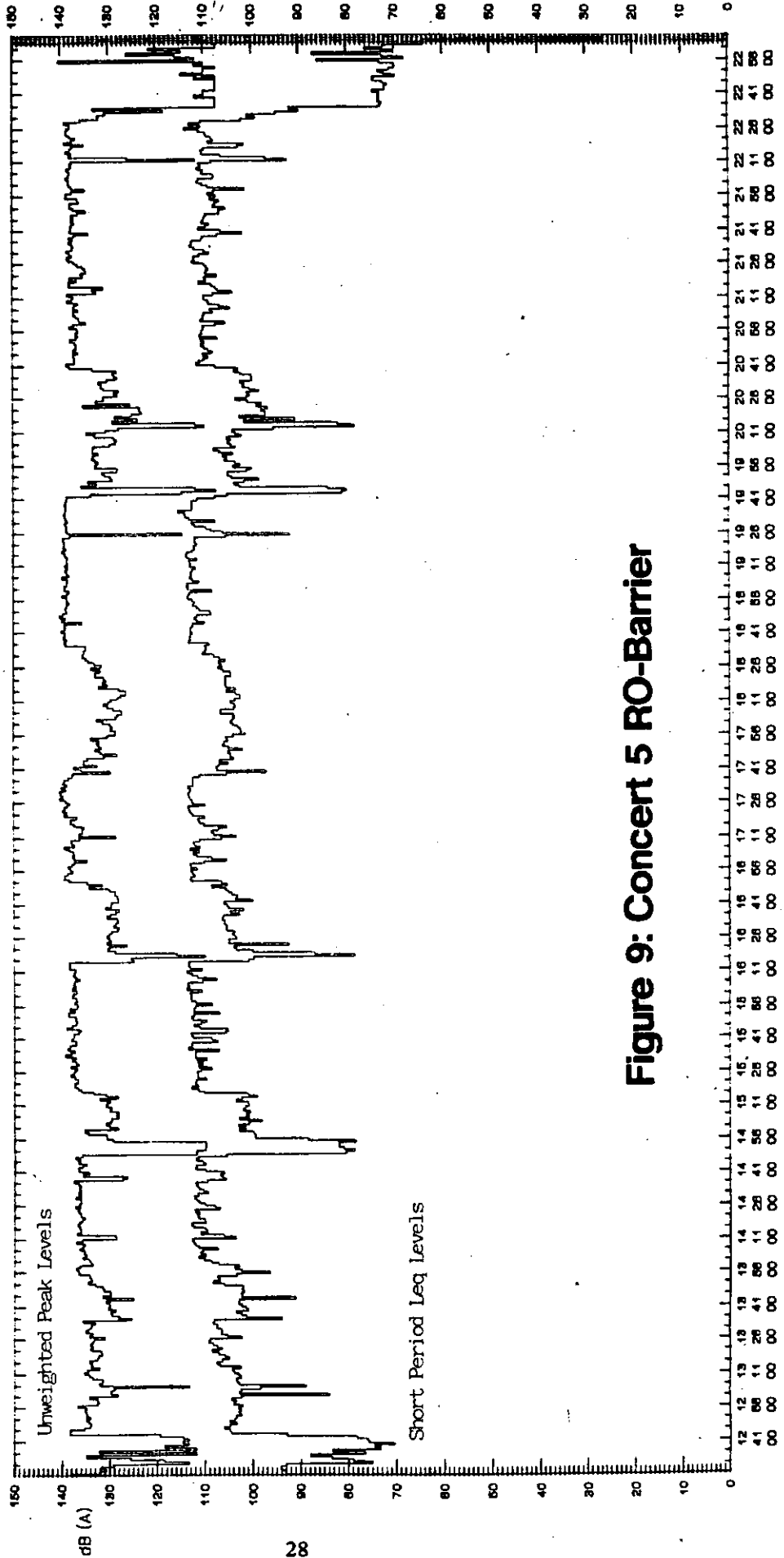


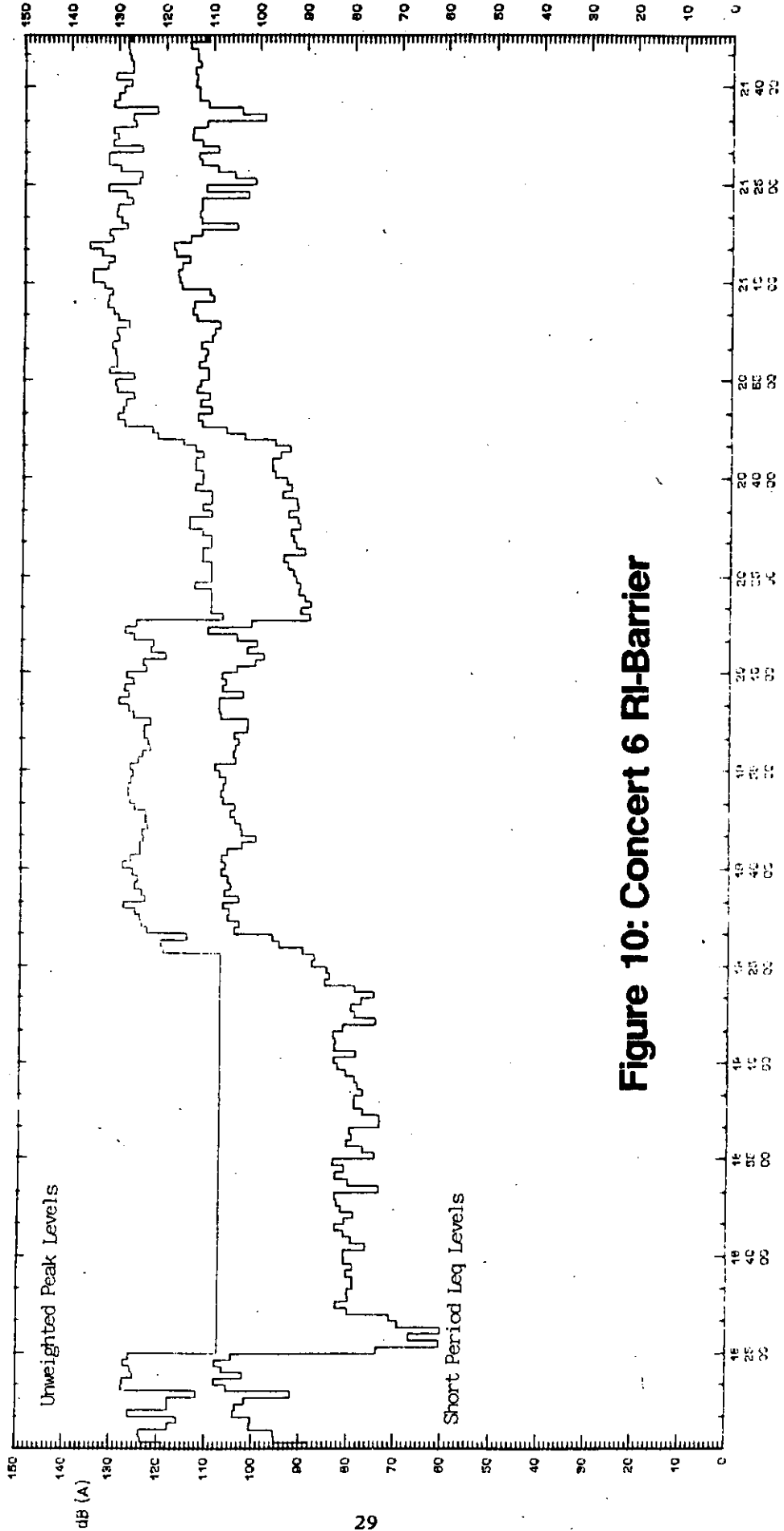
Figure 9: Concert 5 RO-Barrier

Sample Time H:M:SS

# HSE Code of Practice for Pop Concerts

Run Time 3:57:39.7      Periods Completed 219      Sample Period 00:01:00      File Number 18  
 Serial Number A0918      Max Peak Level 118.3 dB(A)      Max Peak Level 136.0 dB(A)      Leq 106.14 dB(A)  
 L (EP, d) 104.70

Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



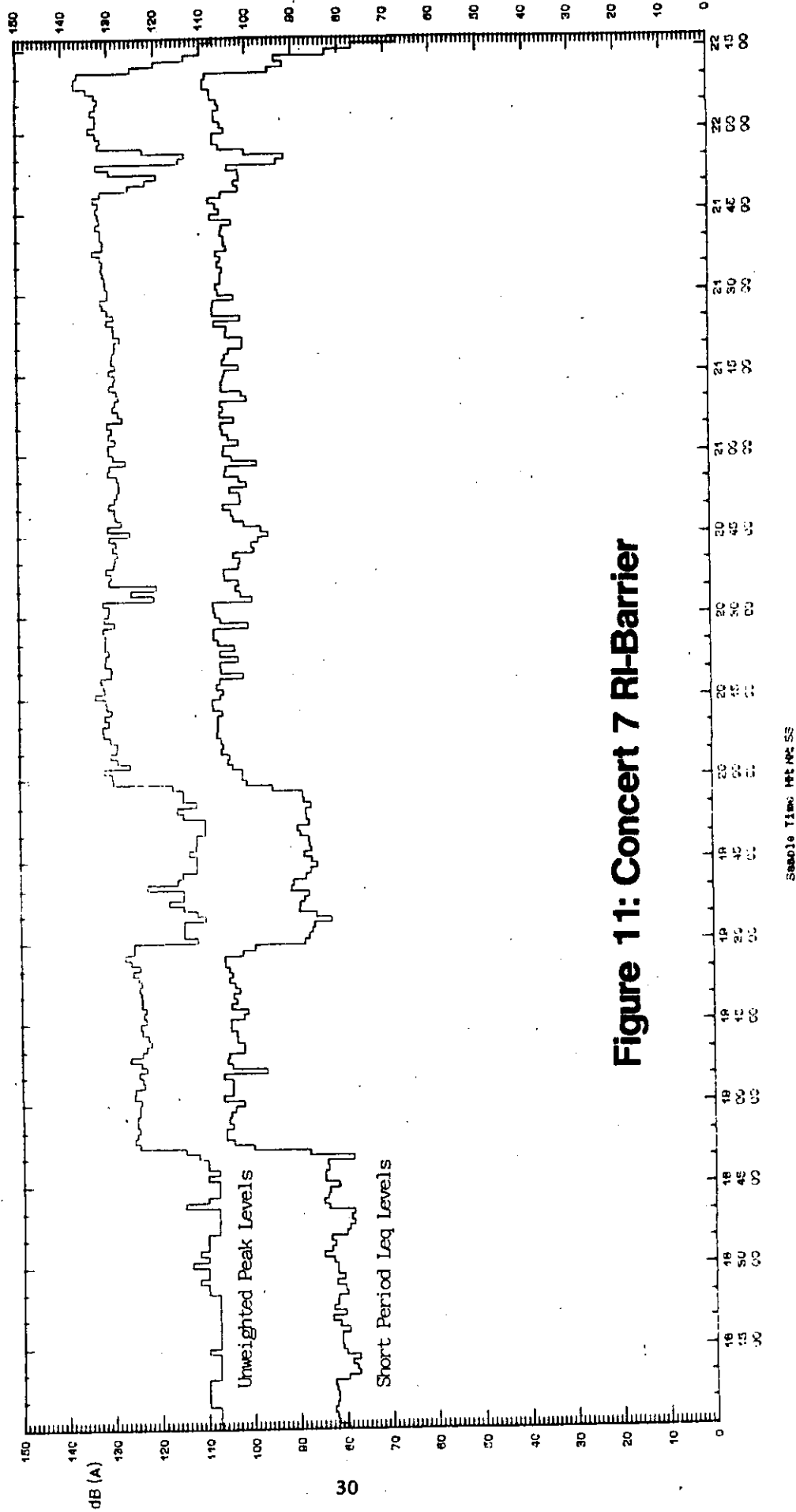
Sample Time HH:MM:SS

**Figure 10: Concert 6 RI-Barrier**



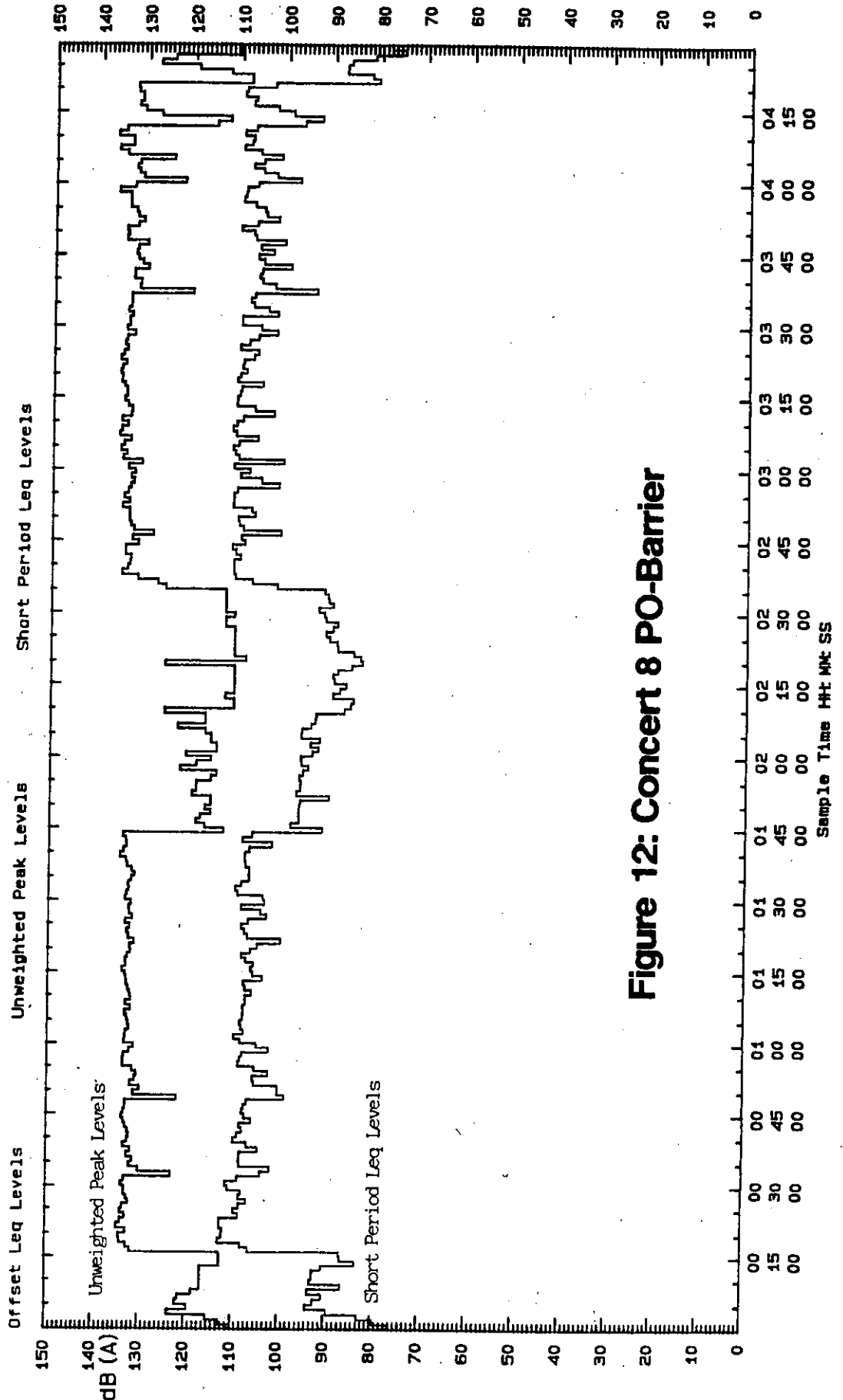
# HSE Code of Practice for Pop Concerts

Run Time 4:18:17.8      Periods Completed 207      Sample Period 03:04:00      File Number 23  
 Serial Number A0918      Max Peak Level 109.5 dB(A)      Max Peak Level 157.3 dB(A)      Leq 109.34 dB(A)  
 L (EP, d) 100.61      Offset Leq Level      Unweighted Peak Level      Short Period Leq Level



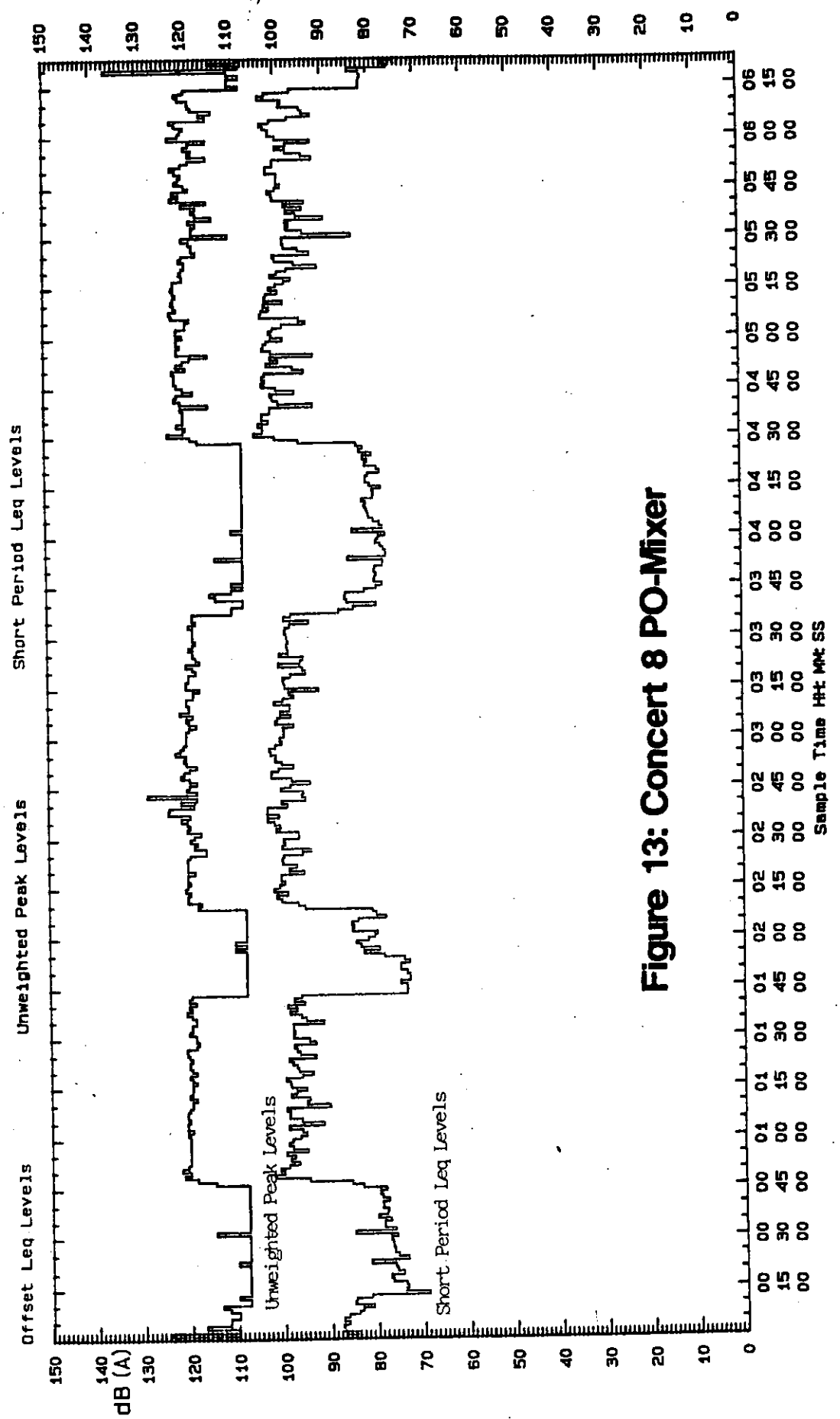
**Figure 11: Concert 7 RI-Barrier**

Run Time 4:28:55.2      Periods Completed 269      Sample period 00:01:00      File Number 90  
 Serial Number A1108      Max Rms Level 112.8 dB(A)      Max Peak Level 136.6 dB(A)      Leq 105.54 dB(A)  
 L(EP,d) 104.02



**Figure 12: Concert 8 PO-Barrier**

Run Time 16:22:57.4      Periods Completed 383      Sample period 00:01:00      File Number 29  
 Serial Number A0916      Max Rms Level 104.9 dB(A)      Max Peak Level 136.6 dB(A)      Leq 97.44 dB(A)  
 L (EP, d) 96.46

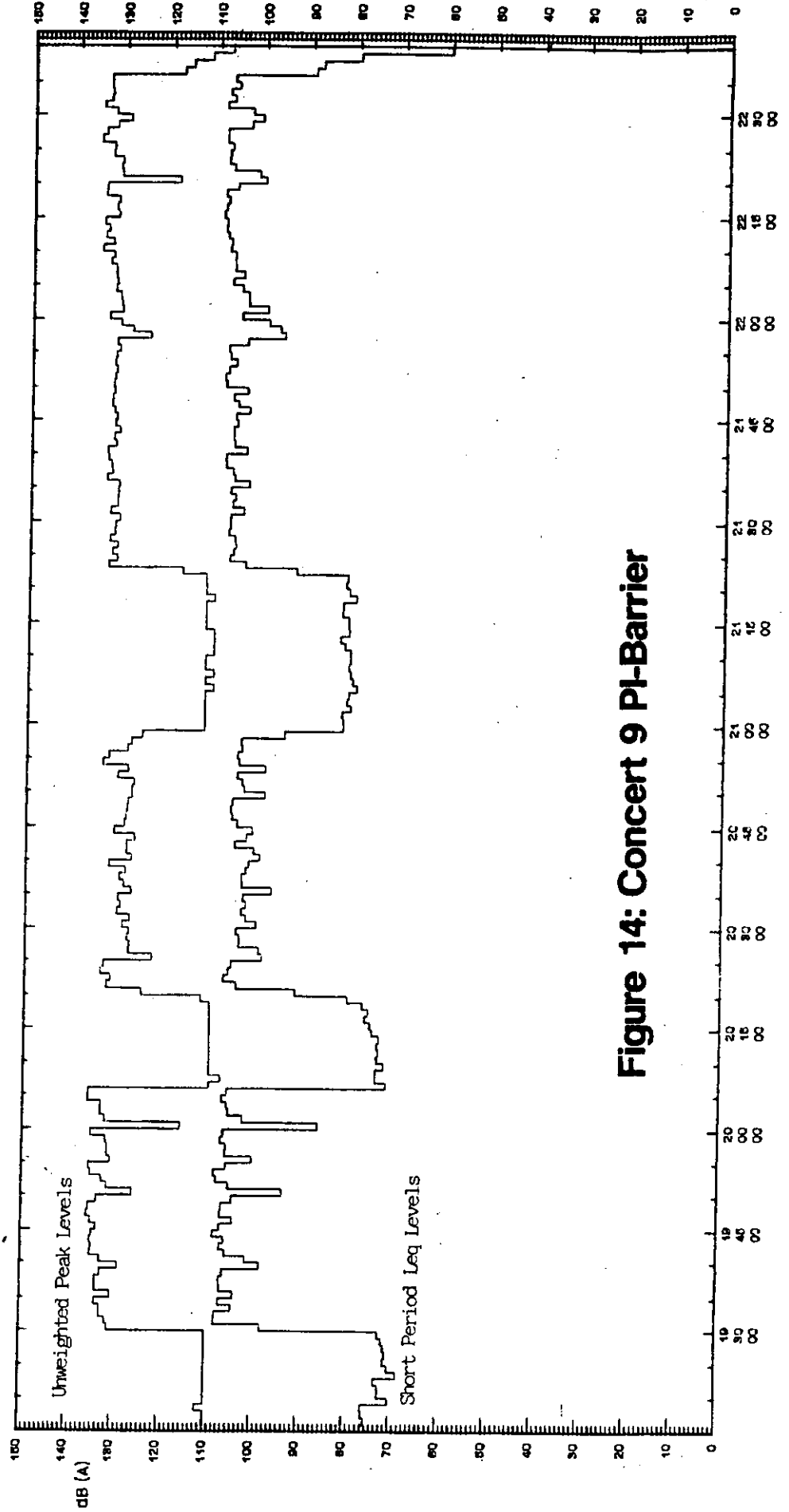


**Figure 13: Concert 8 PO-Mixer**

# HSE Code of Practice for Pop Concerts

Run Time 31:24:00.3      Periods Completed 207      Sample period 00:04:00      File Number 42  
 Serial Number A0010      Max Peak Level 100.0 dB(A)      Max Peak Level 135.5 dB(A)      Leq 104.00 dB(A)  
 L (EP. 0) 100.30

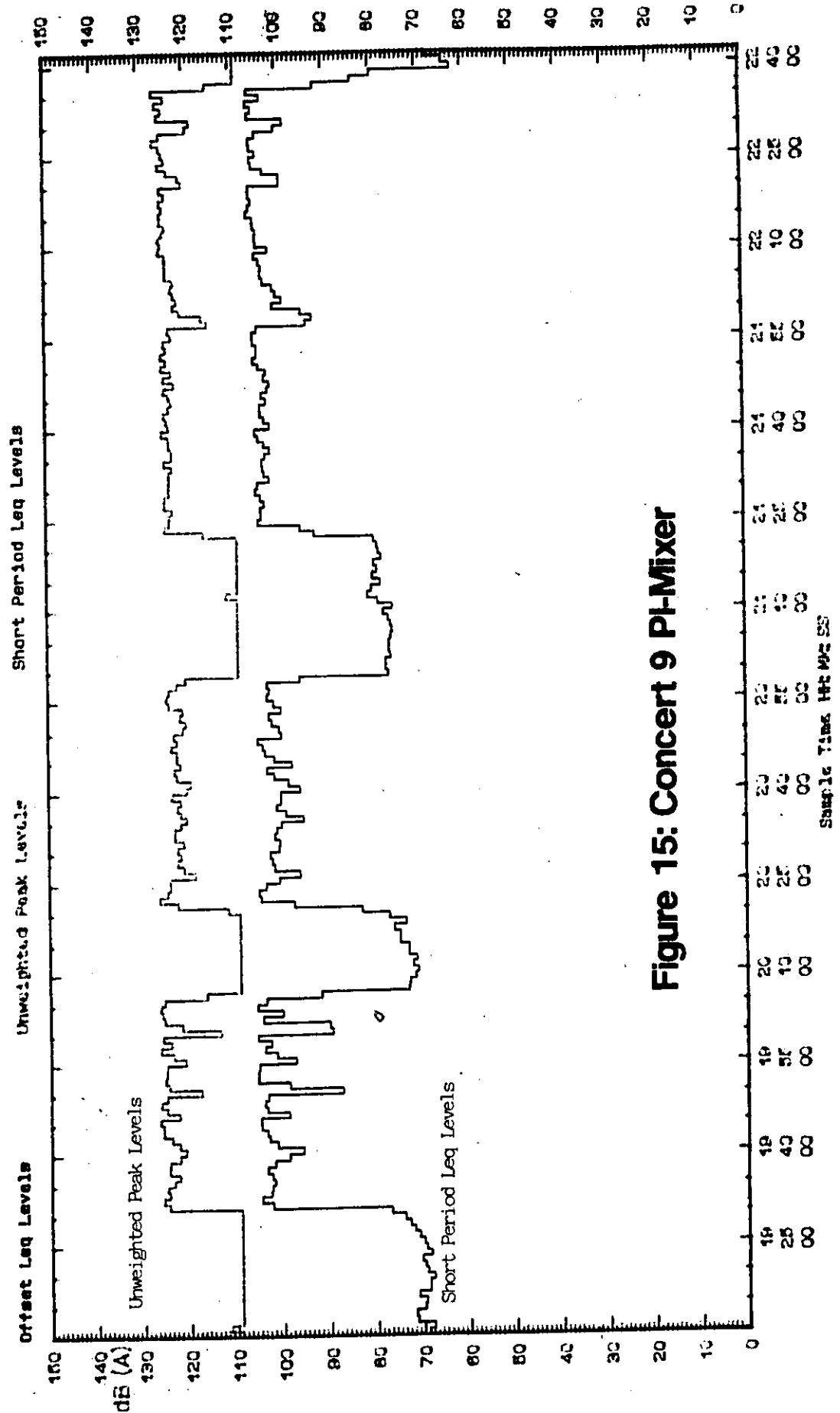
Off-set Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



**Figure 14: Concert 9 PI-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time 3:31:58.9      Periods Completed 212      Sample period 00:01:00      File Number 41  
 Serial Number A1108      Max Rms Level 108.5 dB(A)      Max Peak Level 128.5 dB(A)      Leg 101.44 dB(A)  
 L(FP.d) 87.89

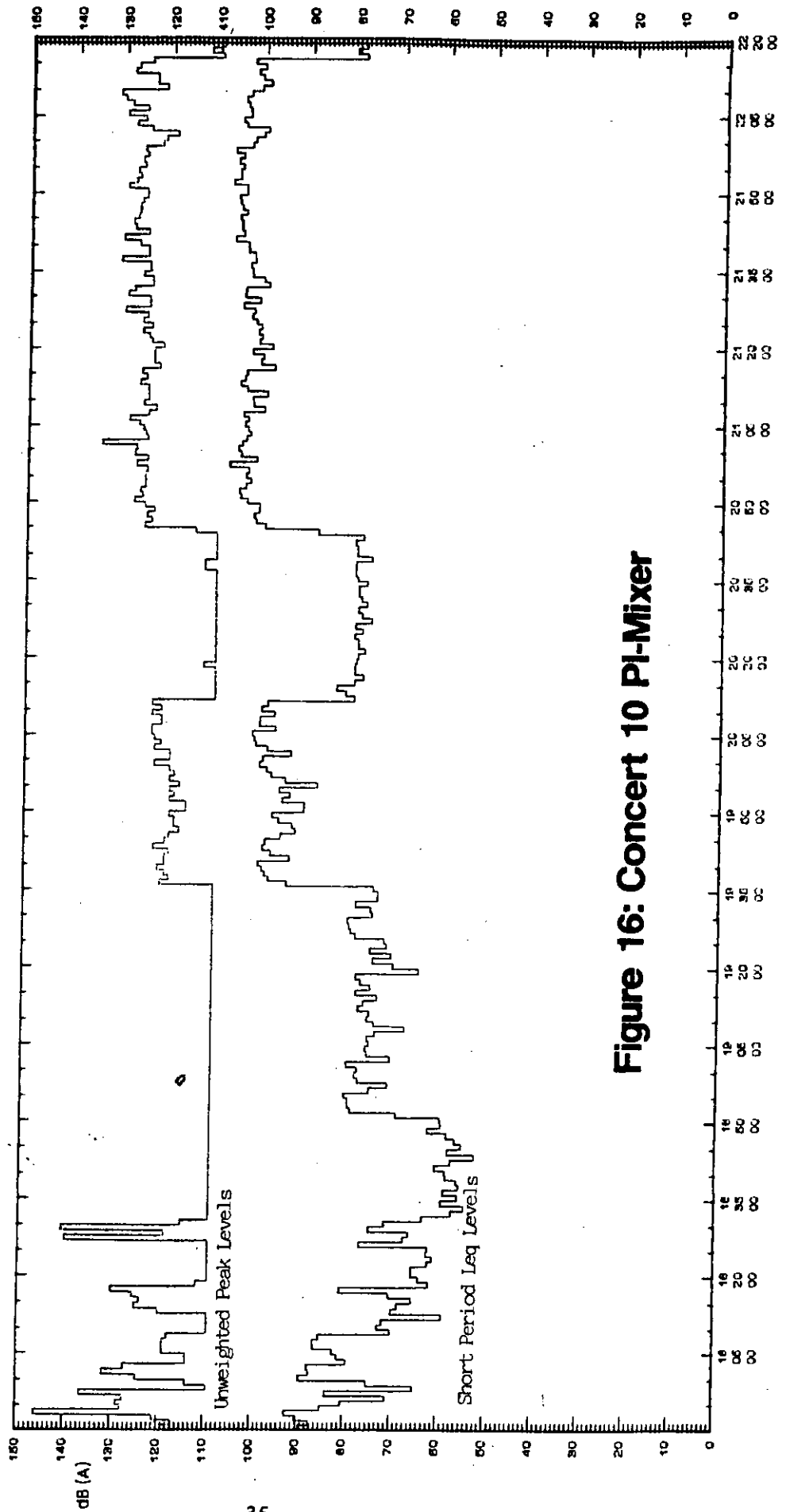


**Figure 15: Concert 9 PI-Mixer**

# HSE Code of Practice for Pop Concerts

Run Time 4:28:18.1      Periods Completed 270      Sample period 02:04:00      File Number 45  
 Serial Number A1103      Max Run Level 100.9 dB(A)      Max Peak Level 148.1 dB(A)      Leg 50.03 dB(A)  
 L (EP, G) 90.00

Offset Leg Levels      Unweighted Peak Levels      Short Period Leg Levels

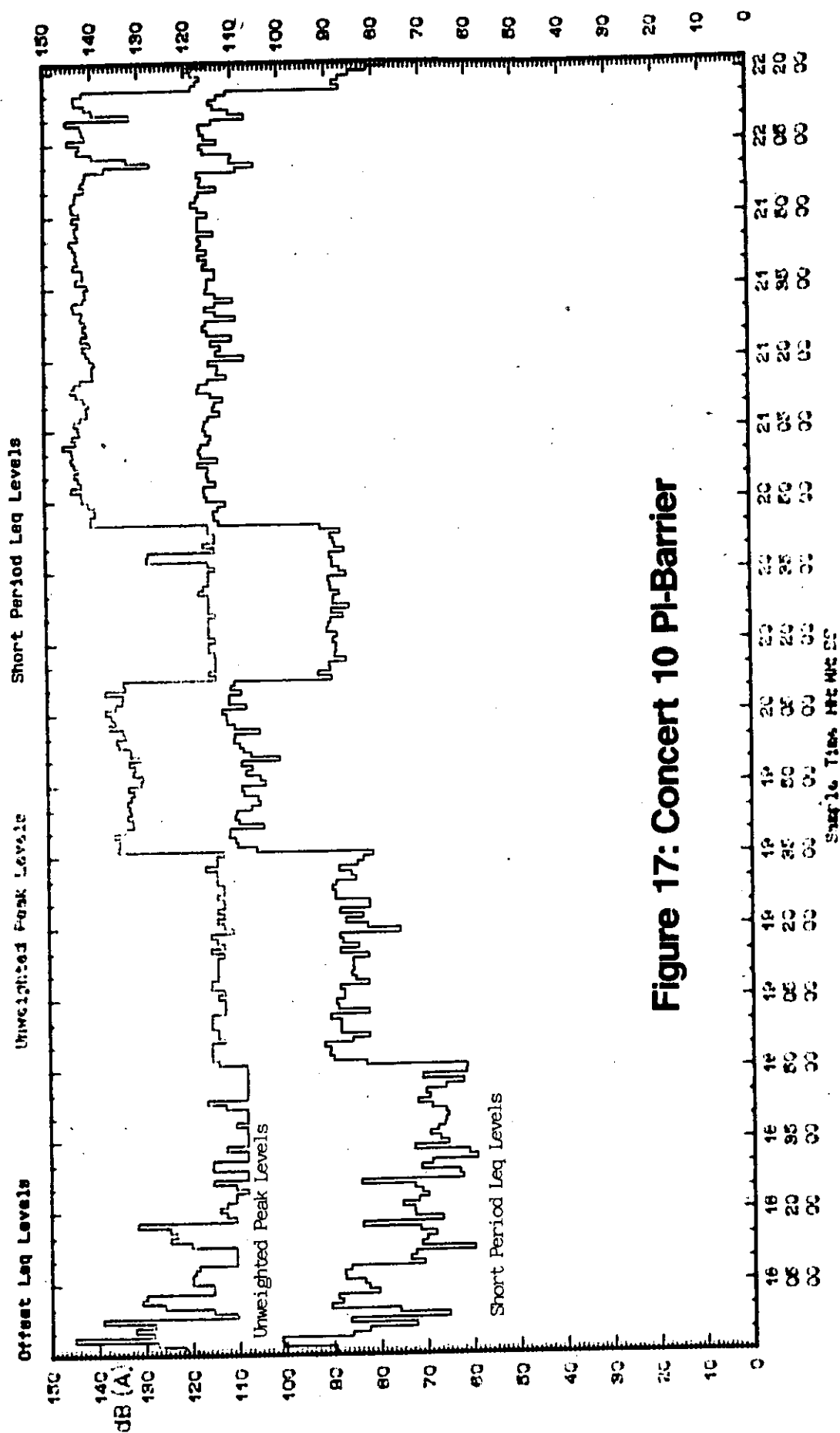


**Figure 16: Concert 10 PI-Mixer**

Sample Time H:M:SS

# HSE Code of Practice for Pop Concerts

Run Time 4:31:30.2      Periods Completed 272      Sample period 00:01:00      File Number 48  
 Serial Number A0818      Max Pns Level 118.4 dB(A)      Max Peak Level 146.0 dB(A)      Leq 110.53 dB(A)  
 L (EP, d) 108.06

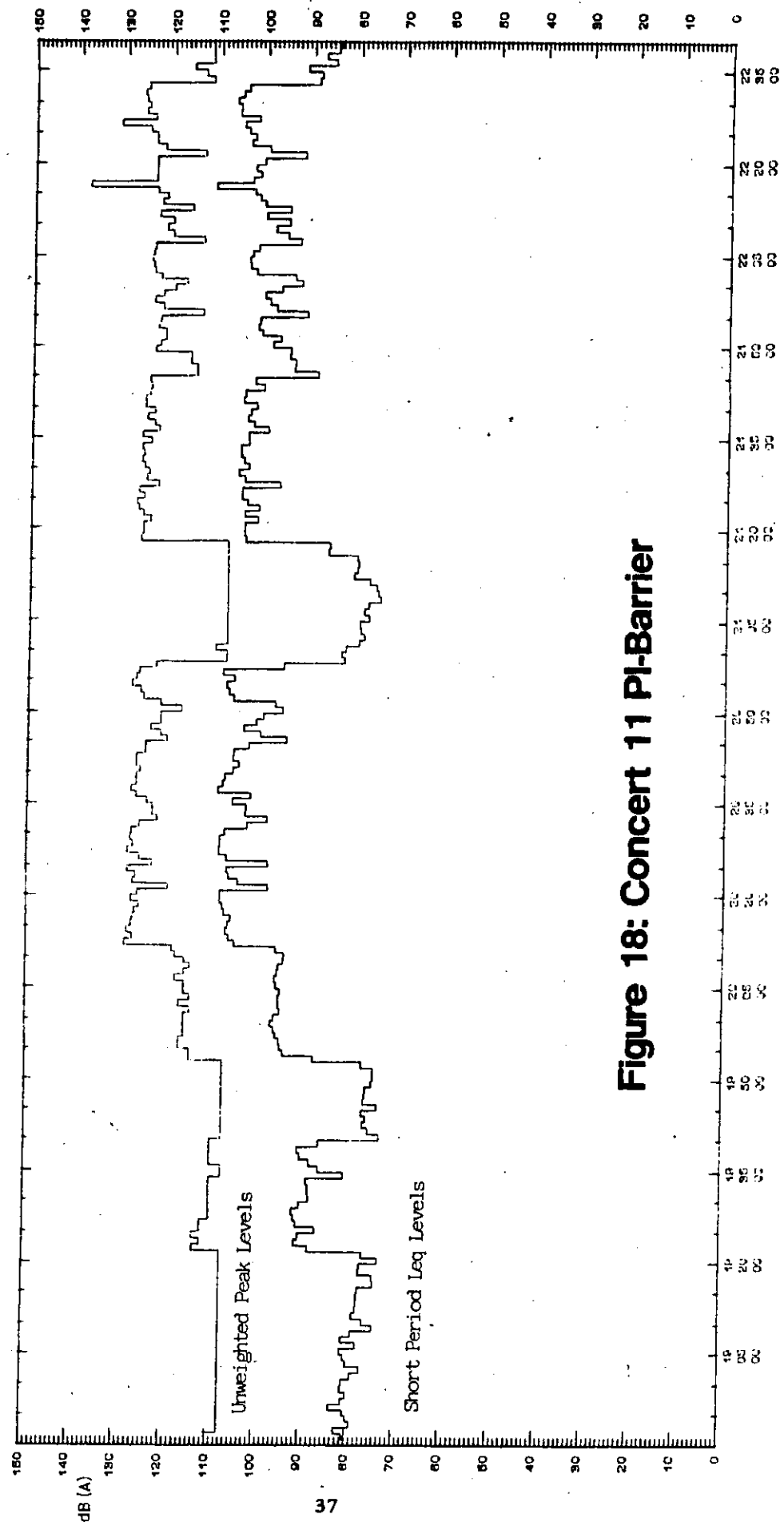


**Figure 17: Concert 10 PI-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time 3:42:55.8      Periods Completed 230      Sample Period 02:04:00      File Number 21  
 Serial Number A0018      Max Peak Level 111.0 dB(A)      Max Peak Level 138.0 dB(A)      Leq 101.30 dB(A)

Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



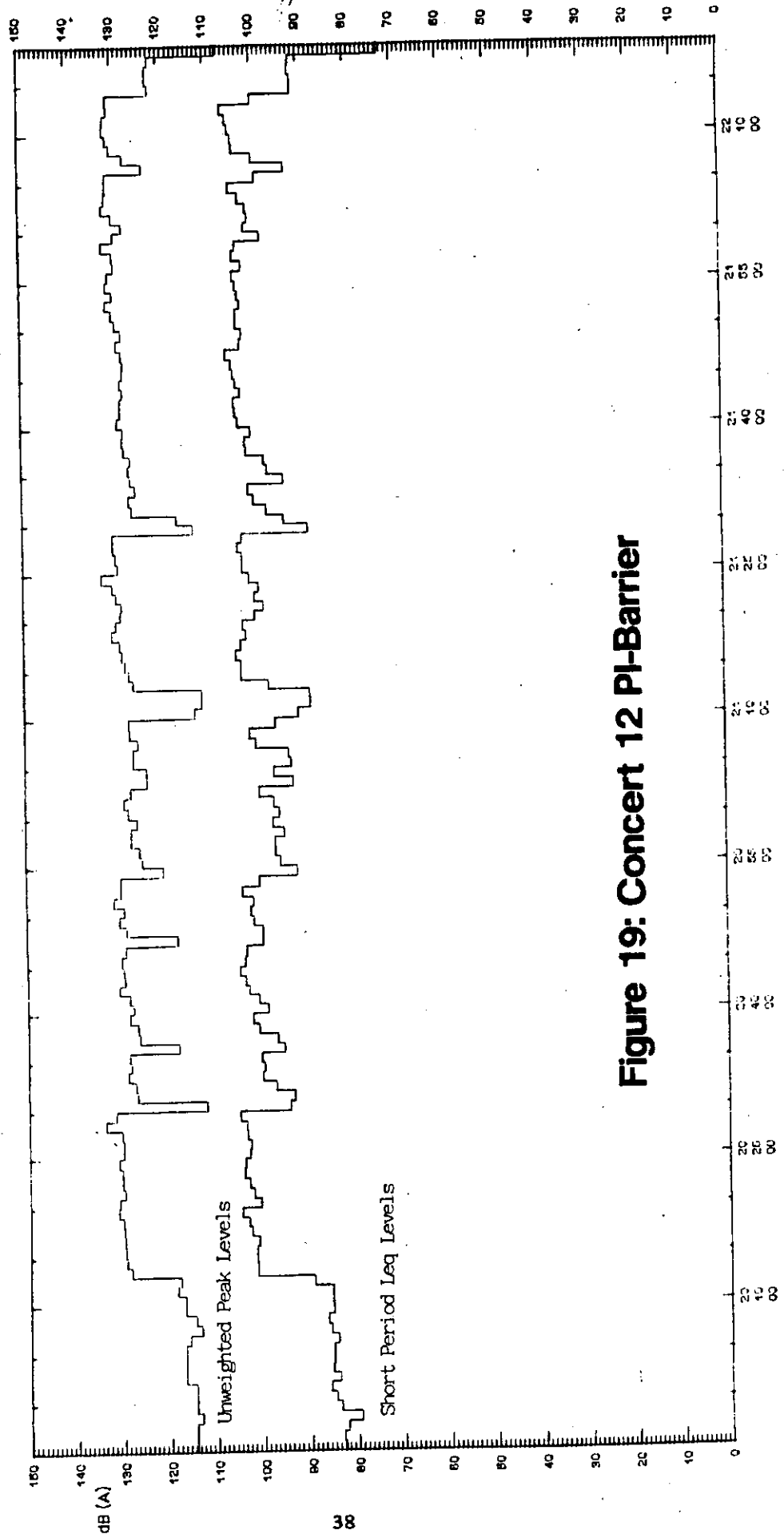
**Figure 18: Concert 11 PI-Barrier**

Sample Time: HH:MM:SS



# HSE Code of Practice for Pop Concerts

Run Time 2:25:47.8      Periods Completed 44      Sample period 02:04:00      File Number 22  
 Serial Number A0010      Max Peak Level 109.5 dB(A)      Max Peak Level 139.5 dB(A)      Leq 101.00 dB(A)  
 L (EP, G) 95.85      Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



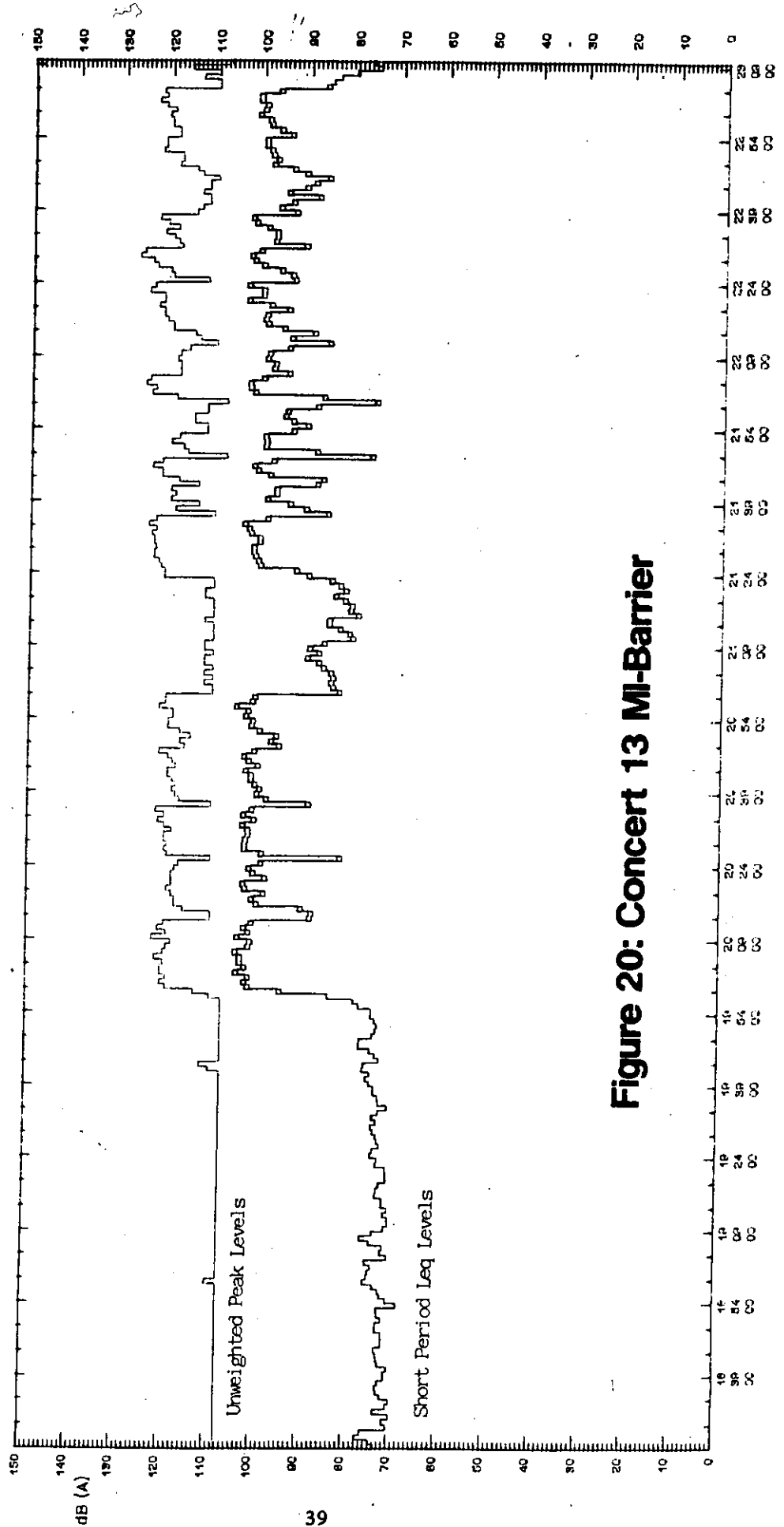
**Figure 19: Concert 12 PI-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time 4:48:49.8      Periods Completed 286      Sample Period 00:01:00      File Number 10  
 Ser(1) Number A0518      Max Peak Level 106.1 dB(A)      Max Peak Level 120.6 dB(A)      Leq 87.84 dB(A)

L(EF,d) 95.38

Offset Leq Levels      Unweighted Peak Levels      Short Period Leq Levels



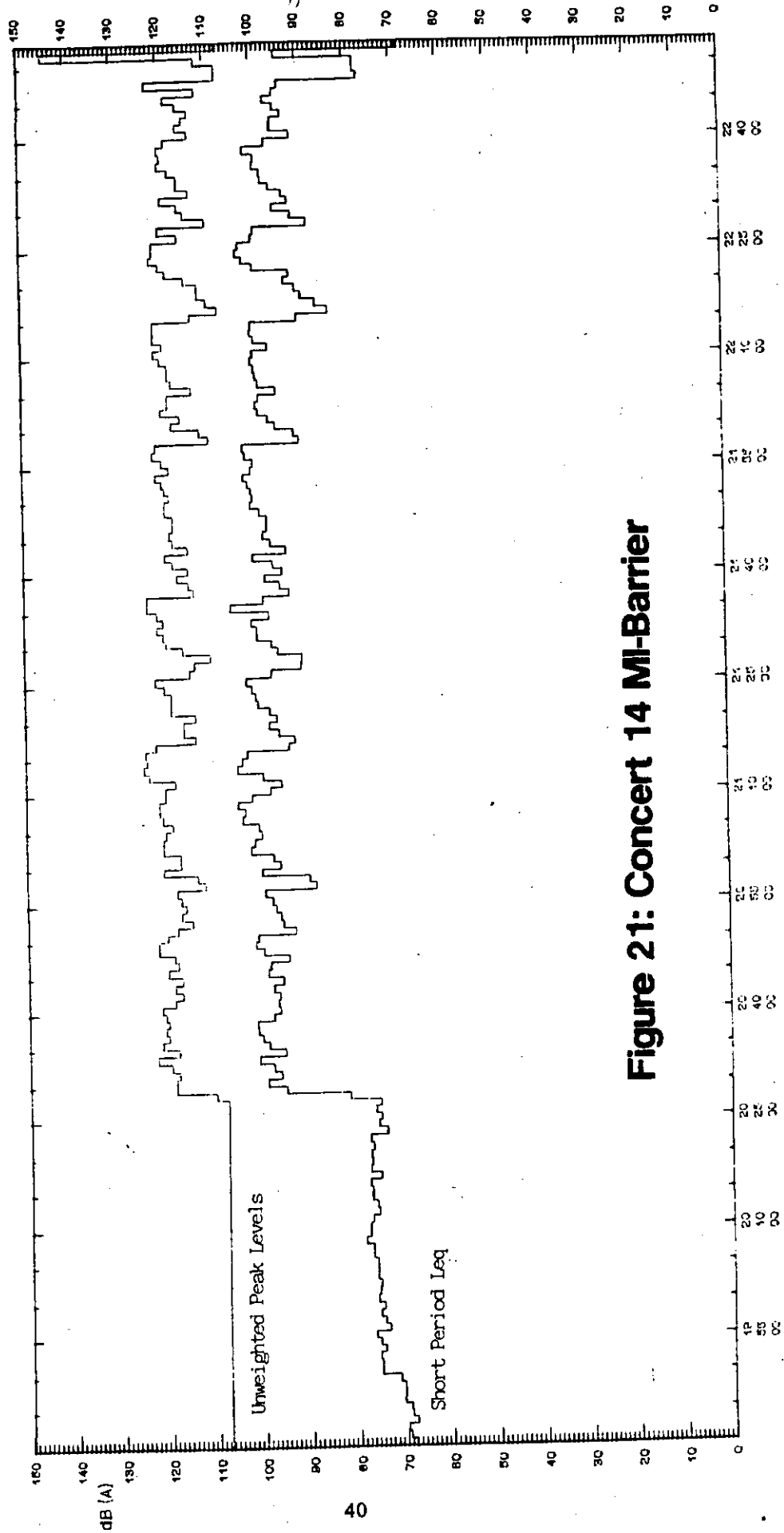
**Figure 20: Concert 13 MI-Barrier**

Sample Time HH:MM:SS

# HSE Code of Practice for Pop Concerts

Run Time 2:12:03.4      Periods Completed 103      Sample Period 00:01:00      File Number 28  
 Bar101 Number A0816      Max Peak Level 105.5 dB(A)      Max Peak Level 144.8 dB(A)      Leq 97.44 dB(A)

Offset Leq Level      Unweighted Peak Levels      Short Period Leq Levels



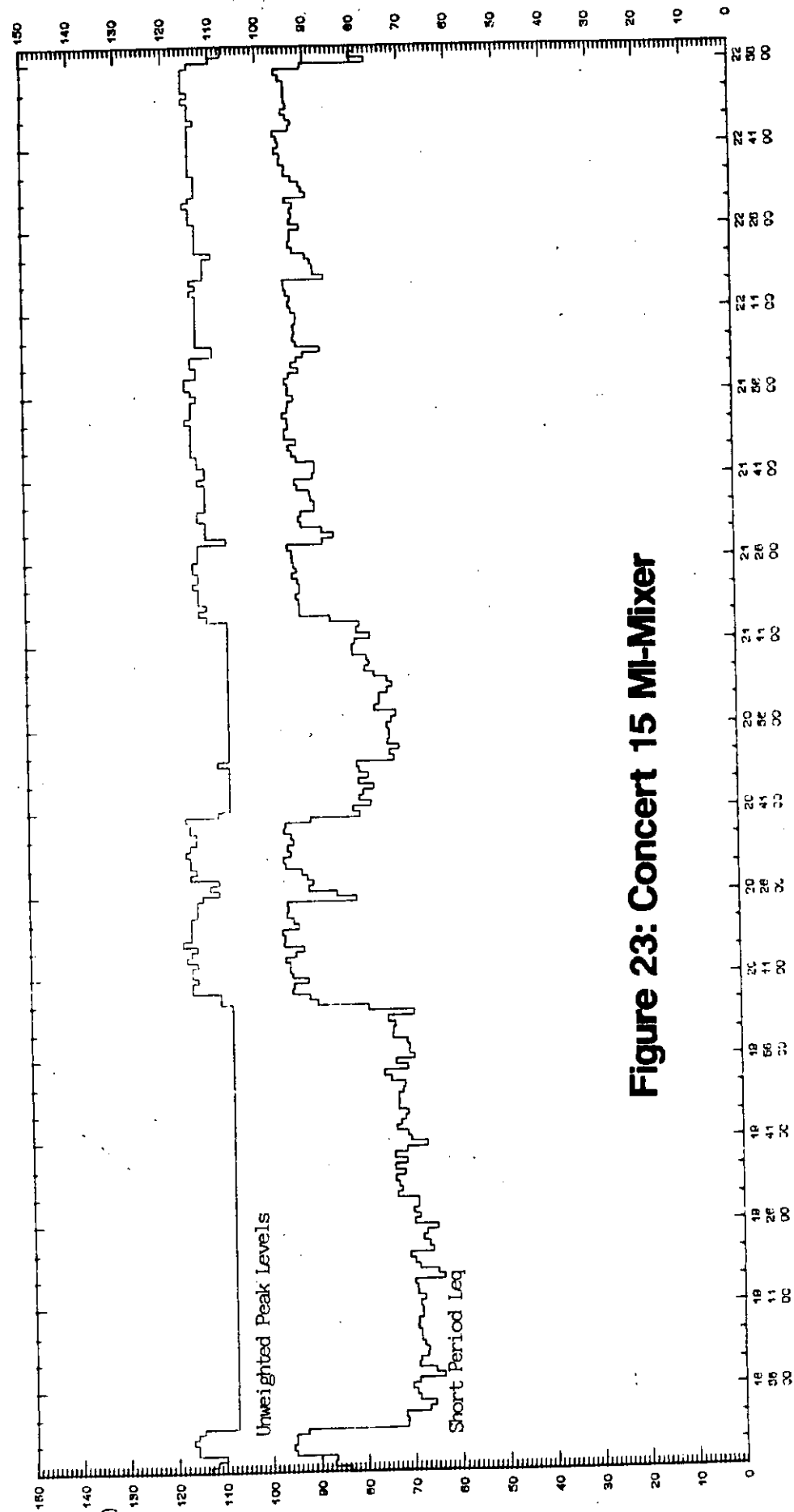
**Figure 21: Concert 14 MI-Barrier**

Sample Time HH:MM:SS



# HSE Code of Practice for Pop Concerts

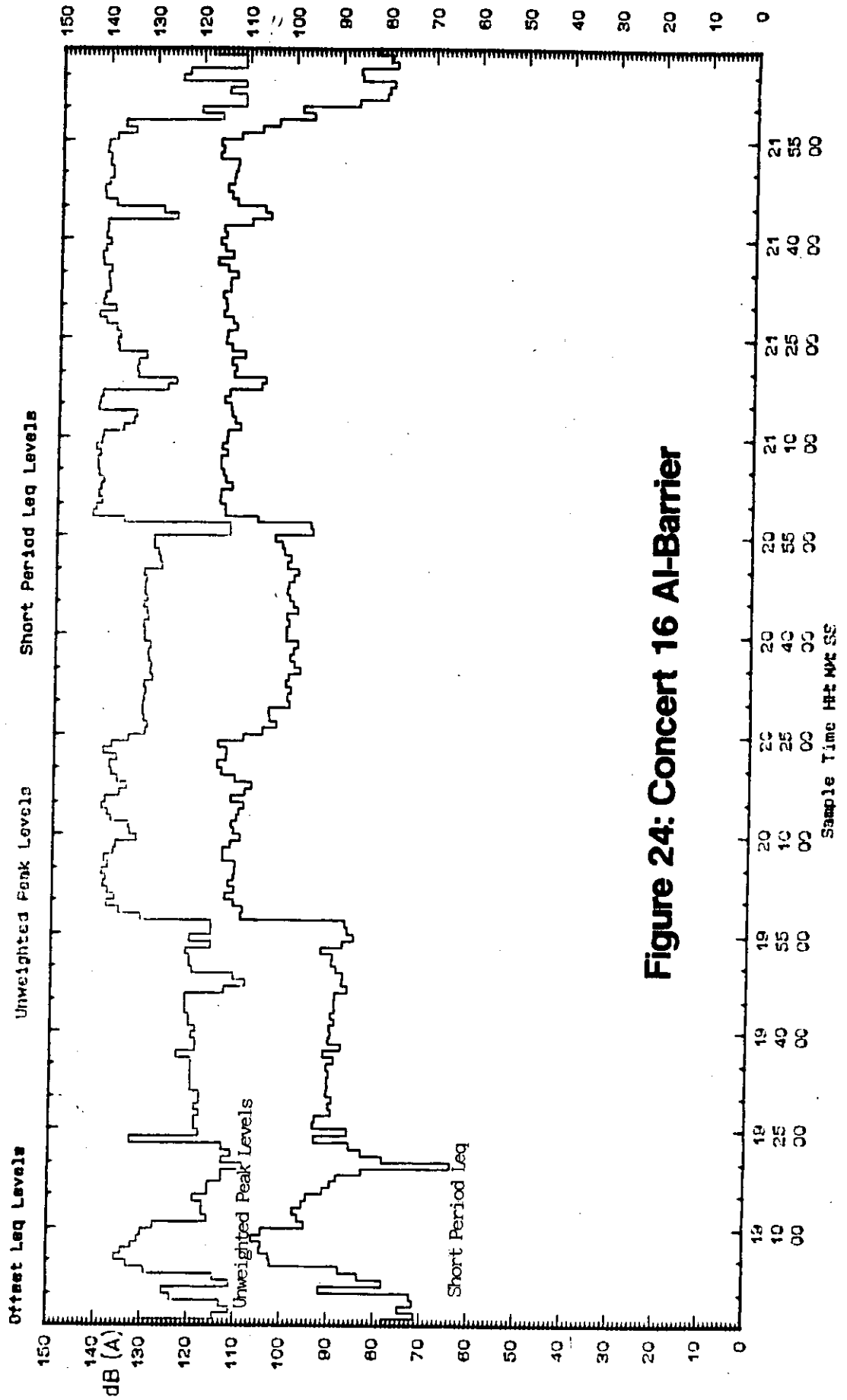
Run Time 4:17:20.6      Periods Completed 208      Sample period 00:01:00      File Number 33  
 Serial Number A0310      Max Peak Level 96.4 dB(A)      Max Peak Level 117.8 dB(A)      Leq 90.66 dB(A)  
 L (EP, d) 87.66      Unweighted Peak Levels      Short Period Leq Levels



**Figure 23: Concert 15 MI-Mixer**

# HSE Code of Practice for Pop Concerts

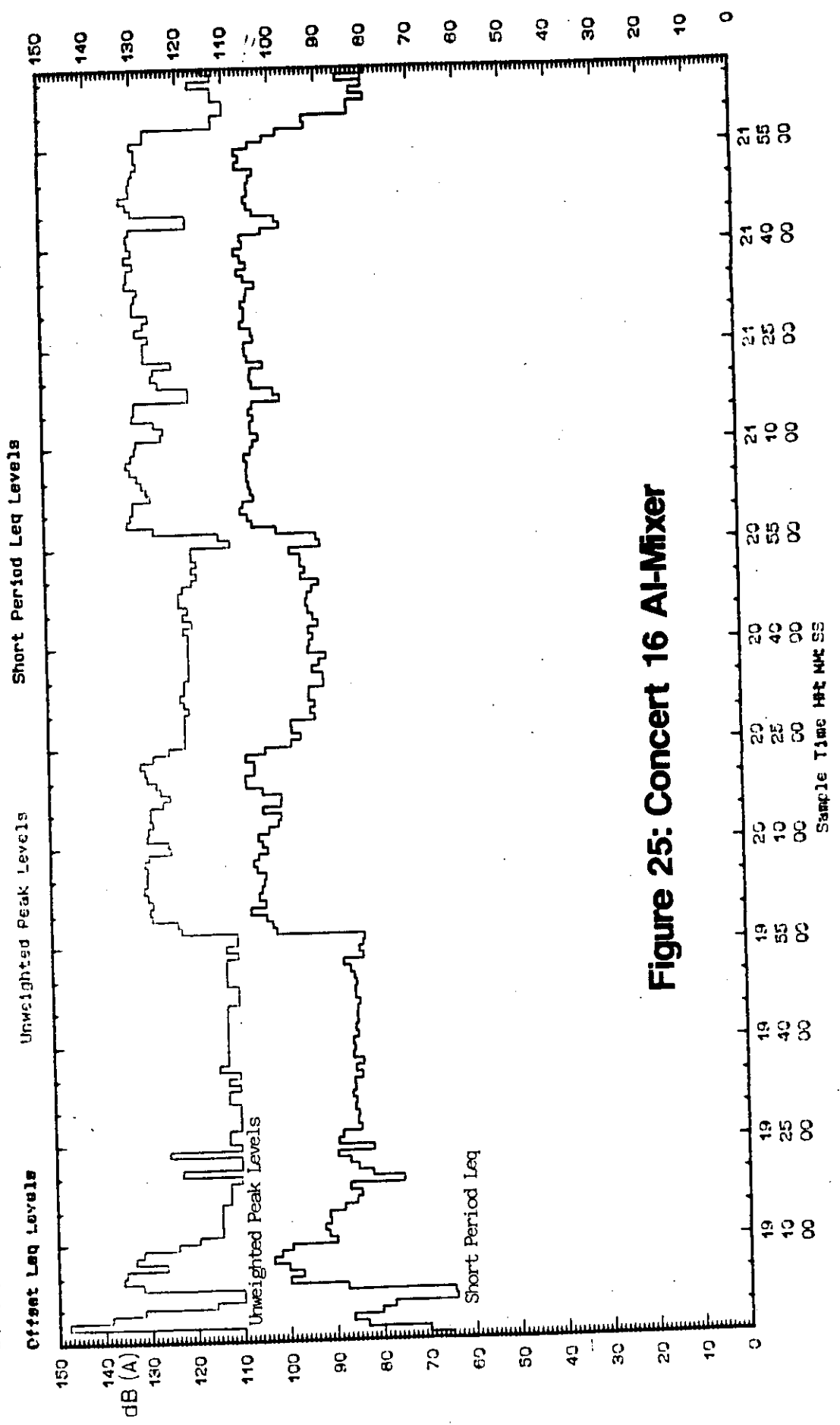
Run Time : 3:13:51.5      Periods Completed 184      Sample period 00:01:00      File Number 48  
 Serial Number A0816      Max Pk Level 118.3 dB(A)      Max Peak Level 142.5 dB(A)      Leq 109.71 dB(A)  
 L (EP, d) 106.77



**Figure 24: Concert 16 AI-Barrier**

# HSE Code of Practice for Pop Concerts

Run Time: S: 11:26.3      Periods Completed: 182      Sample period: 00:01:00      File Number: 48  
 Serial Number: A1108      Max Rms Level: 107.9 dB(A)      Max Peak Level: 147.8 dB(A)      Leq: 101.82 dB(A)  
 L (EP, d): 87.83



**Figure 25: Concert 16 AI-Mixer**

# HSE Code of Practice for Pop Concerts

Run Time 3:00:57.8  
 Series Number A0910  
 L (EP, d) 00.04

Periods Completed 100  
 Max Peak Level 110.1 dB(A)

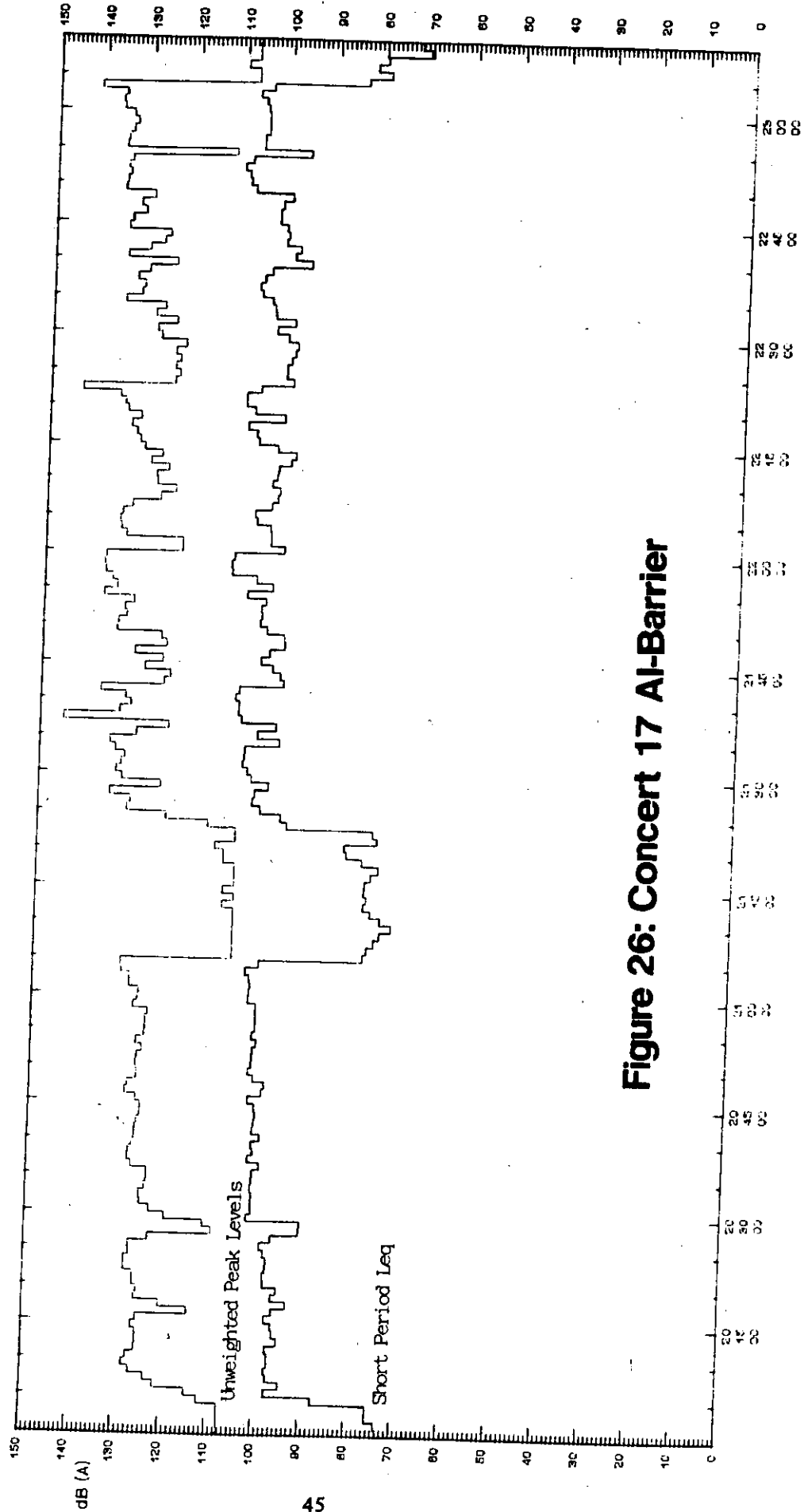
Sample Period 00:01:00  
 Max Peak Level 145.0 dB(A)

File Number 24  
 Leq 102.00 dB(A)

Offset Leq Levels

Unweighted Peak Levels

Short Period Leq Levels



**Figure 26: Concert 17 Al-Barrier**

Source: Tishy M.E. M.C.S.S.



# HSE Code of Practice for Pop Concerts

Run Time 14:08:25.8      Periods Completed 850      Sample period 00:01:00      File Number 52  
 Serial Number A1108      Max Pms Level 110.5 dB(A)      Max Peak Level 141.3 dB(A)      Leq 100.01 dB(A)  
 L(EP,d) 102.48

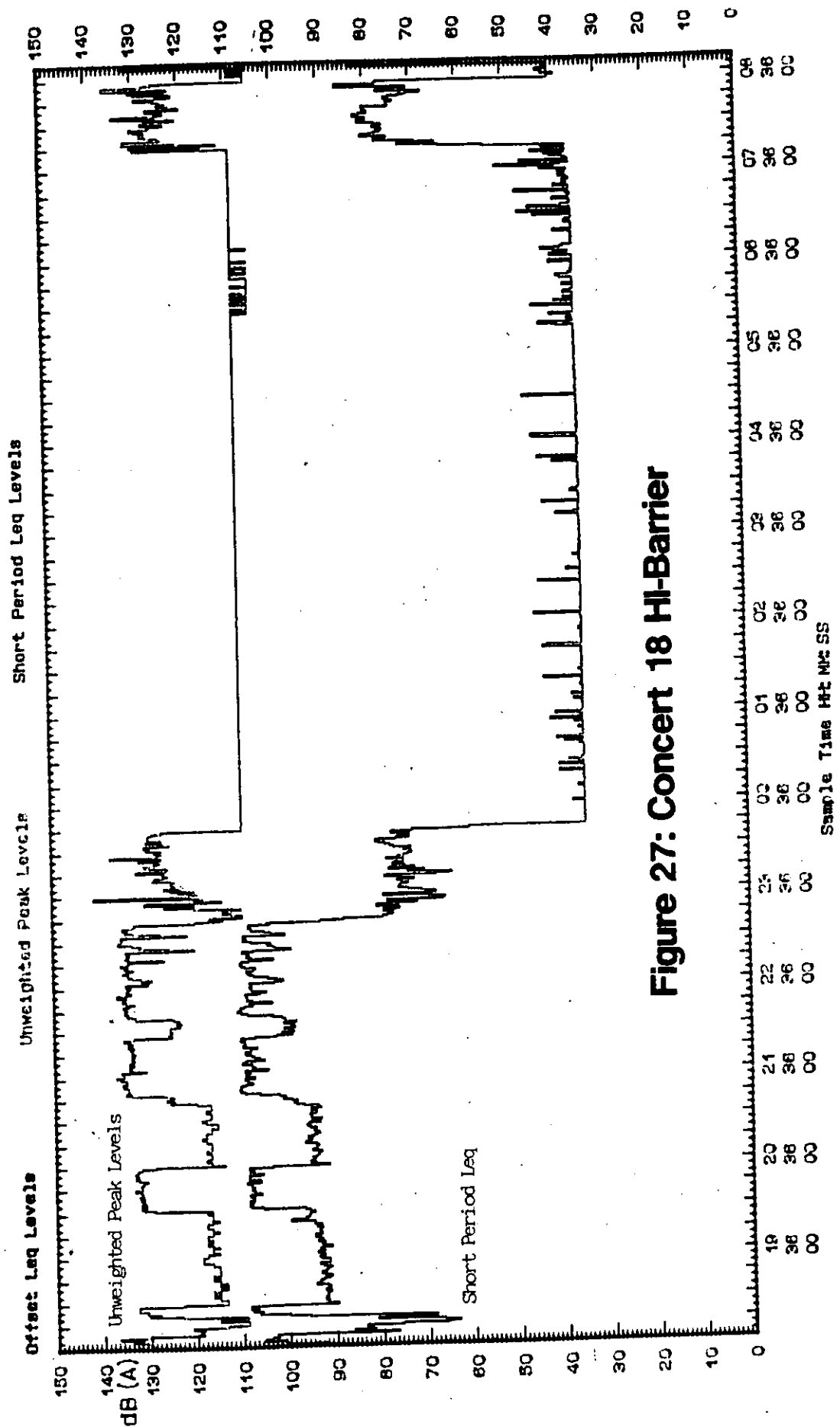
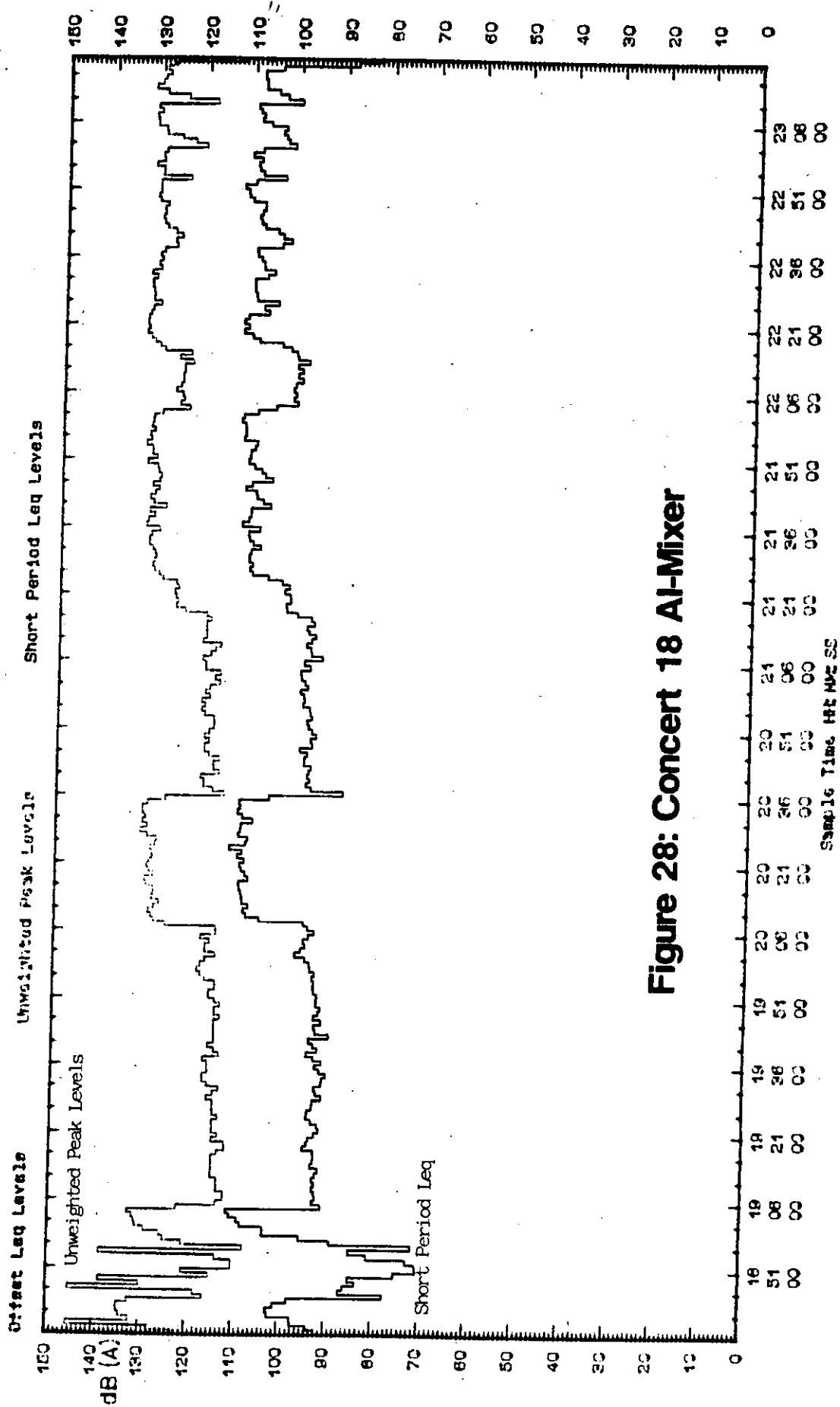


Figure 27: Concert 18 HI-Barrier

# HSE Code of Practice for Pop Concerts

Run Time 4:49:32.0      Periods Completed 264      Sample period 00:01:00      File Number 53  
 Serial Number A0916      Max Pns Level 112.9 dB(A)      Max Peak Level 145.6 dB(A)      Leq 106.60 dB(A)  
 L (EP, d) 109.92



**Figure 28: Concert 18 AI-Mixer**

APPENDIX

# Specifications

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## Acoustical and Electrical

---

### Dynamic Range

110 dB min., 35 to 145 dBA in one range

### Crest Factor

40 dB (based on 1 sec rms integration)

### Pulse Range

80 dB min. using 1 msec burst of 4 kHz

### Single Pulse Response

less than 1.5 dB error for a single cycle of 1 kHz at 140 dB

### Noise Floors

35 dB max. A-weight slow 105 to 114 dB flat weighted peak

### Frequency Response

A-weight meets ANSI S1.4 1983

### Peak Detector Flat

11 Hz to 10 kHz

### Detector Accuracy

True rms, less than 0.4 dB error from 40 to 140 dB

### Display

Custom 16 element LCD 0.1 dB, 0.1% resolution

### Power Supply

9 V Alkaline Battery Duracell MN1604 or equivalent

External Supply: 7 to 16 V dc at 18 mA max.

### Operating Time

40 hr continuous, 3 mo memory retention

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## Standards Met

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ANSI S1.4 1983 Type 2

IEC 651 Type 2

IEC 804 Type 2

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## Environmental

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### Effect of Humidity

Less than 0.5 dB error with 90% humidity at 25 °C (72 °F)

### Effect of Temperature

Less than 0.5 dB error from -20 to 50 °C

### Storage Temperature Range

-30 to 60 °C

### Effect of Magnetic Fields

47 dB (A or C weight) @ 80 A/M (1 Orsted) and 67 dBA @ 800 A/M (10 Orsted)

---

## Memory Saturation

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### Elapsed Time

19.4 days

### Dose

19999%

### TWA

limited to 19.4 days

### Projected Dose

9999%

### Number of Overloads

255



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