

---

---

**Appendix 5.4B**

**Human Noise Level Determination**

---

---

## 1 INTRODUCTION

- 1.1 In order to assess the noise impact of sports events and musical events held in the MPSC, representative sound power levels of the audiences or spectators during such events should be established.
- 1.2 In this appendix, the procedures to obtain the required sound power levels were described. The results were determined in terms of the average sound power per person.
- 1.3 Noise levels from previous relevant events were measured. A model was set up to simulate the noise propagation inside the venue. The simulated results were then compared with the measurements to obtain an estimation of the noise level of human beings.

## 2 RELEVANT EVENTS AND MEASUREMENTS

- 2.1 On-site measurements were conducted at the Hong Kong Stadium for three events. Details of the events are listed in **Table 2-1**. Noise levels were recorded at certain locations on the spectators stand. The locations are marked in **Figure 2-1**.

**Table 2-1 Measured Events in Hong Kong Stadium**

Event	The Meeting of Champions: Kitchee vs Paris Saint-Germain	HKFA Centennial Celebration Match: Hong Kong vs Argentina	2015 Cathay Pacific/HSBC Hong Kong Sevens
Measurement Date	29 July 2014	14 October 2014	28 March 2015
Measurement Time	19:22–21:39	19:28–21:20	13:34–18:19
Attendances	17,153	20,230	39,098

- 2.2 The noise data are analysed and the  $L_{eq}$  (30min) recorded are listed in **Table 2-2** and **Table 2-3**.

**Table 2-2 Recorded  $L_{eq}$  (30min), in dB(A) of football matches in Hong Kong Stadium**

Event Date	29 July 2014				14 October 2014			
Location/Time	A	B	C	D	A	B	C	D
19:30-20:00	82.4	82.7	77.7	82.5	82.9	83.1	78.5	81.6
20:00-20:30	87.8	87.9	82.2	87.9	85.2	84.6	83.3	85.6
20:30-21:00	83.2	82.6	78.2	83.7	84.7	84.4	82.0	84.2

<b>21:00-21:30</b>	85.2	83.7	80.7	85.2	-	-	-	-
--------------------	------	------	------	------	---	---	---	---

**Table 2-3 Recorded  $L_{eq}$  (30min) during Hong Kong Sevens**

Time	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30
	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00
<b>Leq (30min) at Location A, dB(A)</b>	88.2	90.9	89.5	86.9	86.7	92.7	89.2	88.4
<b>Leq (30min) at Location B, dB(A)</b>	87.7	91.3	90.1	87.3	87.1	92.5	89.1	87.3

- 2.3 Noise from loudspeakers of the public address system was not excluded from the above results for a conservative approach. The noise level recorded is considered to be dominated by spectator noise. The higher noise level of 14:30–15:00 and 15:00–15:30 in **Table 2-3** was associated to a music performance which last from 14:40 to 15:07.
- 2.4 The distribution of spectators in each of the events was photographed. This information was used in the modelling of noise propagation in Section 4.

### 3 HUMAN VOICE SPECTRUM

- 3.1 The measured sound pressure spectrum of human noise and some reference sound power spectrum of human voice at various vocal effort<sup>1</sup> are shown in **Table 3-1**. These spectra were plotted in **Figure 3-1**.

**Table 3-1 Sound Spectrum of Human Voice**

Spectra, dB re 1pW vs frequency, Hz	63	125	250	500	1000	2000	4000	8000	A-weighted
<b>Measured spectrum</b>	55.8	57.1	65.5	75.9	82.1	73.7	65.6	55.5	83.0
<b>Normal</b>	45.0	55.0	65.3	69.0	63.0	55.8	49.8	44.5	68.4
<b>Raised</b>	48.0	59.0	69.5	74.9	71.9	63.8	57.3	48.4	75.5
<b>Loud</b>	52.0	63.0	72.1	79.6	80.2	72.9	65.9	54.8	82.6
<b>Shouted</b>	52.0	63.0	73.1	84.0	89.3	82.4	74.9	64.1	91.0

- 3.2 Two observations can be made from the figure. Firstly, the peak power of human voice shifts to higher frequencies when the vocal effort increases. Secondly, the measured spectrum almost coincided with that of the “Shouted” spectrum.
- 3.3 Low frequency noise are more penetrating and hence more probable in affecting NSRs

1: The reference spectrum for human voice can be found in Table 1 of the following document:  
[http://www.odeon.dk/pdf/Application\\_Note\\_SpeechTransmissionIndex.pdf](http://www.odeon.dk/pdf/Application_Note_SpeechTransmissionIndex.pdf)

surrounding the MPSC. Therefore, the spectrum of “Loud” vocal effort was adopted for a conservative purpose in this assessment.

#### 4 3D MODELLING

- 4.1 A special acoustic modelling for the stadium was performed, which took into account the building geometry and design. Typical sound absorption and scattering properties for various building components were adopted in the model.
- 4.2 The spectators were represented by a number of point sources. A sound power frequency spectrum of “Loud” vocal effort was adopted in the modelling. A directivity profile of the voice of human beings<sup>2</sup> was used for the sources representing spectators. The sources were placed on the stand according to the photographic record of the spectators during the event and were configured to face towards the centre of the stadium.
- 4.3 **Table 4-1** list the number of sources used in each of the events. The distribution of the sources and the location of the receivers (i.e. measurements) can be found in **Figure 4-1** to **Figure 4-3** respectively.

**Table 4-1** Number of Point Sources Used

Event Date	29 July 2014	14 October 2014	28 March 2015
Attendances	17,153	20,230	39,098
Number of sources used	135	154	213

#### 5 ACOUSTIC MODEL SIMULATION RESULTS

- 5.1 By varying the assumed sound power level (SWL) per person, one may match the simulation result of the acoustic model with the measured noise level. In other words, for each 30 minute time interval, one can infer a sound power level per person corresponding to the measurement result. The highest noise level measured among different locations were chosen for a conservative approach.

**Table 5-1** Modelling Results of the Events on 29 Jul and 14 Oct 2014, Leq (30min)

Event Date	29 July 2014		14 October 2014	
[in unit dB(A)]	Highest Measured SPL	Corresponding SWL per person	Highest Measured SPL	Corresponding SWL per person
19:30-20:00	82.7	80.2	83.1	81.0
20:00-20:30	87.9	<b>85.4</b>	85.6	<b>82.0</b>

2: Reference for human voice directivity:

<http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?action=shwart&index=an&req=20378930>

<b>20:30-21:00</b>	83.7	<b>80.4</b>	84.7	<b>82.9</b>
<b>21:00-21:30</b>	85.2	<b>81.9</b>	-	-

**Table 5-2 Modelling Results of the Events on 28 Mar 2015, Leq (30min)**

Time	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30
	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00
<b>Highest Measured SPL</b>	88.2	91.3	90.1	87.3	87.1	92.7	89.2	88.4
<b>Corresponding SWL per person</b>	<b>83.6</b>	86.5	85.2	<b>82.5</b>	<b>82.3</b>	88.1	<b>84.6</b>	<b>83.8</b>

- 5.2 Among the sound power level determined, those corresponding to the time period 19:30-20:00 in **Table 5-1** should be discarded as the football matches had not yet begun. Those corresponding to 14:30-15:00 and 15:00-15:30 in **Table 5-2** should also be discarded since a musical performance was taking place during that time as mentioned before. The sound power during 16:30-17:00 in **Table 5-2** was considered as an outlier due to children's playing near the measurement location. The 10 remaining results are bolded in the above tables.
- 5.3 10 sound power levels per person were determined from the measured 30 minute time intervals in sports events. The maximum of these 10 levels was adopted in order to assess the worst case scenario of human noise, which was 85.4 dB(A).

## 6 MUSICAL EVENT HUMAN NOISE LEVEL

- 6.1 In a musical event, the spectator noise is mixed with noise from loudspeakers. It is impossible to measure the noise level of the audiences independently. Therefore, in the noise impact assessment of MPSC, the sound power level of the audiences in a musical event was determined from that of the spectators in a sports event. Human noise in sports event should be louder than that in a musical event. Therefore, this approach was considered as a conservative approach.
- 6.2 The noise criteria for music, singing and instrument performing activities is stipulated in terms of Leq (15min). Hence a human noise level of Leq (15min) shall also be determined for modelling purpose. The above procedures in determining human noise level of Leq (30min) was repeated for the Leq (15min) case. **Table 6-1** to **Table 6-4** shows the corresponding data for this case.
- 6.3 As described in Section 5.2, some of the sound power level determined shall be discarded due to various reasons. Among the 22 sound power levels per person determined from the measured 15 minute time intervals, the maximum level of 86.8 dB(A) was adopted for the worst case scenario.

**Table 6-1 Recorded  $L_{eq}$  (15min), in dB(A) of football matches in Hong Kong Stadium**

Event Date	29 July 2014				14 October 2014			
Location/ Time	A	B	C	D	A	B	C	D
19:30-19:45	-	-	-	-	80.8	80.8	75.7	79.8
19:45-20:00	84.5	84.8	79.7	84.5	84.0	84.3	79.7	82.5
20:00-20:15	89.1	89.2	83.5	89.2	84.2	82.9	81.6	84.6
20:15-20:30	86.2	86.2	80.2	86.1	85.8	85.5	84.3	86.3
20:30-20:45	83.8	83.1	78.4	83.4	85.9	85.2	83.8	85.6
20:45-21:00	82.3	81.9	78.0	83.9	83.2	83.4	78.8	82.3
21:00-21:15	84.5	82.9	78.0	83.4	-	-	-	-
21:15-21:30	85.8	84.4	82.4	86.4	-	-	-	-

**Table 6-2 Recorded  $L_{eq}$  (15min) during Hong Kong Sevens**

<b>Time</b>	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45
	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00
<b><math>L_{eq}</math> (15min) at Location A, dB(A)</b>	87.9	88.6	88.3	92.5	91.6	85.6	86.8	87.0
<b><math>L_{eq}</math> (15min) at Location B, dB(A)</b>	87.1	88.2	88.6	93.0	91.9	86.5	87.4	87.2
<b>Time</b>	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45
	16:15	16:30	16:45	17:00	17:15	17:30	17:45	17:00
<b><math>L_{eq}</math> (15min) at Location A, dB(A)</b>	86.4	87.0	91.4	93.8	90.1	88.2	87.9	88.8
<b><math>L_{eq}</math> (15min) at Location B, dB(A)</b>	87.1	87.1	91.3	93.4	90.1	87.8	87.7	86.8

**Table 6-3 Modelling Results of the Events on 29 Jul and 14 Oct 2014, Leq (15min)**

Event Date	29 July 2014		14 October 2014	
[in unit dB(A)]	Highest Measured SPL	Corresponding SWL per person	Highest Measured SPL	Corresponding SWL per person
19:45-20:00	84.8	82.2	84.3	82.2
20:00-20:15	89.2	<b>85.9</b>	84.6	<b>81.0</b>
20:15-20:30	86.2	<b>84.7</b>	86.3	<b>82.7</b>
20:30-20:45	83.8	<b>82.4</b>	85.9	<b>84.0</b>
20:45-21:00	83.9	<b>80.7</b>	83.4	<b>81.3</b>
21:00-21:15	84.5	<b>83.0</b>	-	-
21:15-21:30	86.4	<b>83.1</b>	-	-

**Table 6-4 Modelling Results of the Events on 28 Mar 2015, Leq (15min)**

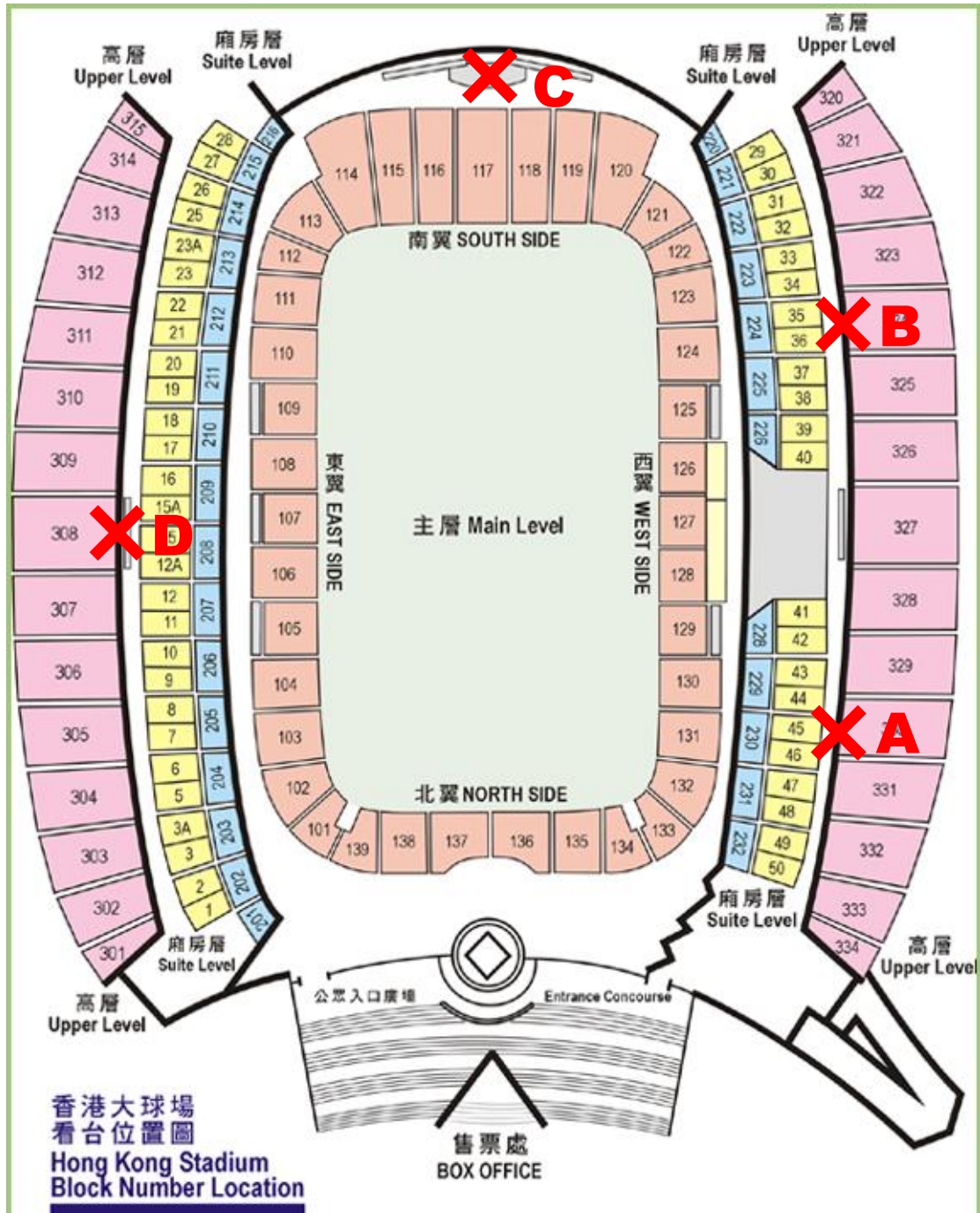
<b>Time</b>	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45
	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00
<b>Highest Measured SPL</b>	87.9	88.6	88.6	93.0	91.9	86.5	87.4	87.2
<b>Corresponding SWL per person</b>	<b>83.3</b>	<b>83.9</b>	83.8	88.2	87.1	<b>81.6</b>	<b>82.5</b>	<b>82.4</b>
<b>Time</b>	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45
	16:15	16:30	16:45	17:00	17:15	17:30	17:45	17:00
<b>Highest Measured SPL</b>	87.1	87.1	91.4	93.8	90.1	88.2	87.9	88.8
<b>Corresponding SWL per person</b>	<b>82.3</b>	<b>82.3</b>	<b>86.8</b>	89.2	<b>85.5</b>	<b>83.6</b>	<b>83.3</b>	<b>84.2</b>

## **7 CONCLUSION**

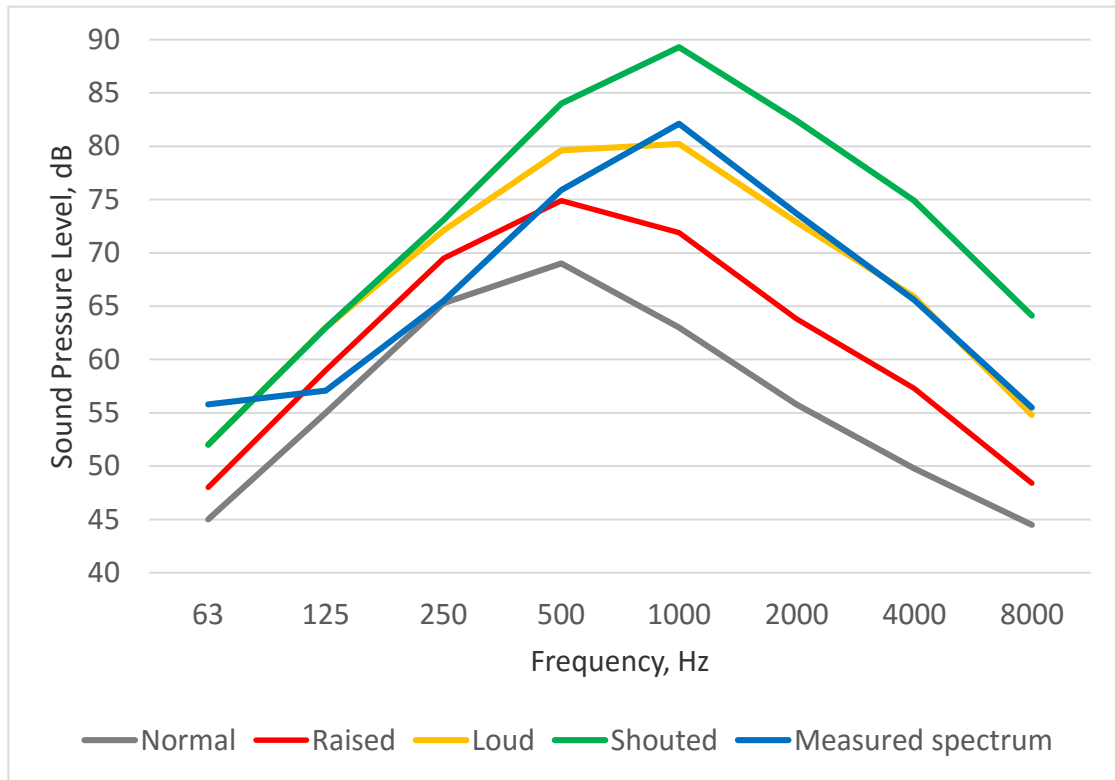
- 7.1 A representative sound power level per person was obtained in order to assess the noise impact from human activities in the MPSC. A series of noise measurements were carried out in the Hong Kong Stadium during sports events. The sound power can be estimated from these measurement results through acoustic modelling of the stadium.
- 7.2 A set of sound power levels were determined, each for a 30 minutes time interval. They demonstrated the varying noise level from human activities during sports events. A representative Leq (30min) of human voice was determined to be 85.4 dB(A) per person.
- 7.3 The Leq (15min) of human voice was needed for the assessment of noise impact of musical events. The same procedure for determining human voice Leq (30min) was repeated for the Leq (15min) case. It was concluded that a representative Leq (15min) human voice was 86.8 dB(A) per person.



Figure 2-1 Measurement Locations on spectator stand of Hong Kong Stadium



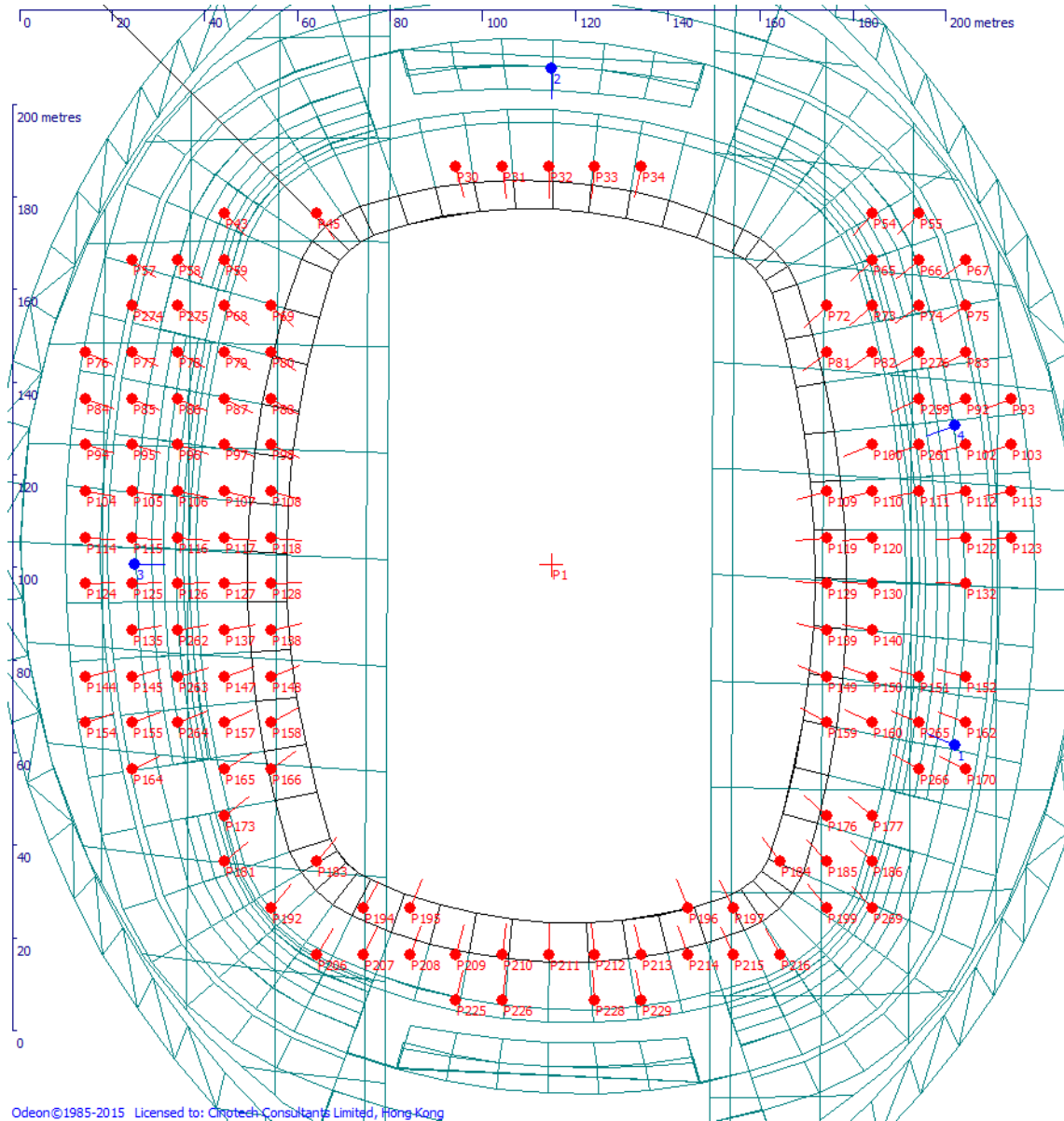
**Figure 3-1 Human Voice Spectrum**



**Figure 4-1 Distribution of sources and locations of receivers for the event on 29 July 2014**

Red points indicate the location of the sources that represent spectators.

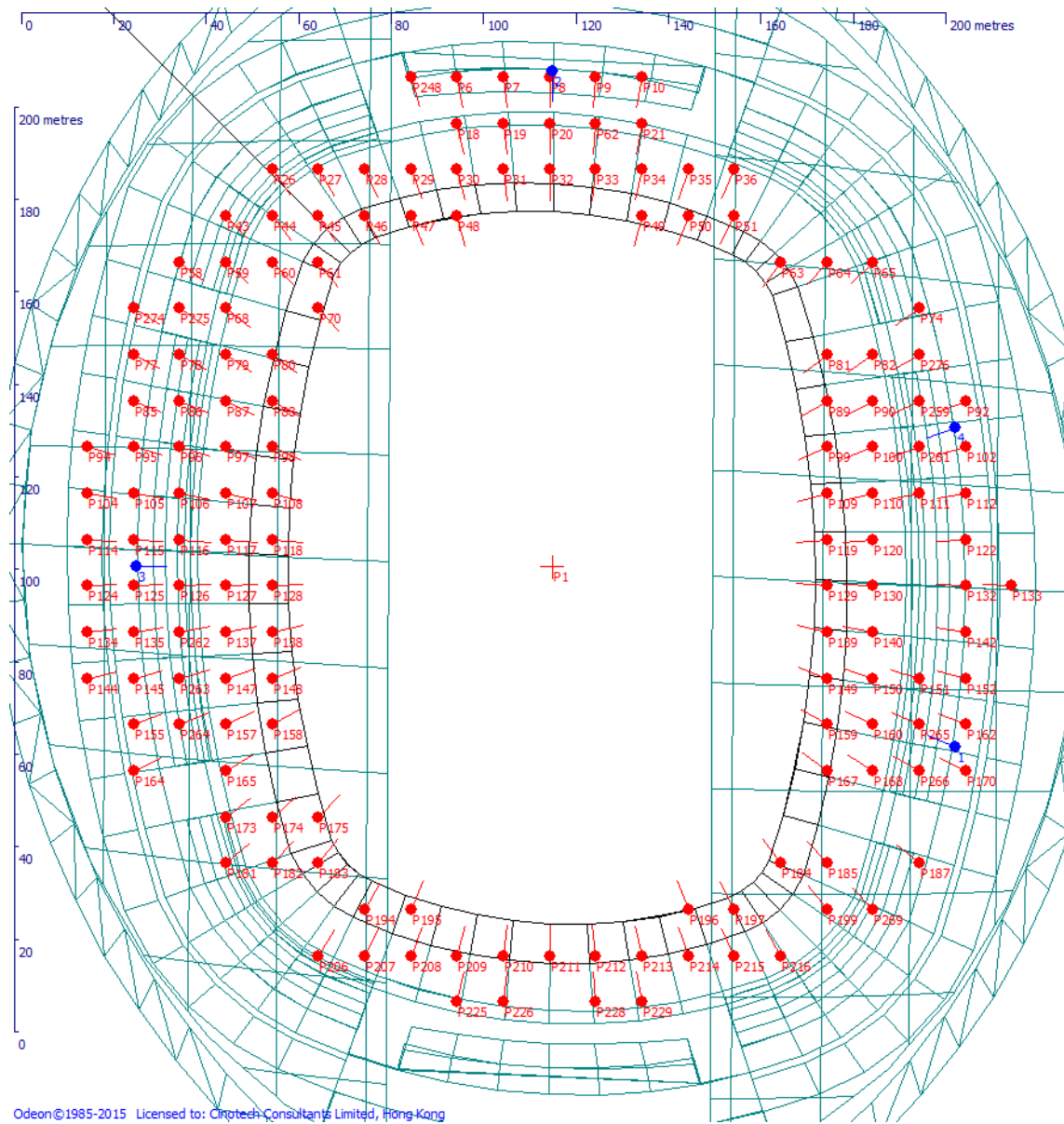
Blue points indicate the location of the modelled receivers corresponding to the measurement locations.



**Figure 4-2 Distribution of sources and locations of receivers for the event on 14 October 2014**

Red points indicate the location of the sources that represent spectators.

Blue points indicate the location of the modelled receivers corresponding to the measurement locations.



**Figure 4-3 Distribution of sources and locations of receivers for the event on 28 March 2015**

Red points indicate the location of the sources that represent spectators.

Blue points indicate the location of the modelled receivers corresponding to the measurement locations.

