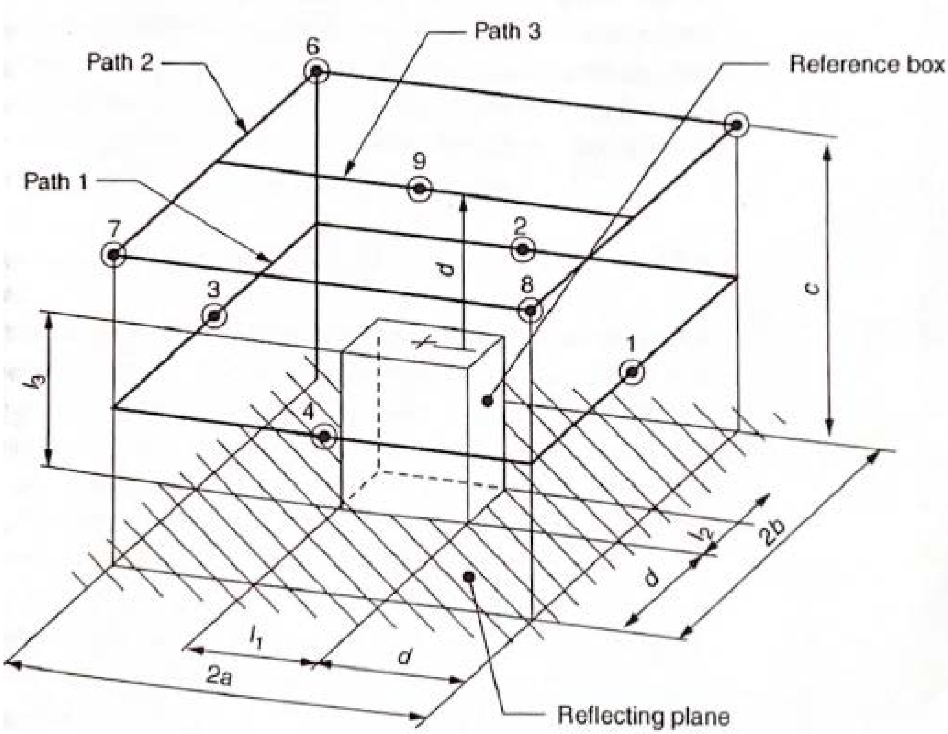
Hemi-Spherical Measuring Surface in a Free Field

Twenty Microphone Positions on Surface of Hemisphere As Defined in ISO 3745

Position Number	x/r	y/r	z/r
1	−1.00	0	0.025
2	0.50	−0.86	0.075
3	0.50	0.86	0.125
4	−0.49	0.85	0.175
5	−0.49	−0.84	0.225
6	0.96	0	0.275
7	0.47	0.82	0.325
8	−0.93	0	0.375
9	0.45	−0.78	0.425
10	0.88	0	0.475
11	−0.43	0.74	0.525
12	−0.41	−0.71	0.575
13	0.39	−0.68	0.625
14	0.37	0.64	0.675
15	−0.69	0	0.725
16	−0.32	−0.55	0.775
17	0.57	0	0.825
18	−0.24	0.42	0.875
19	−0.38	0	0.925
20	0.11	−0.19	0.975



... Microphone positions for a rectangular measurement surface according to ISO CD 3744 (N1497). (Courtesy of the International Organization for Standardization, Geneva, Switzerland.)

Sound-power measurements are sometimes made with the machine mounted on the ground in an open area or in a semi-anechoic chamber, i.e. an anechoic chamber having a hard (reflecting) floor. Sound-pressure level measurements can be made over a hemispherical surface of radius r enclosing it. According to ISO 3745,[3.16] the radius of the hemispherical surface shall be equal to or greater than twice the major source dimension, or four times the average distance of the source from the reflecting floor, whichever is the larger, and not less than 1 m. Table 3.2 gives the coordinates of 10 key measurement points. Figure 3.7 illustrates the relative locations of microphone positions.

Based on eqn (1.9), assuming no sound power transmitted through or absorbed by the ground and neglecting the effects of ground reflection, the sound-power level can be expressed as

$$L_W = \bar{L}_p + 10 \log_{10} 2\pi r^2 \qquad (3.4)$$

where $\bar{L}_p$ is defined by eqn (1.10).

TABLE 3.2. Coordinates of measuring points on a hemispherical surface[3.16]†

(a) Coordinates of key measurement points

No.	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$
1	−0.99	0	0.15
2	0.50	−0.86	0.15
3	0.50	0.86	0.15
4	−0.45	0.77	0.45
5	−0.45	−0.77	0.45
6	0.89	0	0.45
7	0.33	0.57	0.75
8	−0.66	0	0.75
9	0.33	−0.57	0.75
10	0	0	1.0

(b) Recommended microphone positions when the source emits predominant pure tones*

No.	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$
1	0.16	−0.96	0.22
2	0.78	−0.60	0.20
3	0.78	0.55	0.31
4	0.16	0.90	0.41
5	−0.83	0.32	0.45
6	0.83	−0.40	0.38
7	−0.26	−0.65	0.71
8	0.74	−0.07	0.67
9	−0.26	0.50	0.83
10	0.10	−0.10	0.99

* If the source emits predominant pure tones, strong interference effects may occur if several microphone positions are placed at the same height above the reflecting plane. In such cases the use of a microphone array with the coordinates given in (b) is recommended.

† (Reproduced by permission of the British Standards Institution, London.)

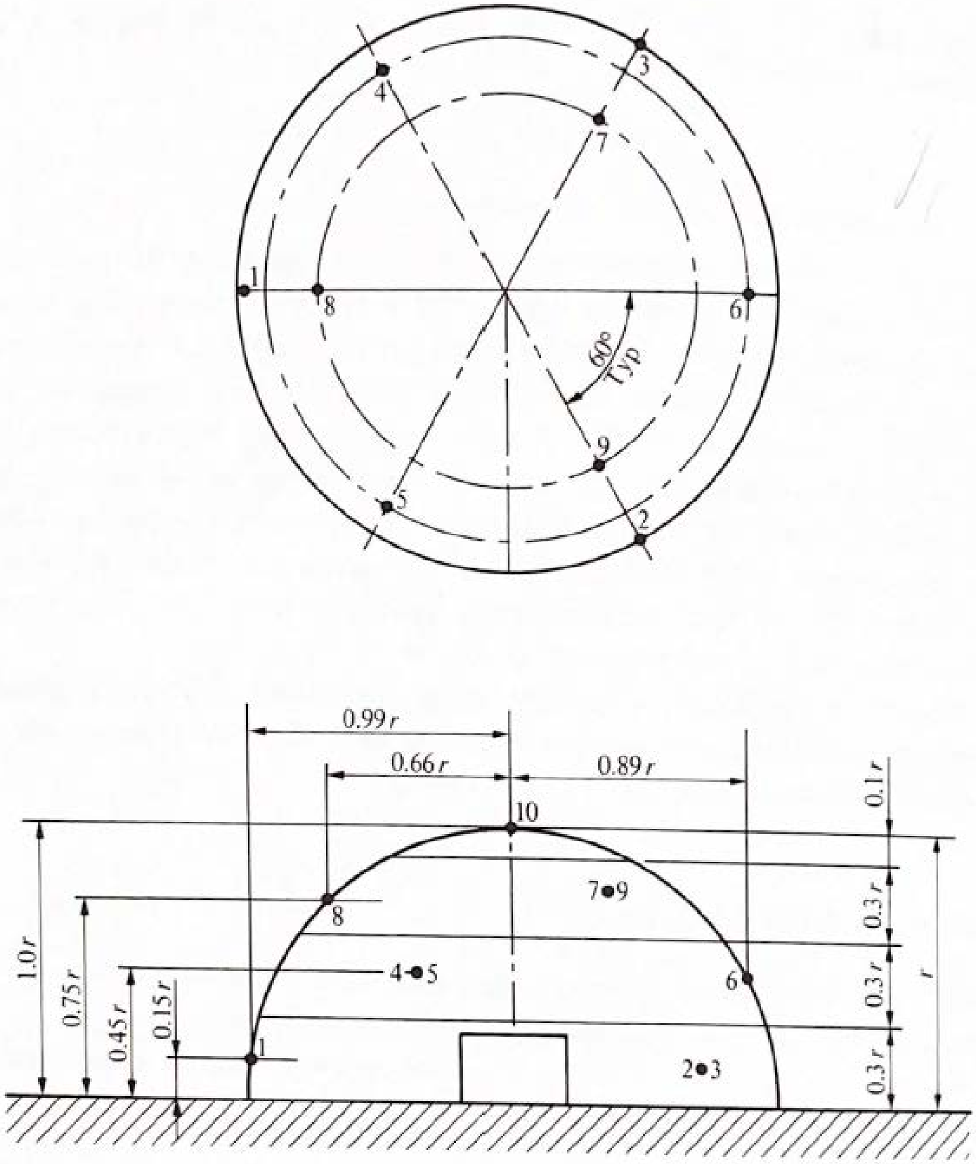


Fig. 3.7. Location of microphones for a 10-point hemispherical measurement (Reproduced by permission of the British Standards Institution, London).[3.16]

Conformal and other Surfaces

Conformal and other measurement surfaces

For long and thin or very large machines it is difficult to take either spherical or hemispherical measurements.

ISO Recommendation 1680[3.4] and BEAMA Publication No. 225[3.5] suggest measurement of the sound-pressure level at a number of points which are at a constant distance from the machine surface (see Fig. 3.8(a)) along prescribed paths in both vertical and horizontal planes. The sound-power level is given by

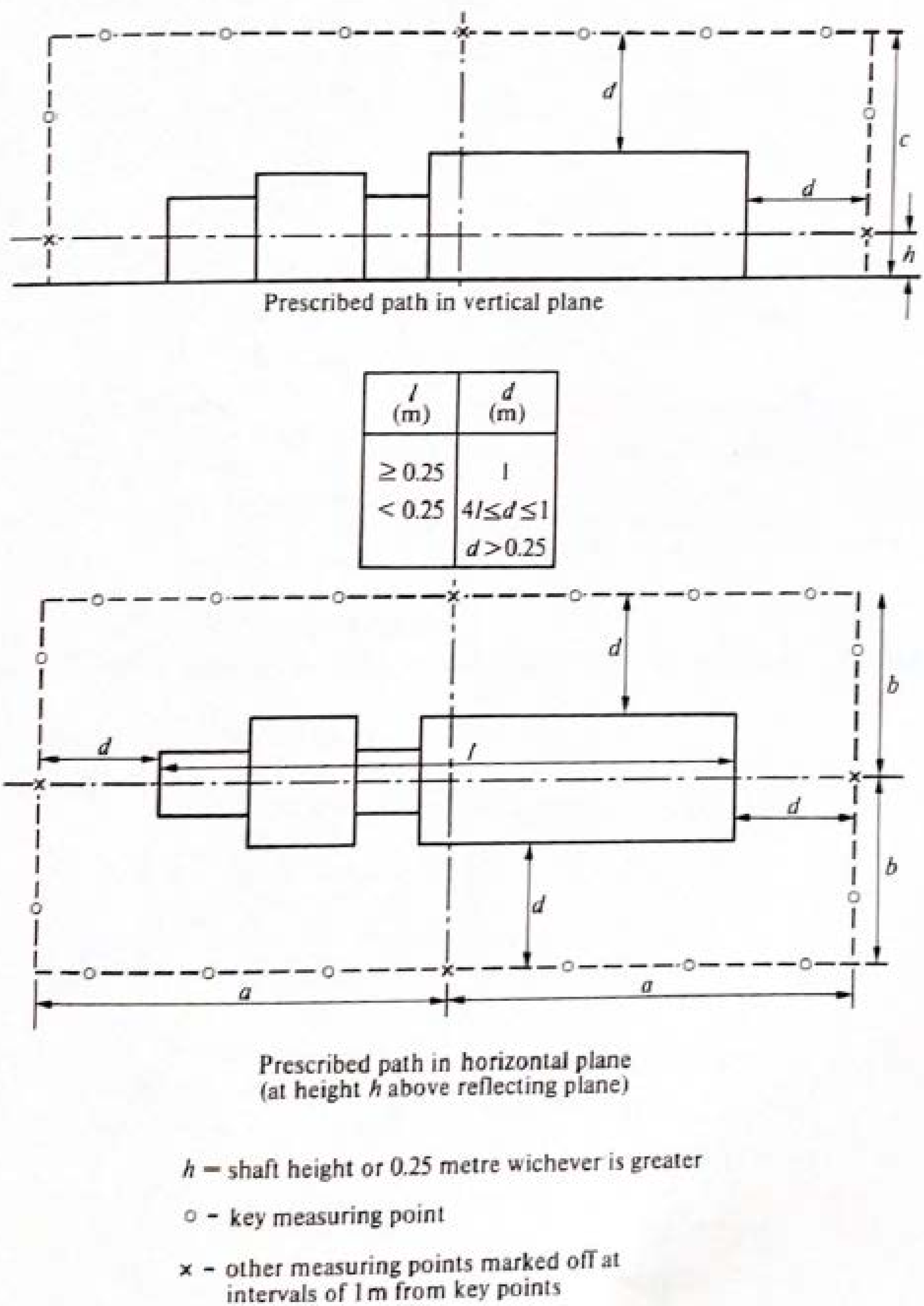
$$L_W = \bar{L}_p + 10 \log_{10} 2\pi r_{eq}^2$$

where the equivalent radius r_{eq} is

$$r_{eq} = \left(\frac{a(b+c)}{2}\right)^{1/2}$$

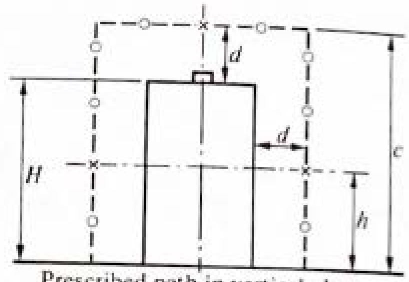
where a, b, and c are as shown in Fig. 3.8(a), (b).

The above r_{eq} expression is derived from the assumption that the



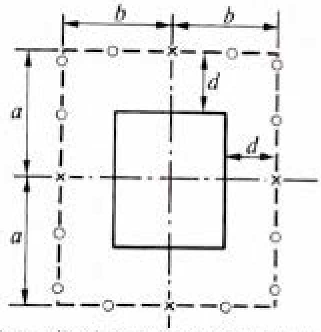
l (m)	d (m)
≥ 0.25	1
< 0.25	$4l \leq d \leq 1$ $d > 0.25$

Fig. 3.8. (a) Location of measuring points and prescribed paths for horizontal machines.[3,5]



Prescribed path in vertical plane

l (m)	d (m)
≥ 0.25	1
< 0.25	$4l \leq d < 1$ $d > 0.25$



$h = \frac{H}{2}$ but not less than 0.25 m

× key measuring points

○ other measuring points marked off at intervals of 1 m from key points

Prescribed path in horizontal plane (at height h above reflecting plane)

Fig. 3.8. (b) Location of measuring points and prescribed paths for vertical machines.[3,5]

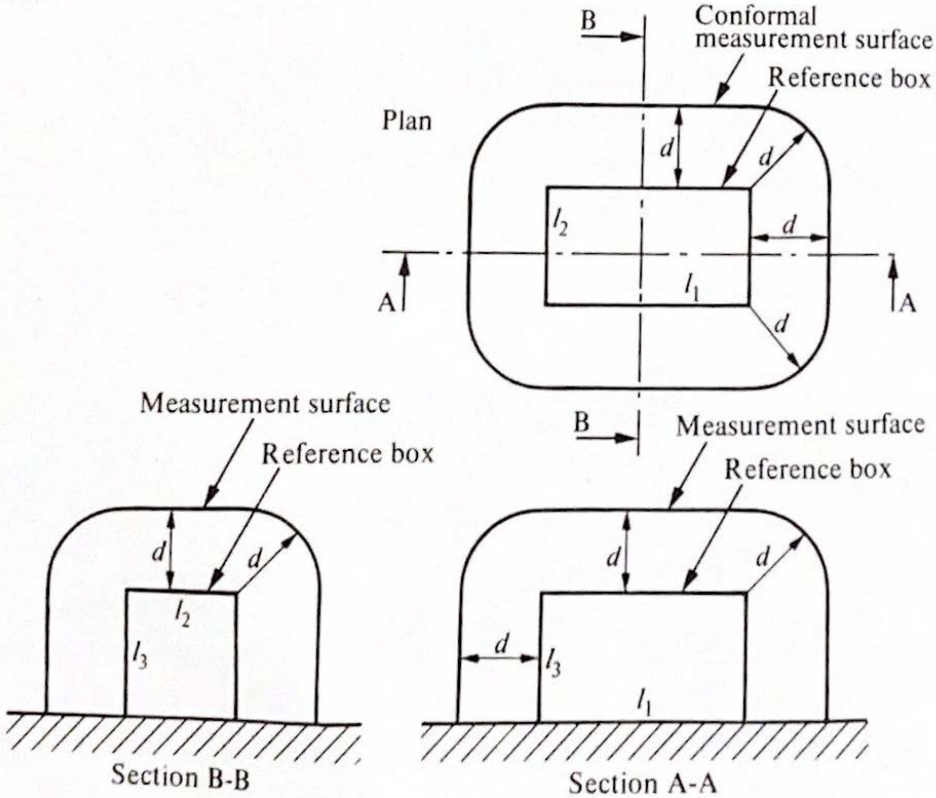
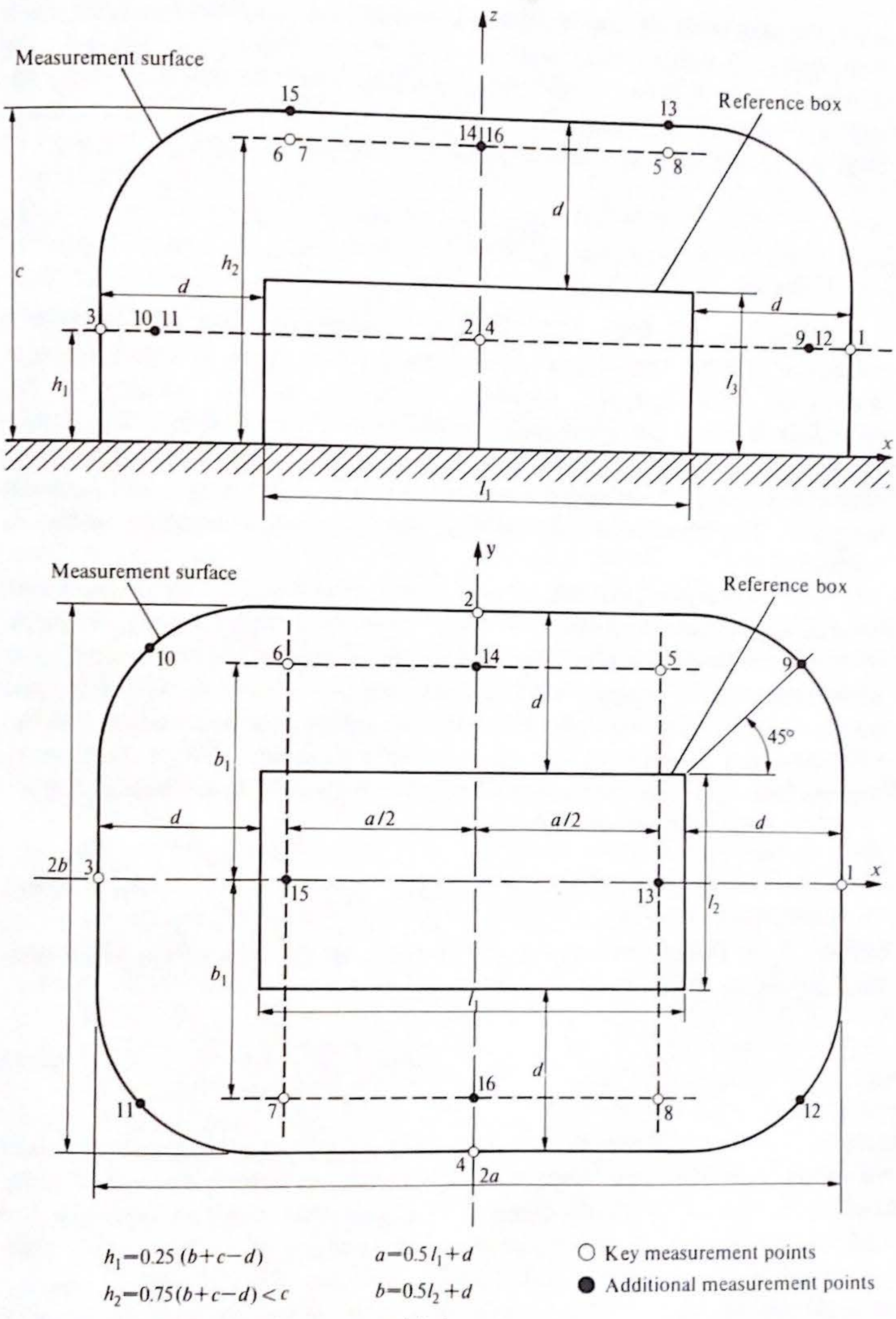


Fig. 3.8. (c) Reference box and conformal surface (reproduced by permission of the British Standards Institution, London).[3,18]



$h_1 = 0.25\,(b+c-d)$ $\quad a = 0.5\,l_1 + d$

$h_2 = 0.75(b+c-d) < c$ $\quad b = 0.5 l_2 + d$

$b_1 = 0.5(b+c-d) < b$ $\quad c = l_3 + d$

where d is the measurement distance, normally 1 m.

The minimum height of the microphone above the ground shall be 0.15 m.

Fig. 3.8. (d) Microphone positions on the conformal surface (reproduced by permission of the British Standards Institution, London).[3,18]

semi-circular ends of the measuring surface are negligible. However, a comparison between this method and the hemispherical method has shown that the area of the semi-circular ends is not negligible for machines having approximately square shapes.[3.1] If the semi-circular ends are to be included, the equivalent radius r_{eq} is

$$r_{eq} = \left[\frac{b+c}{2}\left(a+\frac{b+c}{4}\right)\right]^{1/2}.$$

According to ISO 3744,[3.18] it is necessary first to establish a reference box for the source. The reference box is the smallest possible rectangular box that just encloses the source and terminates on the reflecting plane. If the dimensions of the box l_1, l_2, and l_3 (see Fig. 3.8(c)) are less than 1 m, the hemispherical surface is preferred. If any dimension of the box exceeds 1 m and the reference box is not approximately cubical in shape, then the conformal (or parallelepiped) measurement surface is preferred.

The conformal surface is that surface which is defined as being located everywhere a distance d from the nearest point on the envelope of the reference box (see Fig. 3.8(c)). It is an enclosure formed by a rectangular parallelepiped with round corners, the corners being formed by portions of cylinders and spheres. The measurement distance d is the perpendicular distance to the reference box from the side of the conformal surface. The eight key microphone positions are shown in Fig. 3.8(d).

The sound-power level is given by

$$L_W = \bar{L}_p + 10\log_{10} S_{con}, \tag{3.6}$$

where $\bar{L}_p$ is defined by eqn (1.10) and S_{con} is the area of the conformal surface which is given approximately by

$$S_{con} = 4(ab+bc+ca) \times \frac{a+b+c}{a+b+c+2d} \tag{3.7}$$

where $a = 0.5l_1 + d$, $b = 0.5l_2 + d$, $c = l_3 + d$, and d is the measurement distance, normally 1 m. The value of d shall preferably be one of 0.25, 0.5, 1, 2, 4, or 8 m. If any dimension of the reference box is larger than $2d$, or the spread of sound-pressure level values exceeds 8, eight additional microphone positions should be used (see Fig. 3.8(d)).

If the source radiates noise with a high directivity or if the noise is mainly from a small portion, e.g. the openings of an otherwise enclosed machine, additional measurement positions in the region of high noise radiation shall be used.