11.2.1 Frequency Content

A breakdown of the sound level should be known in order to establish the relative amounts of energy throughout the frequency range. Invariably this breakdown is given in terms of the sound levels in each octave frequency band between 63 Hz and 8 kHz. The actual units supplied can vary. In many cases sound power levels will be supplied. Sometimes, however, sound pressure levels will be stated. When sound pressure levels are supplied it is necessary to know at what distance the measurements have been made and, also, in what conditions — reverberant room, free field, etc.

11.2.2 Source Directivity

The directivity of a source is dependent on the dimensions of the source, the components of the equipment and the particular frequency under investigation. Sources of a constant size become more directive as the frequency increases, alternatively if the frequency remains constant then the directivity increases as the source size increases.

Some cooling tower and chiller manufacturers can supply sound data at various locations around the equipment and at various distances from the equipment. As sound levels in some directions can be 5–10 dB greater than in other directions this type of information is extremely useful when the equipment is to be located outside. Although in most situations it is most convenient to be supplied with sound power data of equipment, in the case of externally located equipment it is best to have sound pressure levels around the equipment. This is because overall sound power levels give no indication of directivity of the equipment whereas sound pressure levels at various locations can give useful information as to which way round to position the equipment and, as such, can save on noise control measures.

In the case of openings such as a louvre and open window–plane sources — the directivity of these apertures can be obtained by reference to Figure 11.2. Normally since these apertures are rectangular then the directivity in the horizontal direction will be different from that in the vertical direction because of the effective dimensions of the source width and height.

11.2.3 Surface Directivity

This is totally dependent on the location of the noise source and for omni directional sound sources has been defined earlier in Chapter 3 as the factor Q in the direct field sound pressure level equation

$$L_p = L_w + 10\log_{10}\left(\frac{Q}{4\pi r^2}\right) \quad 11.1$$

for the direct sound calculation.

Frequency Hz	Width or Height of Louvre														
	0.5	1	1.5	2	2.5	3.5	4.5	5.5	6	7.5	9	10.5	12	15	m
	1.5	3	5	7	9	12	15	18	20	25	30	35	40	50	ft
63	2	2.5	3	3	3.5	3.5	4	4	4	4	4.5	4.5	4.5	4.5	
125	2.5	3	3.5	3.5	4	4	4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
250	3	3.5	4	4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
500	3.5	4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
1K	4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
2K	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
4K	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
8K	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	

Table gives directivity at $\theta = 0$ for either horizontal bearing or vertical bearing of observation point from centre of louvre

Directivity correction for the normal axis of atmospheric louvres and grilles

D.I. KEY $\theta°$							
0	20	40	60	80	100	120	140
2	2	1.5	1.5	1	1	0.5	0
2.5	2.5	2	1.5	1	0.5	0	−1
3	3	2	1.5	0.5	−0.5	−1.5	−3
3.5	3	2.5	1	−0.5	−2	−4.5	−7.5
4	3.5	2.5	1	−2	−6.5	−12	−15
4.5	4	3	0	−15	−20	−20	−20

Directivity correction for a bearing angle away from the normal axis of atmospheric louvres and grilles

Figure 11.2 Plane Source Directivity Corrections

If the omni-directional source is suspended in free space the directivity factor $Q = 1$ and no allowance should be made. This may be the case when considering boiler flues or engine exhaust pipes.

Normally however the source is located on a surface and the source will radiate noise in a hemispherical pattern. In this case the directivity factor $Q = 2$ and an allowance of +3 dB should be made re L_p from equation 11.1. If the source is located at the junction of two surfaces $Q = 4$ and an allowance of +6 dB has to be applied.

For sources located at the junction of three surfaces $Q = 8$ and an allowance of +9 dB is made.

Figure 11.3 provides an illustration of these surface directivity patterns.

Example 1. A chiller is to be located externally next to a rooftop plantroom wall. The octave band sound power levels have been supplied. The sound pressure level at 16 m is required.

	Octave Band Frequency (Hz)							
	63	125	250	500	1k	2k	4k	Hz
L_w	85	87	88	90	89	85	81	dB
$10\log_{10}(1/4\pi r^2)$	−35	−35	−35	−35	−35	−35	−35	dB
$10\log_{10} Q$	+6	+6	+6	+6	+6	+6	+6	dB
L_p	56	58	59	61	60	56	52	dB

For this example $r = 16$m and $Q = 4$.

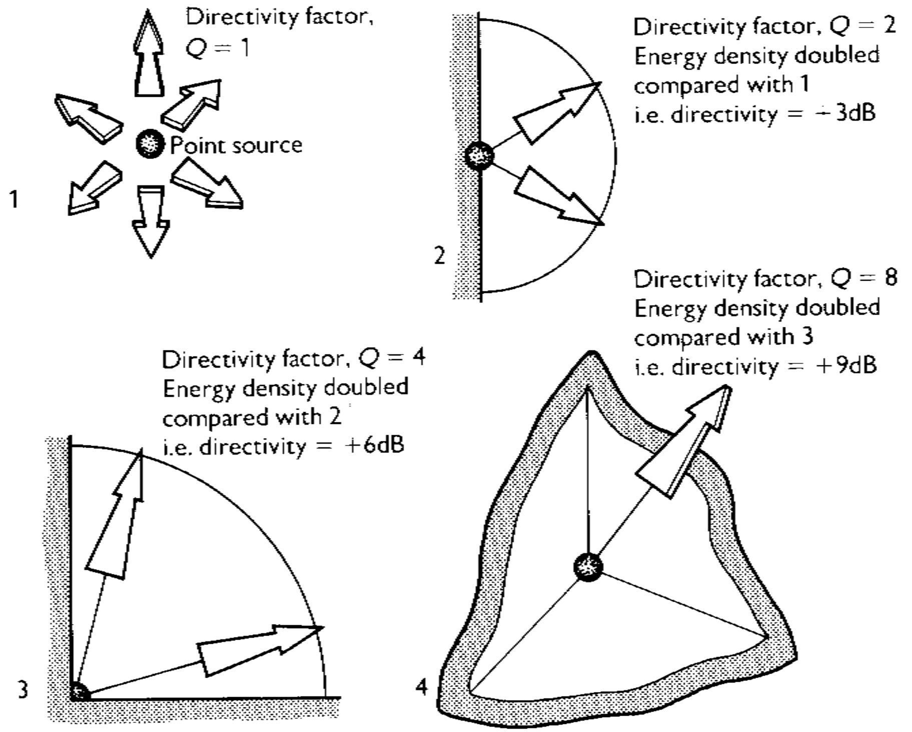

Figure 11.3 Surface Directivity Patterns

11.3 ACOUSTIC PROPAGATION

Once either the sound power level or the sound pressure level and the frequency content are known together with the directivity pattern associated with the source the noise level at the receiver's position is basically assessed from the following:

Distance from source to receiver and the dimensions of the source in relation to the propagation distance (11.3.1)
Whether screening exists between the source and receiver (11.3.2)
The existence of any reflections at the receiving position (11.3.3)

Other factors including atmospheric conditions and ground absorption which although discussed briefly later would not normally be included in a noise to exterior calculation unless the receiving position is at a great distance (11.3.4 and 11.3.5)

11.3.1 Attenuation with Distances

If the source can be considered to be a point source in relation to its distance from the receiving position the normal inverse square law of 6 dB per doubling of distance can be used.