# 71/46

ACOUSTIC TESTING FACILITIES

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## INDUSTRIAL TESTING IN ANECHOIC & FREE FIELD SURROUNDINGS

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INTRODUCTION. The measurement of sound power in a free field environment becomes necessary when

a) the source has strong discrete frequency characteristics.

b) additional information is required on the spatial pattern of sound radiation.

In a free field environment, the sound power generated by a source is determined by summing the acoustic intensity (energy flow per unit area), at a number of points over any closed surface which encloses the source. To emply this method however imposes certain conditions on the test environment, because one cannot measure intensity directly. It has to be computed from measurements of sound pressure level. This means that the measurements have to be made in a region where there is a direct simple relationship between sound intensity and sound pressure.

Figure 1 shows a typical variation of sound pressure level with distance away from a source located in a room, or near reflecting surfaces. In the near field there is no simple relationship between intensity and pressure - particle velocity in the medium not being necessarily in the direction of wave propagation. In the reverberant field, the sound pressure level at any point will generally be a combination of the sound radiated directly from the source, and that which has undergone a number of reflections.

The permissible region of measurement is thus restricted to that part of the free field which lies outside the near field. In this region, intensity is directly proportional to the square of the acoustic pressure, and we have the well-known characteristic of sound pressure decreasing by 6 dB per doubling of distance. The prime design requirement of a free field test environment is therefore that this region is well defined, and as extensive as possible.

OUTDOOR TESTING

The ideal environment would be a completely still, uniform atmosphere, with the source suspended high in the air. Not a very practical sounding arrangement, but one can get close to this by locating the machine under test outdoors in the centre of a very large, paved or concrete surface which is completely free of buildings, walls or other reflecting objects.

Sound pressure levels can then be measured over the surface of a hemisphere, and the sound power and directivity determined in the normal way (see for example Ref. 1). Provided the surface of the test hemisphere is well outside the near field (see below), the only limitations on this type of free field testing, are those imposed by meteorological conditions. To some extent, these can be allowed for (ref 2), but testing should generally be restricted to periods when there is little or no wind, if accurate results are required. Rain by itself does not prevent outdoor testing, but it is likely to completely mask any high frequency components of the source noise. Needless to say background noise in the vicinity must always be at least 6 dB below the source noise at all frequencies of interest.

ANECHOIC CHAMBERS.

If production or development testing is likely to be seriously hampered by limitations on the periods when outdoor tests can be carried out, the alternative is to provide a special room, constructed to provide a substantially reflection free, or "anechoic" environment. The design factors for such rooms are size, shell construction, and internal treatment.

Size

Size is important because it determines the extent of the free field, which in turn determines the size of components which may be tested. The minimum extent of the free field is the boundary between near and far fields. It is not possible to be precise about the extent of the near field - it is a function of the size & shape of the source, and of the frequency of interest. As a general guide however one should not measure within a distance from the source less than one wavelength of the lowest frequency of interest, or nearer than one characteristic dimension of the source, whichever is larger. In any case one should always make a preliminary test by observing the variation of sound pressure level with distance away from the source, and select a radius of test sphere or hemisphere which is well inside the free field.

The furtherest limit of the free field, is its boundary with the reverberant field. For a properly designed chamber, there will be virtually no reverberant field except at very low frequencies, but the furtherest measuring point should not be less than about one quarter of the largest wavelength from the internal surface of the wall.

Thus the extent of the room in any direction should be equal to the greatest distance of the measuring point (determined by the size of the largest likely source), plus one quarter of the longest wavelength of interest.

Shell Construction.

The only requirement on the structure of the room shell is that it must be sufficient to prevent the ingress of any site ambient noise immediately outside the room. How much insulation is required depends on the environment in which the room is located, and the lowest sound levels likely to be measured from equipment under test inside the room. It is likely however that industrial test rooms will require at least 12" solid brick or concrete, and many will require double shell construction. In any case it is preferable to build the shell up on its own floor slab, separated from ground by a resilient support like a neoprene or thick mineral wool pad, or even steel spring mounts. Doors and observation windows must of course be of adequate construction to preserve the acoustic integrety of the shell.

Absorptive Treatment.

The treatment of internal surfaces is all important in the design of anechoic rooms. The average absorption coefficient of the wall lining must be as high as possible at all frequencies of interest. The criterion may be established as follows. At the fartherest measuring point, distance say r from the source, any reverberant energy must be at least a factor of ten below the direct energy. Or, the room constant R, must be greater than $160 \pi r^2$. The required absorption coefficient is then related to this limiting value of the room constant by

$$\overline{\alpha} = R / (S + R)$$

where S is the total internal surface area of the room.

In practice this will require absorption coefficients in excess of 0.9 (reflection factor less than 0.1) down to about 80 Hz. Since absorptive materials "cut off" at a frequency where wavelength is about four times the thickness of the material, the requirement of 80 Hz means that the wall lining material needs to be three to four feet thick. Slightly less thickness is required if the treatment is in the form of mineral wool, or urethane foam wedges, giving a more gradual transition from the propagating medium (air) to the absorptive medium, then if the surface of the absorptive treatment is flat. Figure 2 shows the performance of a 90 cm "wedge" mounted 10 cm from the wall.

REFERENCES


1. L.L. Beranek. "Noise Control" Chap. 8. McGraw Hill 1960

2. Ibid. Chap. 9.

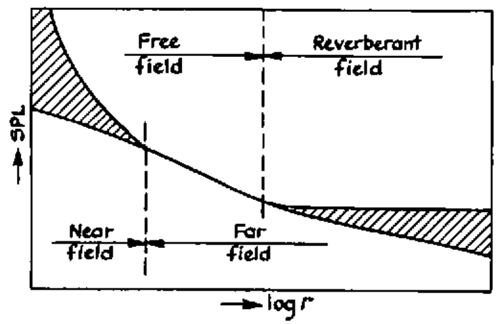
Free
field
Reverberant
field
SPL
Near
field
Far
field
log r

Fig. 1.

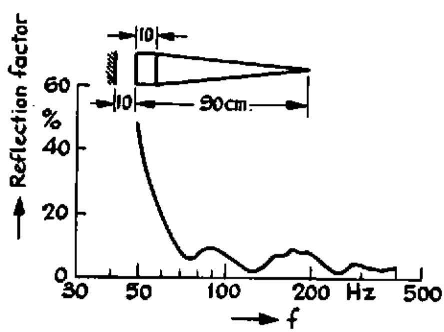
10
10
90cm.
Reflection factor
%
60
40
20
0
30
50
100
200
Hz
500
f

Fig. 2.