NOISE GENERATION BY DUCT TERMINATIONS

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1. INTRODUCTION

Published guides used by design engineers such as the CIBSE Guide 1972 (1), Australian I.R.A.H Guide 1980 (2) and ASHRAE HANDBOOK 1984 (3), generally provide insufficient information for the accurate calculation of noise generation from diffusers and grilles.

The highest accuracy claimed for present design methods, for example, (ASHRAE HANDBOOK 1984 (3)) involves an error of between 3 and 6 dB, and work by Blazier (4) has shown typical errors of 5 to 10 dB in the sound power output given by the manufacturers, of certain terminal devices.

One of the basic parameters in noise control calculations is the sound power level data supplied by manufacturers in their literature. When the manufacturer presents sound data or room Noise Criteria /Ratings it is often based on assumptions about the acoustical conditions of the room into which the device feeds and which may not prove accurate and always assumes ideal flow conditions into the device. When this latter, non real assumption is combined with measurement inaccuracies, errors of up to 13 dB can easily occur.

This paper presents results of measurements on commercial grilles, comparing the measured sound power output with that predicted by the Holmes method.

2. THE EXPERIMENTAL RIG FOR SOUND POWER MEASUREMENTS

To measure the sound power from the duct fittings the free field method was used with its requirement for ten different microphone positions. The method adopted to move the microphone was by means of a traverse system using stepper motors, controlled by an IBM PC. The microphone was connected to a digital frequency analyser and an IEEE-488 card was installed inside the computer in order to retrieve data from the analyser for subsequent analysis.

The measurements were carried out in an anechoic chamber of volume 125 m^3. Air flow was generated from a variable speed fan positioned some distance from the chamber and delivered to the chamber through suitable ducting .
Care was taken to ensure that the air flow was adequately silenced.

3. MEASUREMENT PROCEDURE

The subtraction method of measurement was used which included the measurement of sound levels existing in the anechoic chamber with the fan running but with no air terminal device installed. The increase in the sound pressure level due to the grilles was then measured. BS4196(6) states that if the difference is greater than 6dB then the result can be considered to be unaffected by the background noise. In all cases the measurement differences were greater than 6 dB.

The sound power measurement method described in BS4196 has a fixed microphone array which consists of ten microphone positions distributed over a hemisphere having a radius of not less than one meter. The measurements of the sound pressure level were made at the ten different positions. A time delay of 7 seconds was introduced between each measurement in order to avoid the background noise created by the stepper motors.

The data were transfered from the analyser to the computer via the IEEE interface. At every measuring point the 1/3 octave levels from 20Hz up to 10KHz (31 different levels) were recorded. In total 310 different levels from the 10 measuring positions were stored in a data file . Then these were averaged logarithmicly in order to get the mean levels over the hemisphere.

For each grille the same test was repeated for four different air flow rates. The static pressure P_s , the total pressure P_t the velocity presure P_v , and the grille face velocity were also measured in accordance with the BS4773(7).

BS4196 Part 5:1981 gives the sound power output from a grille in an anechoic room as equal to the averaged sound pressure level, (L_p) at 1m plus 8 dB, this is based on a hemisphere with radius of 1m. The sound power level, (L_w) for each grille and at each flow rate was then calculated from the equation :

$$L_w = L_p + 8$$

4. PREDICTED SOUND POWER FOR GRILLES

The sound power output predicted for each grille was calculated using the method based upon the work of Holmes(5). The method is presented in the Australian I.R.A.H Guide 1980 as follows.

$$L_w = F_g + 10\log(A_g B_e) + 10\log(b/1000) + 50\log(V/B_e) + 10\log(f/62.5)$$

Where

- F_g - is the characteristic spectrum term
- A_g - is the area of the grille in (m^2)
- B_e - is the blockage factor
- b - is the thickness of the grille vanes in (mm)
- V - is the grille face velocity in (m/s)
- f - is the frequency (Hz)

The values of the characteristic spectrum term F_g were calculated from,

$F_g=24$ for S_t = 0.01 to 0.068
$F_g=19.5 - 3.9 \log St$ for S_t = 0.068 to 0.3
$F_g=2.5 - 36.5 \log St$ for S_t = 0.3 to 10 onwards

Where S_t is the Strouhal Number, $S_t = fbB_e/1000V$

The Blockage factor B_e was found using the following equations based on the figures from the Australian I.R.A.H Guide 1980.

For X=1 to 1.8 $X^2 + B^2_e - 3.55X - 3.1B_e + 4.65 = 0$

For X=1.8 to 9 $X^2 + B^2_e -19.75X - 172.86B_e + 135.42=0$

X is the total pressure loss coefficient = $1.67\ P_t/V$

Sample results are presented graphically with the corresponding experimental measurements (see Fig. 1-3).

5. GRAPHICAL RESULTS

Details of the following grilles are given;

type K40- consisting of 3mm wide blades, fixed at an angle of 40^0 to the horizontal and at 19mm centres,

type GHV- consisting of 4mm wide double deflection horizontal front and vertical rear blades at 19mm centres, and

type HHV- consisting of 10mm wide , double deflection vertical front and horizontal rear blades at 25mm centres.

For the grille type K40 there is a very good agreement between the Holmes method and the measured values at low flow velocities. Only at 2kHz and 8kHz is there a difference of

8 dB. When the air flow rate increases there is a difference in all the octave bands. This shows that the Holmes method is more accurate at low air flow rates. (below 300 litres/sec).

For the grilles type GHV and HHV there is a good agreement between the Holmes method and the measured values only at 125 Hz. This shows that further work is required to develop the Holmes theory for these types of grille.

6. CONCLUSIONS

This work has shown that grille face velocity , fin spacing and static pressure loss are interrelated factors which influence the frequency characteristics of grille noise.

It was also found that grilles with a larger number of fins per inch tend to have higher frequency predominance in the grille noise spectrum. They also have higher pressure losses.

The best combination for producing a low sound power level is a small number of fins per inch and a low static pressure loss.

7. REFERENCES

1. CIBSE Guide 1972 chapter 12
2. AUSTRALIAN I.R.A.H Guide 1980
3. ASHRAE HANDBOOK SYSTEMS VOLUME Chapter 35 1984
4. ASHRAE Transactions 1981 Vol.87 Pt.1 pp 647-653
5. Air flow Generated Noise - Part 1, Grilles and Dampers HVRA Report 75, 1973. Holmes M.
6. British Standard 4196 : Part 5: 1981 Precision methods for determination of sound power levels for sources in anechoic and semi-anechoic rooms.
7. British Standard 4773 : Part 1: 1976 Methods for testing and rating air terminal devices for air distribution systems:

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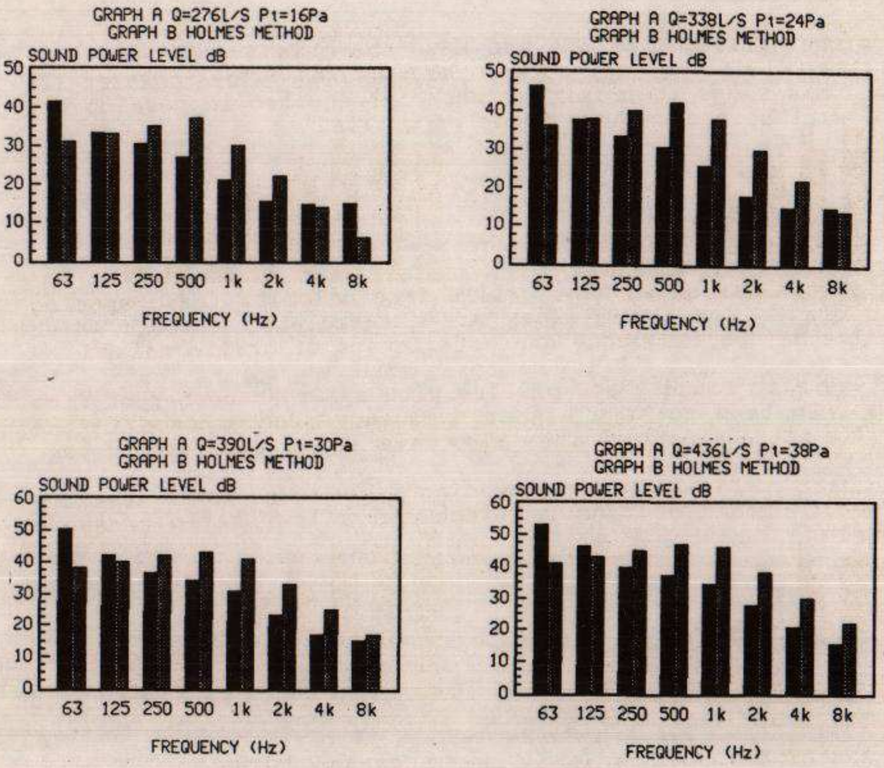

FIG. 1 GILBERTS GRILLE TYPE GHV

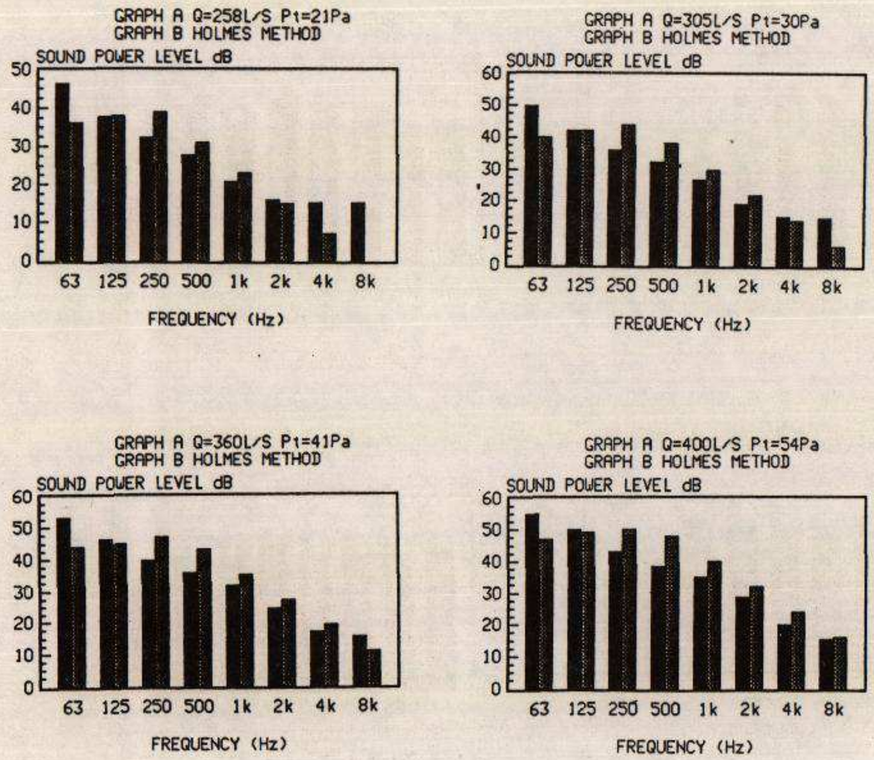

FIG. 2 GILBERTS GRILLE TYPE HHV

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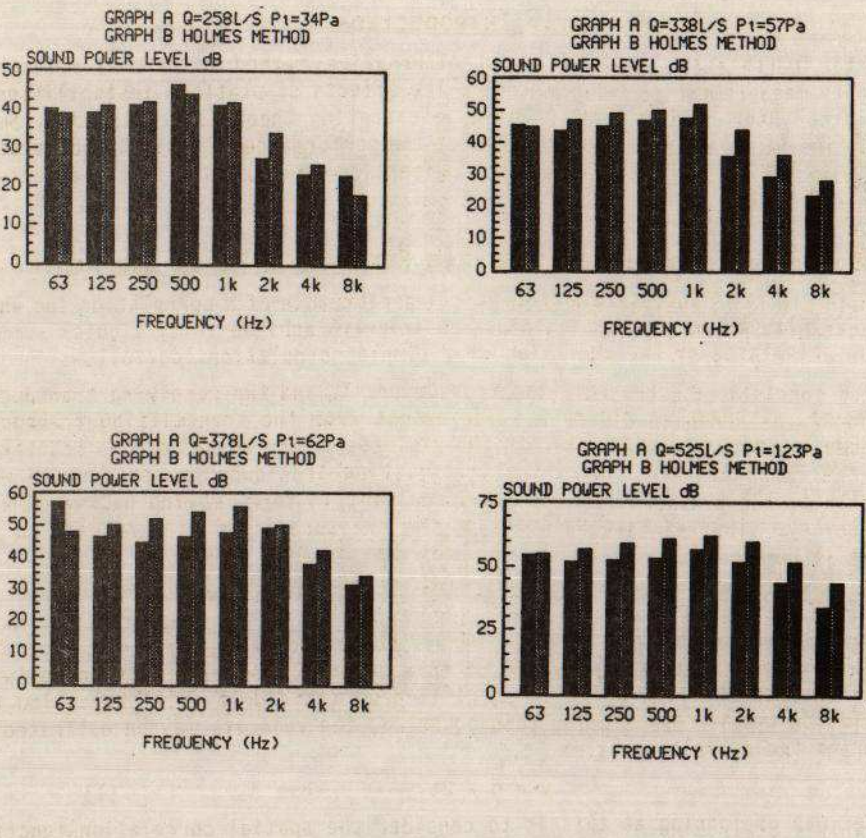

FIG. 3 GILBERTS GRILLE TYPE K40