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A CEGB HIGH INTENSITY ACOUSTIC NOISE FACILITY AT GRAVESEND

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1. INTRODUCTION

This facility, designed as a general purpose acoustic and vibration workshop, was constructed underground in what was the condenser pit of two of the turbo-generator sets installed in the old Gravesend Power Station, now part of the CEGB Scientific Services Centre at Gravesend. It comprises a 5.5m x 4.4m x 3.5m high reverberation chamber, a 4.5m x 2m x 2.5m high anechoic room, an amplifier room and a control room/laboratory. The walls of the chamber are a minimum of 0.45m in thickness in order to reduce the noise outside the chamber to an acceptable level. To this end, large double leaf acoustic doors are also employed. The reverberation chamber and the anechoic room are linked by a 1.2m square opening in the 0.45m thick wall separating them. Normally, this opening is closed by two heavy sound reducing doors, but can be used for testing the noise reduction properties of panels etc. Because it was envisaged that some of the test specimens would be large, provision was made to extend the size of the reverberation chamber by removing two large panels in the 0.45m thick roof (leaving an opening 3.05m x 3.05m) and then building a temporary extension above it, its weight being supported on massive steel beams built into the structure. These removable roof panels, and similar ones in the roof of the anechoic room, also facilitate the installation of test specimens which would otherwise be too large to pass through the comparatively restricted access at the basement floor level. Lifting equipment with a capacity of 8 tonnes is available. The facility is used to undertake investigations in both the structural acoustics and environmental acoustics (noise control) fields as well as for general vibration work of a noisy nature.

2. NOISE GENERATOR

An important aspect of this facility is the high intensity acoustic noise generator. This is a LING ALTEC EPT 200 electropneumatic transducer.

Noise levels which are continuously variable from low to high values, are generated by the modulation of a flow of compressed air. According to the manufacturers the transducer is capable of reproducing sine, random, or any complex wave form within its operating frequency range (1).

2.1 OPERATION

The electropneumatic valve consists of an aluminium cylinder with 240 circumferential slots which is flexurally supported on rubber. This is the only moving part in the transducer. A stationary stainless steel cylinder is located within the aluminium cylinder and is concentric with it. This also has 240 circumferential slots. Axial movement of the aluminium cylinder allows the slots in both cylinders to vary their degree of coincidence, thus altering the cross sectional area available for the flow of compressed air. An inductive drive system is used to energise the reciprocating valve, the end section of which is a one-turn secondary winding of an air core transformer. The primary winding consists of two driver (or voice) coils which are co-axial with the shorted turn portion of the reciprocating valve. The driver coils, connected in series, induce current in the shorted turn, which reacts to an electro magnetic field causing the valve to move, and thus modulates the air flow.

2.2 SPECIFICATION

The manufacturer's specification indicates a maximum acoustic output power of 10,000 watts. The frequency range is 20 to 5 K.Hz, with full sine modulation to 1,250 Hz. The flow of air to the transducer must be pulse free, clean and dry, and have a delivery rate of 0.708 $m^3/5$ (1500 C.F.M.) and $206.8 \times 10^3 N/m^2$ (30 psig) at the transducer, to enable the maximum power to be delivered. At Gravesend a dedicated Ingersall-Rand 'Centac' compressor is used.

2.3 PERFORMANCE

It has been shown (2) that the frequency range over which maximum power can be developed depends upon the horn used. Figure 1 shows the manufacturers sine output rating for the transducer alone and superimposed is the performance with two different horn configurations. The same reference has calculated the sound power output of the acoustic transducer with a configuration of a 50 Hz horn into the reverberation chamber using:-

$$L_w = L_p + X$$

where:- L_w is sound power (dB above 1pW)

L_p is room averaged sound pressure level (dB above 20μPa)

X is expression involving room dimensions and reverberation time

and $$X = -10 \log \frac{T}{T_o} + 10 \log \frac{V}{V_o} + 10 \log 1+\frac{S\lambda}{8V} + 10 \log \frac{B}{1000} - 14$$

where:- T is the reverberation time in seconds

T_o is 1 second

V is room volume in m^3

V_o is 1 m^3

S is room surface area in m^2

λ is wavelength of sound at centre frequency of the third-octave band in metres

B is barometric pressure in millibars

Although the manufacturer claims 10 kilowatts is the maximum output power, the tests indicated that the maximum power was only 7.6 kilowatts. Air flow measurements made at the time indicated a shortfall of some 12% of the maximum flow rate required (by the manufacturers figures) to achieve full power output. A further check indicated that the maximum power achievable with the measured flow rate was about 7 kilowatts according to the manufacturers data. This illustrates the great dependence on air flow rate.

2.4 LIFE

Verbal life quotations have been indicated as approaching 500 hours at full power. No written confirmation of this has been found. In fact, the varying test conditions required for each test, make a life figure difficult to quote. Limited experience at Gravesend has shown that the transducer fails for many different reasons, and more often than a 500 hour life would indicate. This could, of course, be due to mishandling in the learning stages of operation.

2.5 MAINTENANCE

Maintenance usually consists of the replacement of damaged components following a failure of the transducer. Initially it took about a week to restore the transducer to working condition, assuming replacement parts were available. Currently this is reduced to 2 or 3 days, depending on the failure. The very precise nature of the assembly requires skilled technicians to effect repairs.

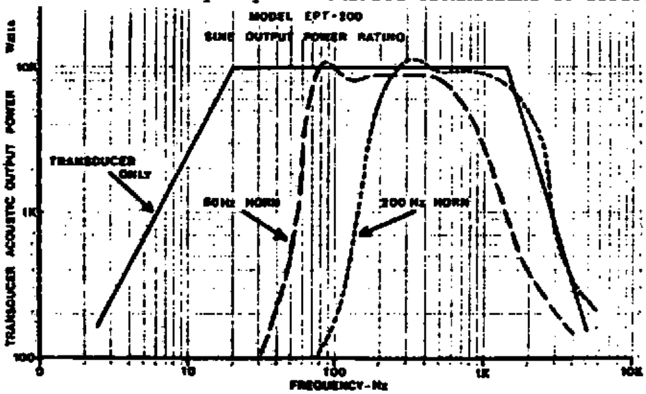

Fig. 1 MANUFACTURERS SINE OUTPUT RATING SHOWING EFFECT OF HORNS.

3. MEASURING INSTRUMENTATION

The facility is equipped for making measurements to an acceptable level of accuracy in the noise, strain, and vibration fields.

3.1 B&K ¼" microphones, type 4136, complete with type 2618 pre-amplifiers and power supplies type 2807, are used for the detection and measurement of high intensity noise, with the aid of a B&K microphone amplifier type 2603 for readout. The microphones are calibrated, at regular intervals, in a High Pressure Calibrator type B&K 4221. The calibration signal is provided by a

Sine, Random Generator type B&K 1027.

3.2 Structural responses to acoustic noise are measured using strain gauges and accelerometers. Typically, the strain-gauge outputs are measured through FYLDE ELECTRONICS type FE-492-BBS bridge conditioners and type FE-255-DA data amplifiers. Acceleration outputs are measured through ENDEVCO charge amplifiers type 2735, from piezoelectric accelerometers. It is desirable, in high noise fields, to use accelerometers which exhibit a low sensitivity to acoustic noise.

4. OPERATIONAL PROBLEMS

Experience has indicated that it is unwise to leave certain components within the test chamber while testing is in progress. Among the most vulnerable of these are light fittings and some electrical fittings. Particularly vulnerable are fluorescent tube fittings where screws come undone, 'starters' fail and the lining material of the tube becomes detached and forms small heaps of powder within the tube. Electrical fittings such as switches steadily deteriorate, and micro-switches can be caused to operate under high noise conditions, in the absence of external mechanical movement.

Instrumentation is especially at risk. Connections made in electrical connector blocks are made open-circuit when the clamping screws come loose. Unsupported wires break. Microphones in travelling wave tubes require to be well gripped to keep them in place, and this gripping action can damage bodies and internals unless great care is taken.

Microphone grids, and then the cartridges, come unscrewed; pre-amplifiers dismantle themselves.

Loose connecting bolts, in the structure under test, or in the travelling wave tube, begin to fret. Loose washers exhibit 'acoustic sawing' and cut readily into bolt shanks. Joints in wooden travelling wave tubes must be well made, as poor joints readily heat up under test.

All of the internal surfaces of the test chamber doors, and any other chamber components must have locking devices on bolts, nuts and screws. Frequently locking washers are inadequate; a combination of welding and 'loctite', as required, is the best solution.

5. ACKNOWLEDGEMENT

This paper is published by permission of the Director General, CEGB, South East Region.

6. REFERENCES

1. Ling Electronics, data sheet No EPT-200-1266B.

2. D M WARD 1978 CEGB. SSD. I.NOTE 347/78
Initial trials of the acoustic test facility at Gravesend.