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THE NPL HEARING PROTECTOR TEST RIG

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INTRODUCTION

For hearing conservation purposes the attenuation of hearing protectors is measured subjectively to BS 5108:1983 using a threshold test method and the present NPL rig employs a microcomputer controlled test unit.

TEST PROCEDURE

The measurement of protector attenuation is made using a group of twenty test subjects, the procedure being to determine the binaural free field threshold of hearing both with and without the protector in position. The attenuation of the device is then taken as the mean difference between the two threshold values, in decibels.

The acoustical requirements of the test are particularly demanding and at NPL, to ensure that the sound field is sufficiently diffuse at the position occupied by the subject's head, a tetrahedral array of loudspeakers is used. Measurements are made over the frequency range 63 to 8000 Hz using 1/3-octave bands of noise and the problem of coherence is overcome by using an independent noise generator for each loudspeaker, each channel having its own set of filters and attenuators.

At each visit the subject makes three complete sets of measurements, one without a protector in position and two with, commonly referred to as open and closed-ear measurements respectively. Both the test sequence of open and closed ear measurements and the presentation order of test frequencies are randomised.

To measure hearing threshold level a self-recording audiometric test method is used where the subject controls the level of the test sound and produces a trace which effectively records the level at which he just hears the sound and also the level at which he no longer hears the test signal. Previously the traces produced have had to be read by one reader and checked by another to ensure accuracy; the hearing threshold level, in principle, being obtained by averaging the peaks and troughs of the trace although in practice, traces are irregular and a degree of intuitive interpretation is required by the trace reader. The software incorporates an algorithm which reads traces and moves the test to the next frequency when sufficient data have been obtained.

Previously, randomisation of the test order, selection of test frequency and adjustment of the initial presentation level have also been carried out by the operator. The new NPL system relieves the operator of such tasks and thus the possibility of error, but leaves the operator firmly in control of the test.

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TEST SYSTEM

The system has been built around a Norwegian Electronics Type 828 Test System for Hearing Protectors. This single unit provides four independent channels, each with its own generator, filter and attenuator, and these can be independently addressed to allow the output to each loudspeaker to be individually set. Using an IEEE bus, a BBC microcomputer with a 6502 second processor controls and monitors the various stages in the test. (See Figure 1).

SOFTWARE PHILOSOPHY

The software provides a set of procedures whereby the 828 test system can be computer controlled under prompted operator usage. The complete program suite is written in BASIC, the choice of which might appear inappropriate for the control of electronic apparatus.

However, set against the inherent disadvantages of low processing speed and a possible looseness of structure, BASIC enabled:

1. Programs to be written, developed and debugged rapidly.
2. Ready access to the software by the end user to allow future changes or extensions to be made.
3. Changes to be made by personnel who have reached only the first level of programing skill.

Possible speed limitations have been dealt with by a hardware solution in the form of a second processor coupled to the BBC machine.

A tight discipline was applied to program structure and the extensive use of REMARK statements and of procedures, which are called by name, assists in producing an understandable listing for future development purposes. Components of the program suite are as shown in Figure 1.

Long-term usage of computer based systems can lead to operator fatigue and subsequent lapses of awareness. This difficulty has been addressed in the program suite by pacing the operator through each procedure with a series of prompts, each of which calls for a positive decision and action. Extensive error trapping has been incorporated and system tolerance levels have been set to prevent the continued use of a malfunctioning system or the handling of erroneous data.

CHECKING AND CALIBRATION

System checks have been arranged into several levels of sophistication which allow usage on a daily, intermediate or long-term basis. A separate routine enables a free-form selection of the 828 test system variables so that the more traditional fine tuning adjustments can be made. In particular this enables system compliance testing with respect to the standard.

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At the daily level, a short-duration audio check and a limited series of voltage checks are made. Rapid confirmation is thus obtained of the correct operation of the filters, amplifier and loudspeaker associated with each of the four channels.

In the intermediate check routine, a voltage and acoustic assessment is made on all four channels over the normal test frequency range of 63 to 8000 Hz.

The long-term check provides a means whereby the individual channels may be acoustically balanced with respect to the SPL as measured at the centre of the tetrahedron. Overall system calibration at both high and low levels provides an automatic check of system linearity.

Throughout the program each prompt is presented as a single instruction which is not replaced by the next instruction until cleared by the operator. The practice is also made of keeping a separate traditional log book of the system parameter values and at the appropriate points in the routines the operator is prompted to enter the measured values in the log. Hence, over a period it should be possible to detect any system drift by reviewing the contents of the log book.

AUDIOMETRIC TEST

These routines give a fully automated sequence in which all data relevant to a given set of hearing protectors are obtained. Where possible, default and machine-generated sequences are used and the information is stored to disc in a manner which enables future random access searches to be made.

A constant level broad-band noise is generated in the 'Fitting' routine which is used to ensure an effective fit of the test protectors prior to testing. During the initial keyboard entry of test details a machine-generated pseudo-random sequence of open or closed ear condition is generated to allow two protectors to be tested at a single sitting. Also, during entry of test details, the frequency band sequence for the following three cycle test is generated. The selection of the 63 Hz band is optional and the other bands are created from a random sequence which has stringent order conditions applied to to ensure that low frequencies do not occur early in the test sequence.

In the audiometric routine a 'Practice' run option is provided to facilitate subject familiarity with the test procedure in order to give full compliance with the standard. Testing passes automatically to the next test frequency band when a sufficient number of reversals have been monitored.

The level at which reversal occurs is controlled by the subject test button which is monitored by the microcomputer analogue port. The averaging of the reversals is machine processed to provide the relevant hearing threshold level and the result, together with a full audiogram trace, are displayed on the screen. Normally the test continues under fully automatic control but in some cases the trace may not lend itself to analysis by the machine. In this event the operator is prompted and manual input of the level is requested. On

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completion of the three test runs, data are summarised into a tabulated printout and a full audiogram plot is provided.

ANALYSIS

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Built in procedures provide a limited statistical output but there is provision to incorporate further search and analysis procedures should these be required.

REFERENCES

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BS 5108:1983 British Standard method for measurement of sound attenuation of hearing protectors.

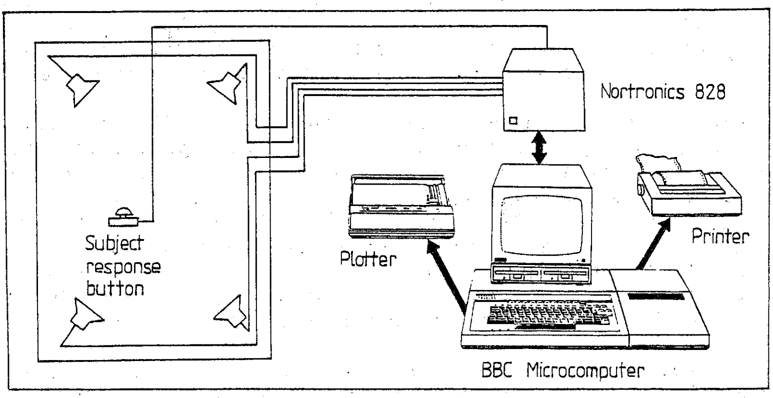

Figure 1. Test system

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SYSTEM CHECKS AND CALIBRATION	PROTECTOR TEST	ANALYSIS
Daily	Test data entry	Statistical summary
Intermediate	Test order	Data search
Long-term	Frequency order	
System verification	Protector fitting	
	Audiometric test	
	Print and plot	

Figure 2. Components of program suite.