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Lifetime of electret microphones by thermal degradation analysis via electroacoustic measurements

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ABSTRACT

Electronic equipment frequently utilises low cost electret microphones. In this paper, a complete accelerated life-test on commercial electret microphones is presented using thermal chamber testing. The test was conducted on the microphones under study at three different temperatures. After each thermal probe, the electroacoustic characteristics of each transducer was analysed for obtaining the degradation model. In the literature such tests have been performed through charge losses on the electret materials. Life models were obtained for the degradation failures revealed from the tests and a complete temperature model was then developed, which can calculate the useful life of the microphones under any of these conditions.

1. Introduction

At present, more numbers of electronic equipment employ low cost electret microphones, which is not an indicator of poor quality. Nevertheless, electret microphones are available in consumer electronic gear such as telephone terminals, portable sound recorders, toys, etc. Moreover, they are extensively used as part of professional electronic equipment, as in controllers-limiters of sound pressure level, like those utilised in hospitals, pubs and small discotheques. The substantial use of these electret microphones [1] motivated us to investigate and acquire data on their quality and reliability.

In current consumer equipment, electret and MEMS microphones coexist, both operating with the electrostatic principle, which has a non-linear behaviour and needs bias to operate in a linear zone. Electret microphones use as bias permanent polarisation induced at the time of manufacture in a plastic polymer sheet, which is the electret material. This polarisation attracts the free charge on the metallic electrodes of the device, which is necessary for the proper working of principle of electrostatic transduction. As is widely acknowledged, the sensitivity of such types of microphones is proportional to the free charge induced and, therefore, to the permanent polarisation of the electret material. Therefore, any polarisation loss will, over time, result in loss of both the response and transducer performance. Analyses of the degradation of the electret materials are available in the literature [2–3]; however, identifying studies employing electroacoustic measurements is difficult. Moreover, the authors believe it could be useful to repeat the reliability analyses of consumer electret microphones to investigate how new materials can improve their behaviour despite their low price.

In this paper, three tests were performed on 30 samples of the same production batch of a single manufacturer. From among the total population, 3 subsets of 10 microphones were selected, one for each temperature. Periodically, the microphones were removed from the thermal chamber for electroacoustic measurements.

Chapter two discusses the samples and methods, and chapter three records the test results related to the variations in the frequency response of the microphones to temperature and the degradation analysis. In chapter four, the reliability and life data analysis are reported, while chapter five draws the conclusions.

2. Samples and methods

2.1. Samples

The electret microphones tested are low in cost, have high vibration

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Table 1
Manufacturer specifications of the electret microphones under test.

Specifications	Value
Sensitivity	− 44 ± 5 dB (0 dB = 1 V/Pa, 1 kHz) eq. 6.3 mV/Pa.
Impedance	Less than 2.2 kΩ
Directivity	Omnidirectional
Frequency range	20 Hz – 20 kHz
Max supply voltage	10 V
Standard operating voltage	2 V
Current consumption	Max. 0.5 mA
Sensitivity reduction	Within–3 dB and 1.5 V
S/N ratio	Less than 58 dB
Capsule diameter	6 mm

Fig. 1. Electret microphone capsule (sample).

rejection and are designed for general applications, particularly suitable for incorporation into portable equipment.

To perform the experiments, we purchased 100 microphone electret capsules, selecting 10 microphones for each temperature test.

In Table 1 the high sensibility and appropriate signal-noise ratio are highlighted, considering the small size and low price (2 $). Active low cost electronic devices are incorporated (FET amplifier) into the microphone capsules; therefore, the microphones need continuous voltage supply and a 5 V source was used for that function. Fig. 1 shows a single sample of an electret microphone capsule.

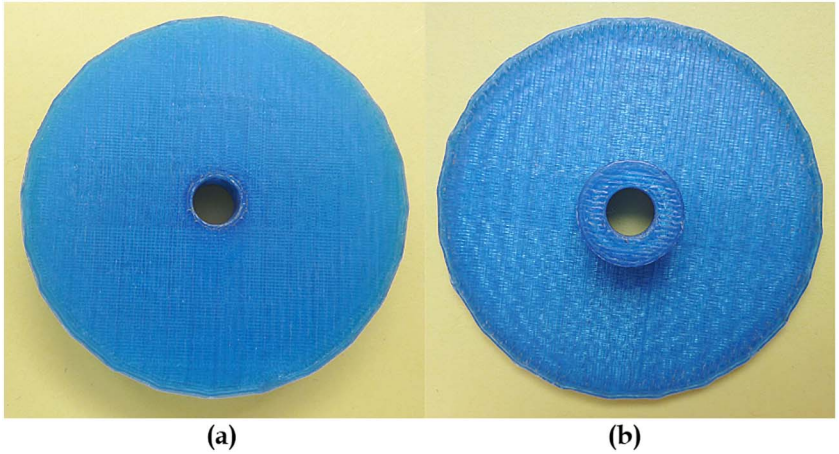

Fig. 2. Microphone-calibrator special adapter **(a)** Top view **(b)** Bottom view.

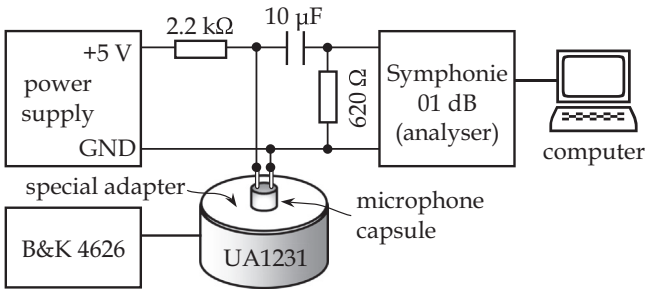

Fig. 3. Block diagram of the measurement setup.

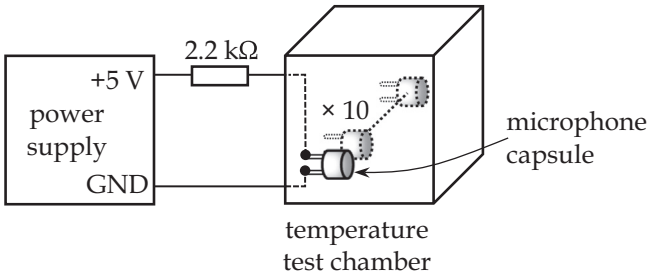

Fig. 4. Block diagram of the temperature tests.

2.2. Measurement method

2.2.1. Sensitivity

The parameter for analysis in our degradation experiments is microphone sensitivity, $\boldsymbol{S}$

$$\boldsymbol{S} = \frac{\mathrm{V}}{\mathrm{p}}, \tag{1}$$

where V is the output voltage and p is the acoustic pressure on the transducer. To generate the acoustic pressure p, the Bruel & Kjaer 4226 Multifunction Acoustic Calibrator was used. This device emitted pure tones at the central frequencies of the octave bands from 31.5 Hz to 16 kHz and additionally, at 12.5 kHz. For this reliability test, we applied to the microphones only the 94 dB and 114 dB Sound Pressure Levels (*SPL*). The former acoustic measurements were recorded during the degradation process, every time the 10 sample microphones were