Aerosol Tests

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Introduction

To determine the characteristics of "sound" of aerosol product being released from can, some basic experiments were performed using:
(a) reference acoustic microphone
(b) piezo film as "contact" microphone
(c) piezo film as acoustic microphone
(d) piezo film as thermal detector
The aerosol used in these tests was a deodorant spray, 45 mm diameter x 150 mm height approx

(a) Reference acoustic microphone

A B&K Type 4004 studio microphone, powered by Type 2812 power supply, was used to record the sound pressure level near to jet. Sensitivity 10 mV/Pa, frequency response on axis flat (within 2 dB) from 10 Hz to 40 kHz. Signals were recorded using HP3561A dynamic signal analyzer in "time buffer" mode, 50 kHz measurement bandwidth. Traces could be processed to yield average spectral magnitude, instantaneous magnitude, etc.

Results: a substantially flat spectrum of sound pressure was observed, extending out beyond the calibrated frequency range of the microphone. Peak sound pressure was around 90 dB SPL, at a frequency of 30 kHz (measured at 15 mm distance from nozzle).

(See trace labelled "B&K mic 15 mm from nozzle")

(b) Piezo film as "contact" microphone

A standard MSI piezo film sensor (p/n 1001777, referred to as "dart sensor") was fixed vertically on the aerosol can wall, using the self-adhesive tape already laminated to the sensor. Sensor active area and lead-out traces were shielded using an overlay of copper foil tape, connected to grounded can. Signals were initially recorded using sensor connected direct to 1 M oscilloscope probe - later, better results were obtained shunting the sensor with 10 K resistor to remove low frequency components.

Results: the broad-band noise seen using the reference microphone was also detected by the film sensor acting as "dynamic strain gauge" or contact microphone, but a particular band of frequencies (approx 2 kHz to 15 kHz) came through stronger. Overall signal level was low (typical 30 microvolt rms at 10 kHz) but signal:noise was reasonable (>25 dB).

(see trace labelled "Dart sensor on can, 1.3 nF//10K")

Secondary experiment: to determine why the low frequency band predominated, another identical piezo film sensor was bonded to opposite side of can, in same orientation, and driven with periodic noise from the built-in generator of the HP3561A. The spectrum of the received vibration signal was compared with the average spectrum of the aerosol-induced vibration, and an approximate correspondance was seen between the two traces. This suggests that the can wall vibrates with certain modes which are excited by the escaping jet.

(see trace labelled "Comparison: aerosol vs piezo-induced spectra)

(c) Piezo film as acoustic microphone

A custom version of the "dart sensor" (identical, but omitting the adhesive tape) was formed into a cylinder using a small strip of adhesive tape to fix. This cylinder (approx 10 mm diameter, intitially 16 mm long, later cut to 12.5 mm long) was mounted such that the aerosol jet passed through the center. The intent was to allow the sound emitted by the jet to cause a radial pressure signal, resulting in circumferential stretch of the film. With the original length of the cylinder, it was noted that the escaping product began to hit the inner wall. This created large amplitude, low frequency signals (although the broadband "noise" signal could still be seen). Cutting the cylinder length back to 12.5 mm improved this situation a little, but some product still hit the inner wall. This event can be seen on the displayed time record.

"Noise" amplitude much higher in this experiment, compared with "contact microphone": typically 10 mV rms at 5 kHz.

(see trace labelled "Dart sensor cylinder, jet through center")

(d) Piezo film as thermal detector

The same "contact microphone" used in (b) above was later connected to a charge amplifier (B&K Type 2635) set to a low frequency limit (-10%) of 0.2 Hz. The intent was to determine whether low frequency strain signals could be detected in the can wall as the button was depressed. In fact, a low frequency signal was detected, but the origin was a sudden cooling of the can wall when product was released. The low frequency signal appeared to be virtually linear ramp, with peak amplitude dependent upon duration of product release. The charge output showed approx 0.63 nC per second of aerosol release time (equivalent to 0.48 V open-circuit per second).

(see trace labelled "Aerosol can: thermal response (Q)")

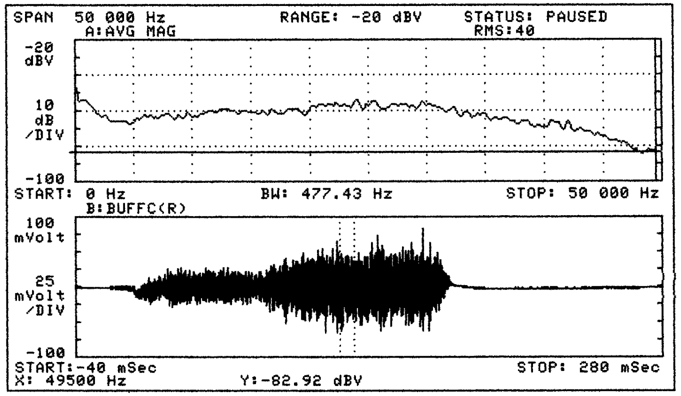
In a further verification, the thermal signal was intentionally differentiated with respect to time, by using a much shorter time constant in the measurement. The sensor was connected direct to a 10 M probe (13 ms time constant, compared with 1.6 s using charge amp). This arrangement showed a virtually rectangular voltage waveform as product was released, with constant amplitude of 10 mV during the dispense.

(see trace labelled "Aerosol can: thermal response (10M)")

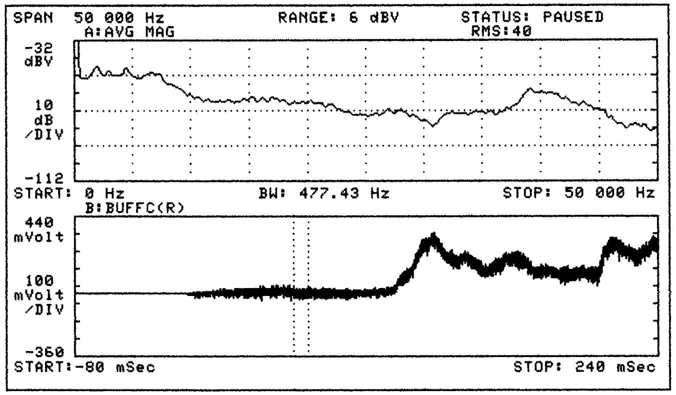
Conclusions and discussion

Significant acoustic and vibration energy is emitted as an aerosol jet is released. This can be detected as an airborne signal to a closely-mounted microphone, or as a vibration signal transmitted through the nozzle assembly back into the can, using a contact microphone. A thermal signal is also generated as the pressure and volume inside the can changes (estimated at around -0.25 deg C per second), and may be detected using piezo film as a thermal detector.

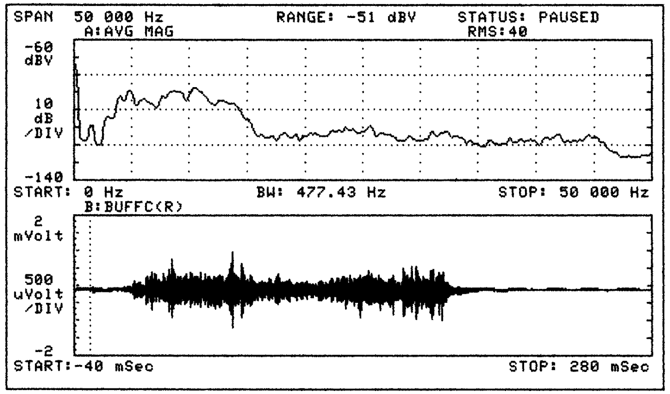
B&K MIC ~15mm FROM NOZZLE 10mV/Pa



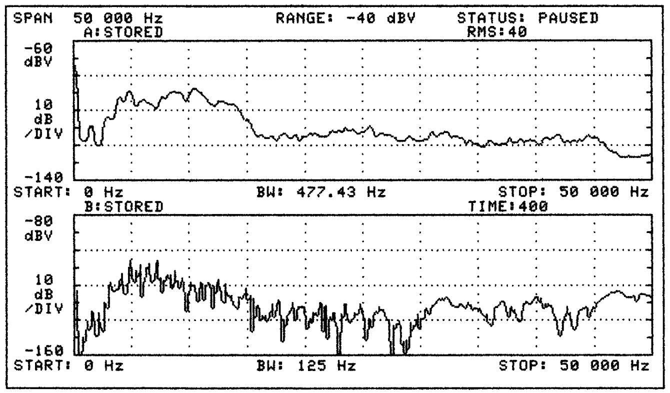
DART SENSOR CYLINDER, JET THROUGH CENTRE



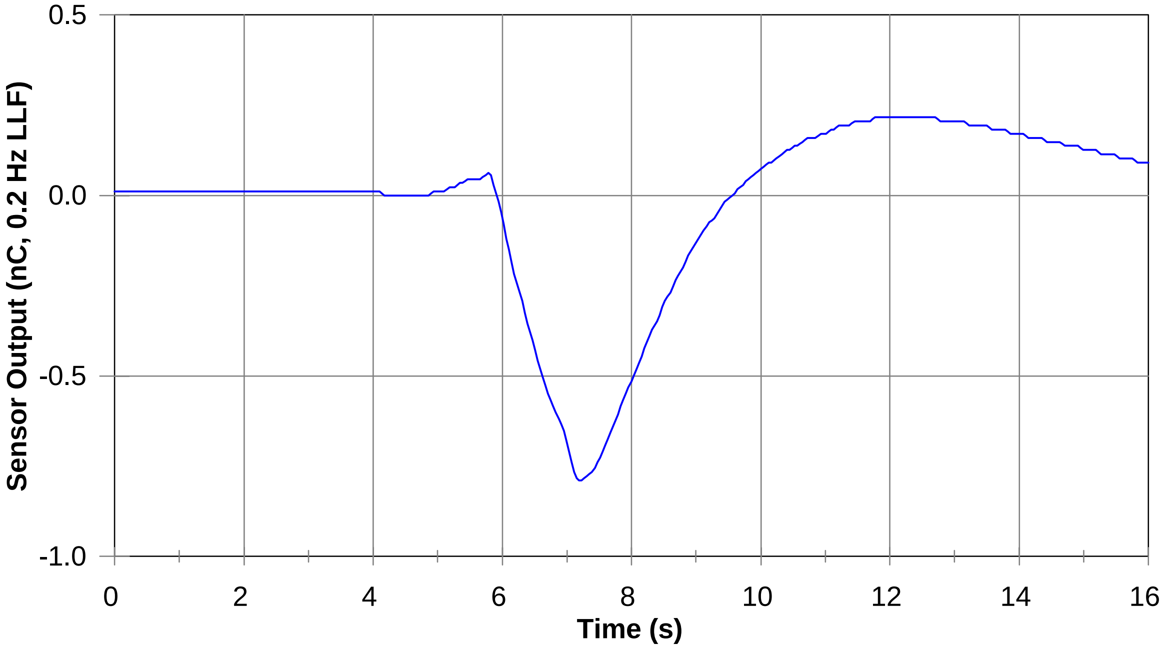
DART SENSOR ON CAN, 1.3nF // 10KΩ



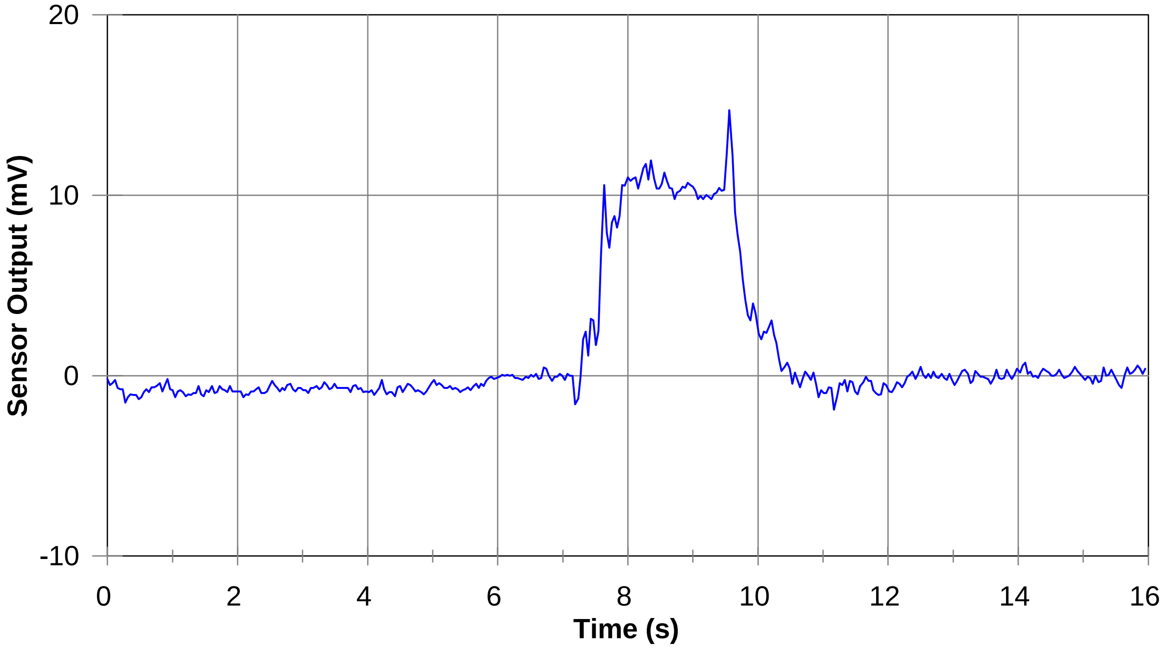
COMPARISON: AEROSOL vs PIEZO-INDUCED SPECTRA



Aerosol Can: thermal response (Q)



Aerosol Can: thermal response (10 M)



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