Comparison Of Product Sound Level Emissions: Direct Hemi-Anechoic Versus Reference Reverberant Methods

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INTRODUCTION

There are numerous methods of quantifying the sound level emissions from consumer products, many of which are contained in international standards. These methods are generally divided into reverberant field and "free field" (including hemi-anechoic) types. They can further be divided into direct and reference sound power determinations. This article provides an approximate statistical comparison of the results obtained by a direct hemi-anechoic method versus a reference reverberant method for a consumer product, namely a conventional household refrigerator-freezer. The statistical validity is limited by the sample size of six.

DIRECT HEMI-ANECHOIC

The measurements undertaken for this phase of the testing were conducted in accordance with the procedures described in ISO 3744 which is an engineering grade method for a free field above a reflecting plane (hemi-anechoic). The measurements were performed in the hemi-anechoic chamber of the Atoma Technical Centre, a division of Intier Automotive located in Newmarket, Ontario. This facility has been qualified in accordance with ISO 3745 for frequencies above 80 Hz.

Based on the dimensions of the appliance (approximately 75 cm x 75 cm x 164 cm), a parallelepiped defined the measurement surface at a distance of 1.0 m in each dimension with the refrigerator upright on the floor. A microphone was located at the centre of each face and at each three-way corner of the parallelepiped, above the reflecting plane (i.e., nine microphones in total).

Part A – Typical Cycle

After 24-hours of continuous typical operation to reach steady-state, sound levels averaged over 30 seconds were recorded simultaneously for all microphones at 1, 5, and 7 minutes from the beginning of a cooling cycle. The sound power was calculated as described in the standard based on the nine sound levels and the dimensions of the parallelepiped. These sound powers were then equated to sound pressures from an idealized point source at one meter over a reflecting plane. The 1, 5, and 7-minute equivalent sound levels in dBA were averaged to produce an overall sound level from a typical operating cycle.

Part B – Component Contributions

The sound level measurements were repeated in the middle of the subsequent cycle, but with the individual components operating sequentially (i.e., the compressor, then the evaporator fan, and finally the condenser fan). The same calculations were performed to arrive at 1-metre equivalent sound levels for each component. The total sound level of each unit was then calculated based upon the energy sum of the component sound levels.

REFERENCE REVERBERATION

These measurements were conducted by a laboratory associated with the product manufacturer, and as such, details on the measurement procedure were not fully disclosed. However, it is understood that the measurements were conducted in general accordance with ISO 3742 which includes determination of the sound power of a source using a comparison to a reference sound source in a reverberant room.

Specifically, a 32-second average sound level of a reference sound source was measured with a traversing microphone in a reverberant chamber. The difference between this measured sound level and the calibrated sound power level of the reference source is then assumed to be a 'test-facility constant', ***K***, independent of the source under test.

Part A – Typical Cycle

The same operational protocol was followed for the sound level measurement of the same series of refrigerators as measured in Section 2, above. The sound power levels at 1, 5, and 7-minutes were calculated by adding ***K*** to the average sound level over 32-seconds from the traversing microphone. These were then equated to equivalent 1-metre free-field sound levels above a reflecting plane. The 1, 5, and 7-minute values were averaged to produce a typical operating cycle sound level.

Part B – Component Contributions

As described in Section 2.2, the measurements were repeated with the refrigerator components operating sequentially. The 1-metre equivalent sound levels from each component were then added on an energy basis to compute the total sound level of each unit.

RESULTS

The overall 1-metre equivalent sound levels for the six refrigerator units (Part A) are presented in Table I for both the direct hemi-anechoic and reference reverberant methods.

As well, the total 1-metre equivalent sound levels for each unit are presented, based on the summation of the component sound levels (Part B).

Table I: 1 m Equivalent Sound Levels [dBA]

Unit	ISO 3744[1]		ISO 3742[2]	
	Overall[3]	Sum[4]	Overall[3]	Sum[4]
1	45.0	45.3	45.4	44.9
2	43.8	42.3	46.6	45.5
3	45.1	43.2	47.6	45.5
4	40.2	41.1	41.4	40.9
5	40.6	40.0	42.9	40.6
6	40.1	40.0	41.9	39.8
μ	42.5	42.0	44.3	42.9
R	4.9	5.3	6.2	5.7

[1] ISO 3744 is the Direct Hemi-anechoic method.
[2] ISO 3742 refers to the Reference Reverberation method.
[3] Overall is the average measured sound level of a typical cycle
[4] Sum is the total of component sound levels.

The data indicates that the range of values is comparable for both measurement methods, and that there is a slight bias (lower) for the direct hemi-anechoic method. This bias may be partly due to the inherent property of reverberation methods of representing all of the sound power, whereas hemi-anechoic methods typically only sample the radiated sound power at discrete points.

The data sets were plotted against each other for graphical interpretation of the relationships between the two measurement methods (ISO 3744 and ISO 3742) and the two descriptors (Overall and Sum). Figures 1 and 2 present these plots, with the statistical indicators shown on the graphs.

CONCLUSION

The foregoing indicates that despite a small negative bias for sound level data measured under free-field conditions (particularly for directional sources or components) in comparison to reverberant field measurements, the correlation is very strong. This bias could be overcome by increasing the microphone mesh density, particularly near areas with higher directional characteristics. One of the main advantages of the ISO 3744 method is that the individual sound levels at each microphone position can be used to estimate the directional characteristics of the sound source. This is not possible under the reverberant field conditions found in ISO 3742.

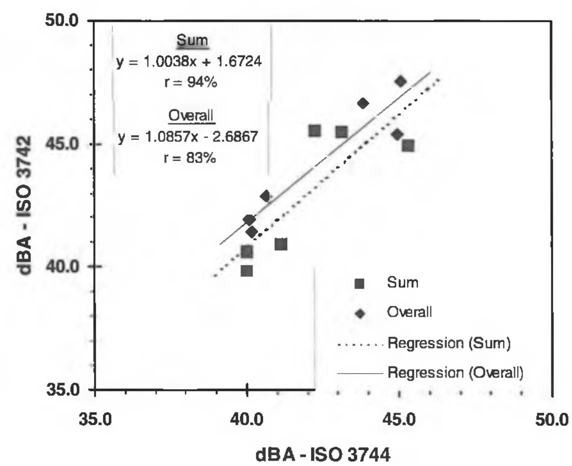

Figure 1: Method comparison with descriptor as parameter

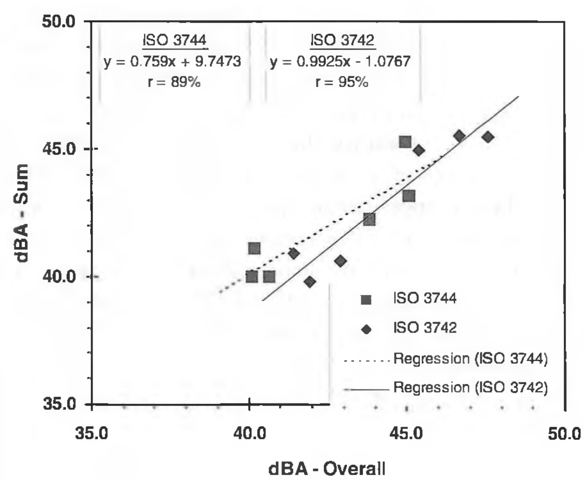

Figure 2: Descriptor comparison with methodas parameter