Technical Note

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Project title	Leaf Blower Noise	Job number	261937-00
cc	D.C. Council's Committee of the Whole	File reference	
Prepared by	Chris Pollock, PE Geoffrey Sparks	Date	July 16, 2018
Subject	**Bill No. B22.234, the Leaf Blower Regulation Amendment Act of 2017 - Written Statement by Arup**		

1 Executive Summary

Arup tested 7 commonly used leaf blowers, 3 gas and 4 battery powered, to help answer the question of what makes which type have more noise impact. The following written statement summarizes the testing procedure, results, and oral testimony presented by Arup to the D.C. Council’s Committee of the Whole on July 2, 2018.

In summary Arup’s testing indicates:

- The sound characteristics of gas leaf blowers measured have a significantly greater low frequency sound component in comparison to battery leaf blowers measured
- The low frequency sound energy of the gas leaf blowers measured transmits more readily over longer distances making them more readily audible and of greater noise impact to the community
- The low frequency sound energy of gas leaf blowers measured transmits more easily through home windows and glass doors, meaning they sound louder indoors than the battery leaf blowers measured

2 Sound Testing Methodology

2.1 Gas and Battery Leaf Blowers

The big question Arup was asked to help answer in this testing is what makes which type have a greater noise impact? This study did not investigate the noise level at the operator ears relative to exposure, but rather the impact on people and the community surrounding the leaf blowers as they are being used. Leaf blowers are often rated based on air flow rate, or the amount of air being pushed or blown per minute. The grouping of leaf blowers used aimed to capture commercial leaf blowers used in the industry, with a specific focus on commercially used similar flow rate units for both gas and battery powered blowers.

2.2 Testing

In order to answer the question above, a set of tests were designed to allow the capture of side by side noise levels for various leaf blower types. It was arranged for 7 commonly used blowers to be used, all were either new or in a well maintained working order with 3 being gas leaf blowers and 4 being battery leaf blowers.

Table 1: Leaf blowers used for testing

Manufacturer	Model	Power Source
Greenworks	GBB 700	Battery
Greenworks	GBB 600	Battery
Stihl	BGA 100	Battery
Ego	600 Chevron	Battery
Redmax	EBZ8500	Gas
Stihl	BR 700X	Gas
Echo	PB760LN	Gas

On the morning of June 17, 2018, in Lincoln, Massachusetts, the leaf blowers were set up in an open driveway entrance road, and parking lot of the Lincoln Department of Public works. This is a quiet location without close proximity to sound reflecting surfaces, where noise measurement locations were marked off at 5, 50, 100, 200 and 400 feet from the location where each of the 7 leaf blowers were operated. To simulate measurements at a greater distance we also measured at 800 feet, which was located across another street in an Audubon park.

Each blower was operated for at least 30 seconds for every measurement at full throttle and the nozzle at least 2 inches (50 mm) above the ground. At the 50 foot distance, measurements at 8 locations (at 45 degree increments) around each blower were measured as outlined in American National Standards Institute for Outdoor Power Equipment – Internal Combustion Engine-Powered Handheld and Backpack Blowers and Blower Vacuums – Safety Requirements and Performance Testing Procedures/OPEI B175.2-2012.

Measurements were made with a calibrated type 1 sound level meter with a wind screen installed and mounted on a tripod at 5 feet (1.5 meters) above the ground. The sound level meter was a Brüel & Kjaer 2250, as is common for advanced sound measurements in the acoustics industry. This meter captures one-third octave band sound levels in real time, and provides statistical time based averaging for L_{90}, L_{EQ}, L_{10} and other filtered results to best ensure that extraneous noise from the community was not a significant impact on the results. The L_{90} measurements are used for purposes of discussion and review as that metric captures the steady state noise level of the leaf blower in use while also filtering out other extraneous site noise events including intermittent traffic. This is a conservative approach in reviewing the data and a method that is widely accepted within the acoustic consulting industry. Other metrics that are commonly used including the L_{EQ} and L_{50}, will indicate higher noise values than the data presented here as L_{90} values. See the Appendix at the end of this note for definitions of L_{EQ}, L_{50}, and L_{90}

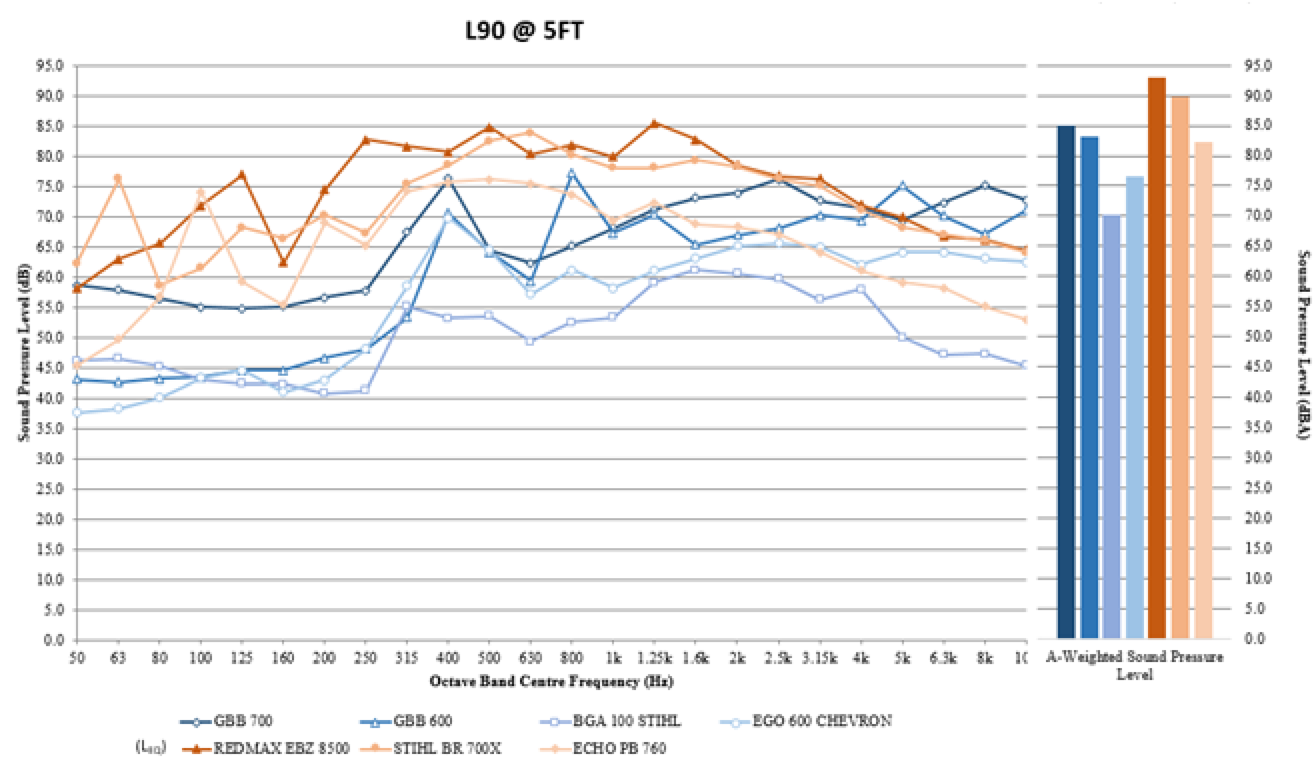
Sound levels are variations in sound pressure. The decibel scale (dB) is the commonly used metric for sound pressure levels, which is a log scale because the number value of sound pressure varies very widely. For the purposes of the data analysis, dB levels of 20-30 are a quiet bedroom or whisper, dB levels in the 40-60 range are a normal conversation, dB levels above 70 are a loud voice or busy street traffic, and sound levels above 80-90 dB would be loud music. Human hearing filters sound in a specific way, meaning that we are very attuned to voice frequencies and less attuned to low frequency sounds. For this reason, we often us an 'A' weighting scale, as a single number for the perceived overall loudness of a sound. These values are shown as dB(A) sound pressure levels.

3 Results

3.1 Graphs

The following graphs summarize the measured data of the 7 leaf blowers. Battery powered leaf blowers are shaded in blue and gas-powered leaf blowers are shaded in orange. The horizontal axis of the chart shows frequency, with the left side being very low frequency ‘rumble’ sounds, and the right side being high frequency ‘hissing’ sounds. The vertical axis shows increasing sound pressure level as you go up the chart. Most outdoor measurements of noise, in locations with any distant traffic will have more low frequency than high frequency noise, and the ambient sound in this case of this character also.

Figure 1: Sound Pressure Levels measured at 5 feet



Note: the L_{EQ} reading was used for the Redmax EBZ 8500 due to an elongated measurement period with the blower idling which influence the L_{90} result.

Figure 2: Sound Pressure Levels measured at 50 feet

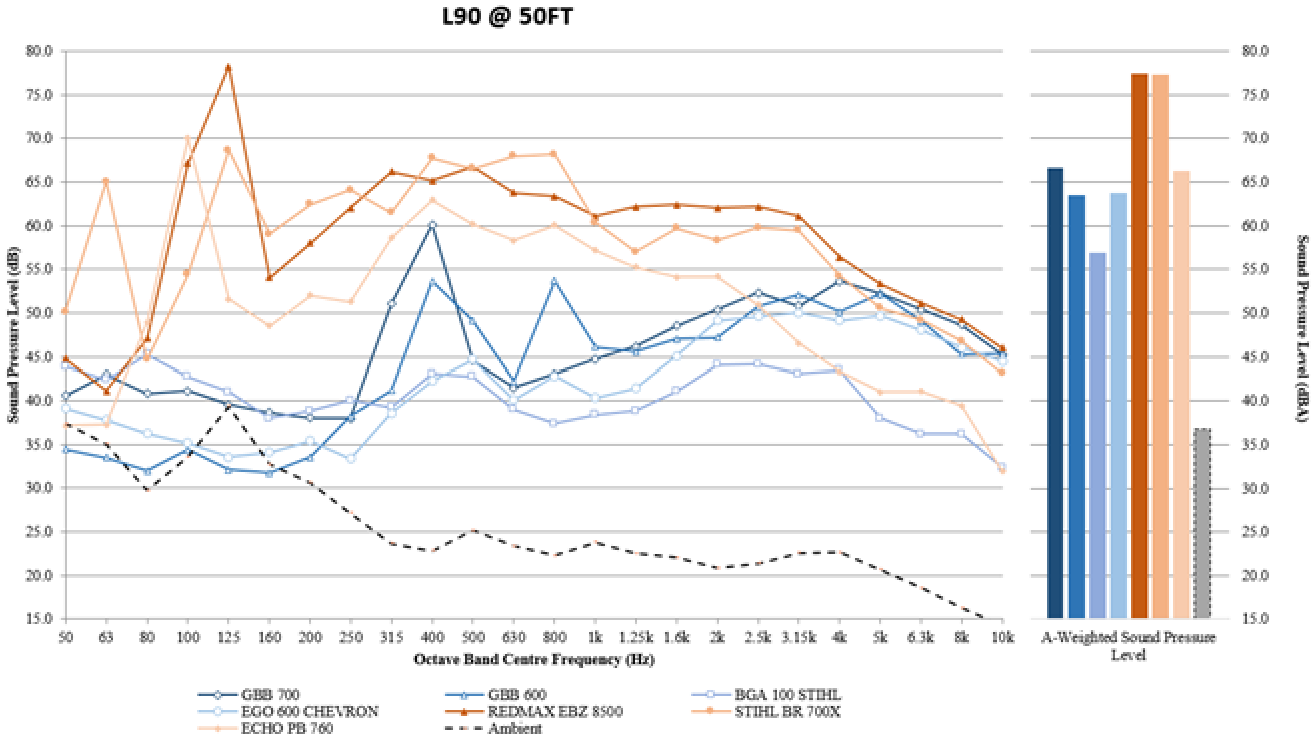


Figure 3: Sound Pressure Levels measured at 100 feet

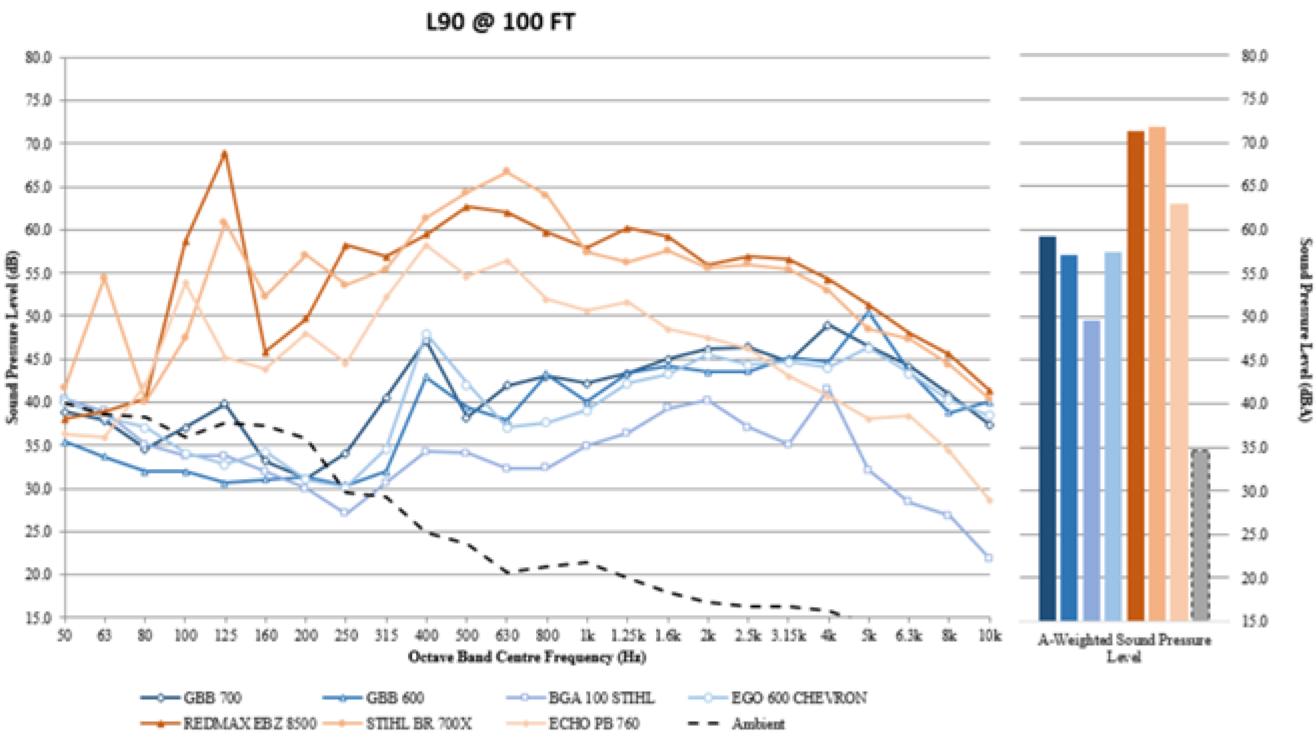


Figure 4: Sound Pressure Levels measured at 200 feet

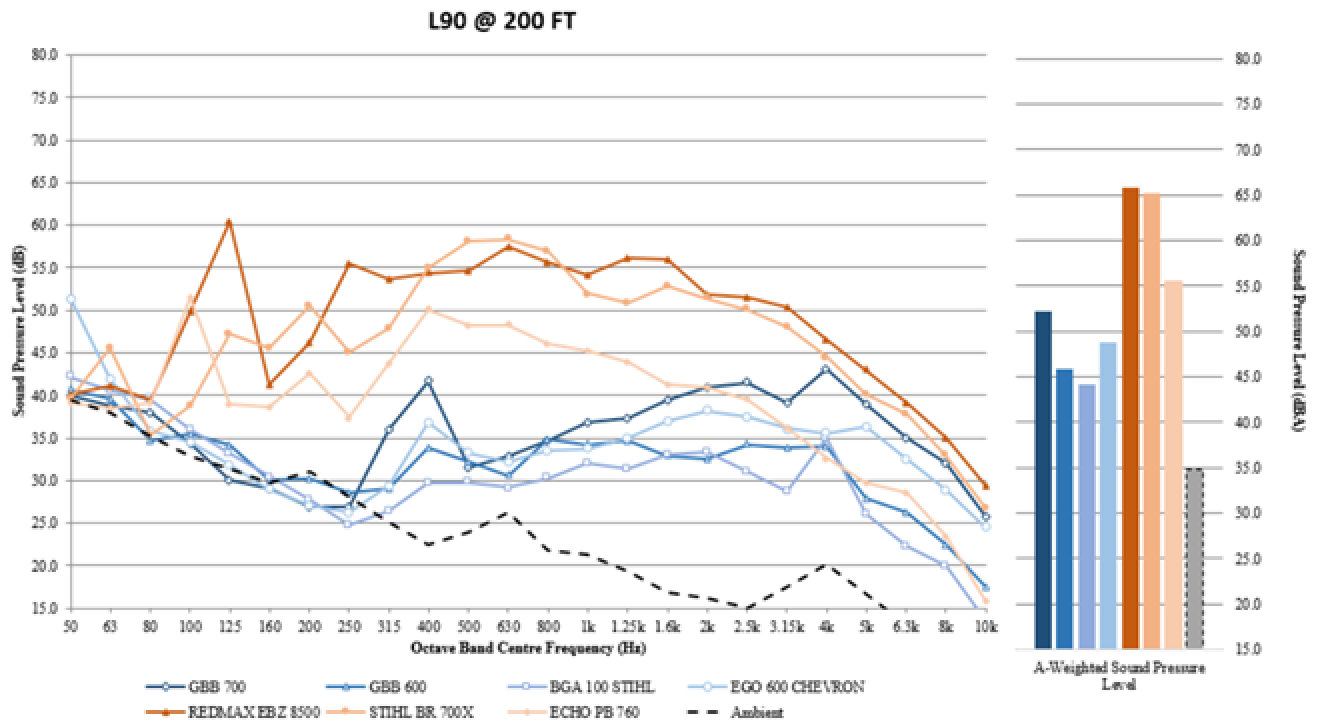


Figure 5: Sound Pressure Levels measured at 400 feet

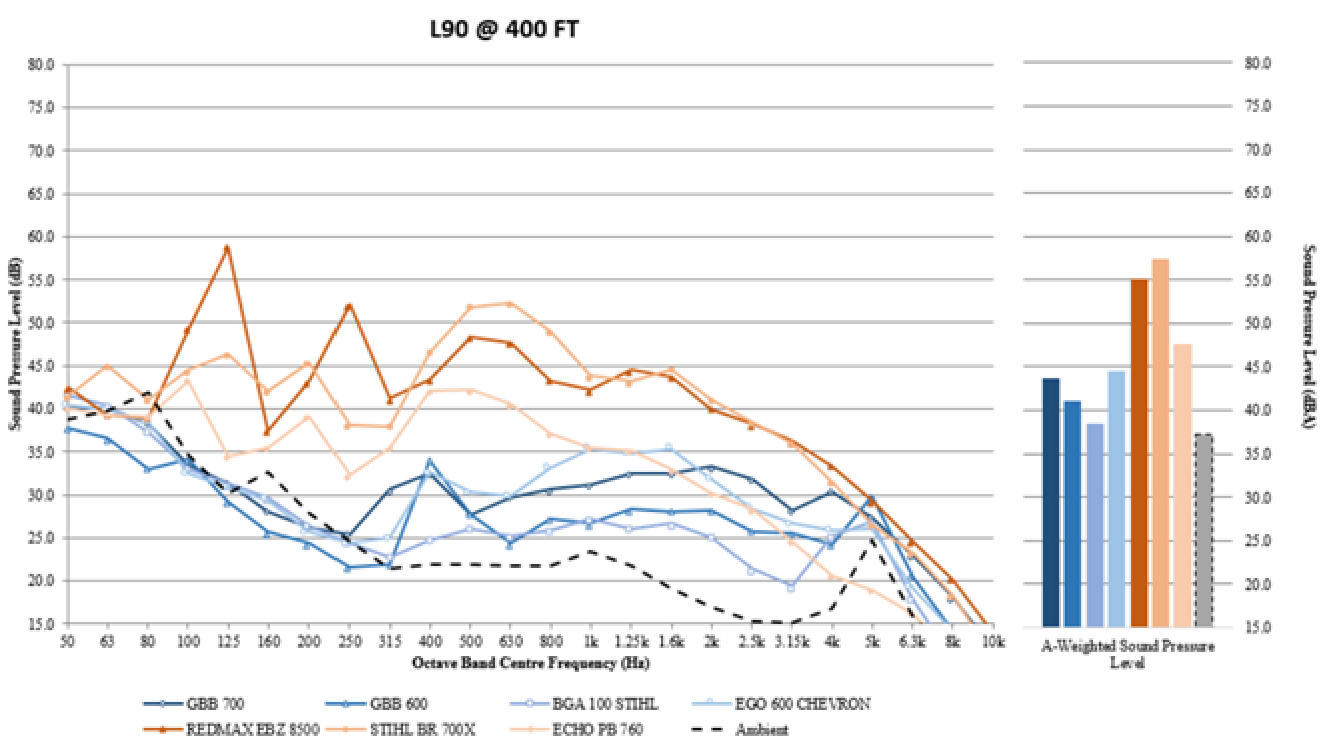


Figure 6: Sound Pressure Levels measured at 800 feet

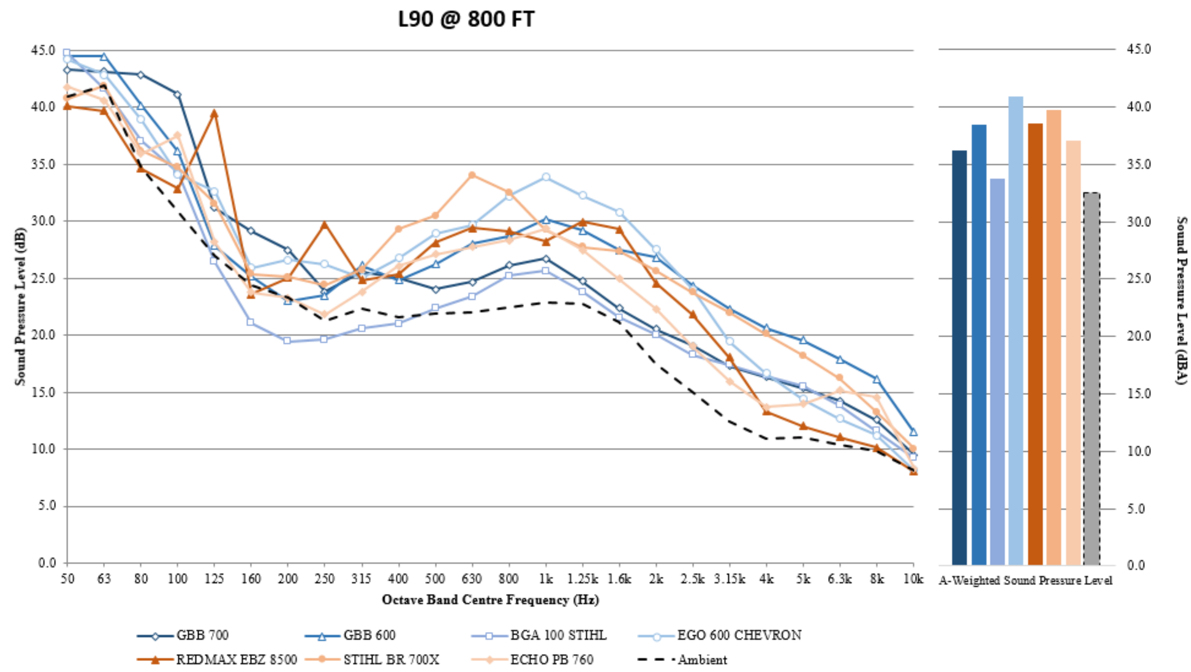
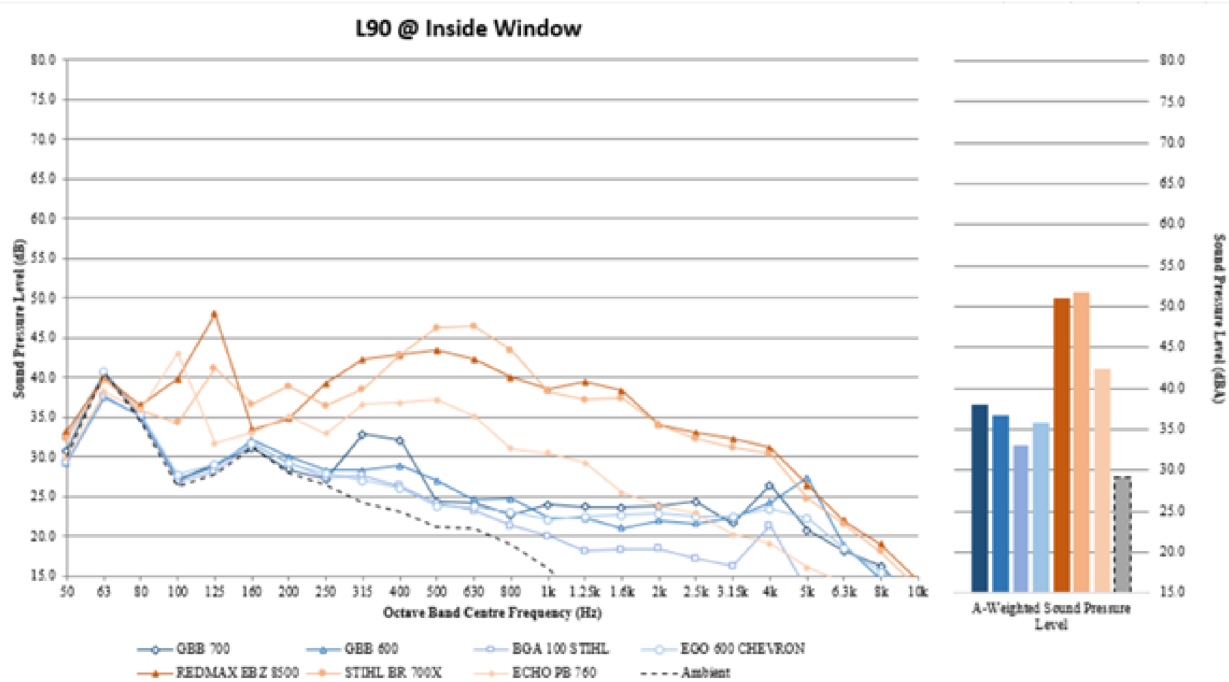


Figure 7: Sound Pressure Level measured inside a residence with leaf blowers 50 feet from the window



3.2 Discussion

From the measured data graphed above, it is observed clearly that the group of gas leaf blowers (shaded in orange) all exhibit a much higher level of sound energy in the low frequency bands at all distances. In a number of cases, this engine noise is a peak at 100 to 125 Hz. This low frequency energy is quite distinctly different for the gas leaf blowers than the battery powered leaf blowers.

Audibility over larger distances: The chart above shows that at only the peaks of low frequency engine sound were prominently above the ambient noise measured. Based on the experience of measuring sound, Arup witnessed that the three gas powered leaf blowers at an 800 foot distance were audible, two being clearly audible and the third being noticeable, while all of the battery powered leaf blowers were not distinguishable above the ambient community sound levels at that distance. Since these peaks on the chart do not occur with the battery powered leaf blowers it can be concluded that this is the character of the sound that travels over greater distances and is more audible throughout a community.

Audibility within Houses: One of the challenges with low frequency noise is that it requires heavy construction or materials to stop the sound transmitting. This is very clear when it comes to windows and glass doors in houses. The heavy drywall or brick walls of a house may do a very good job at blocking noise from outside, but any low frequency sound transmits easily through the lighter weight windows. This is a common issue with the drone of road traffic or aircraft overhead, and a number of states and federal programs provide funding to upgrade housing in impacted areas. With leaf blowers, the low frequency components of the gas leaf blowers are what is most easily transmitted, and this is clearly seen in Figure 7 at 100-125 Hz as well as in the air ‘whooshing’ frequencies up to around 500 Hz which also transmits into the house very easily. These sound levels of gas powered leaf blowers as measured inside the house, are significantly above those of the battery powered leaf blowers.

4 Audio Demonstrations

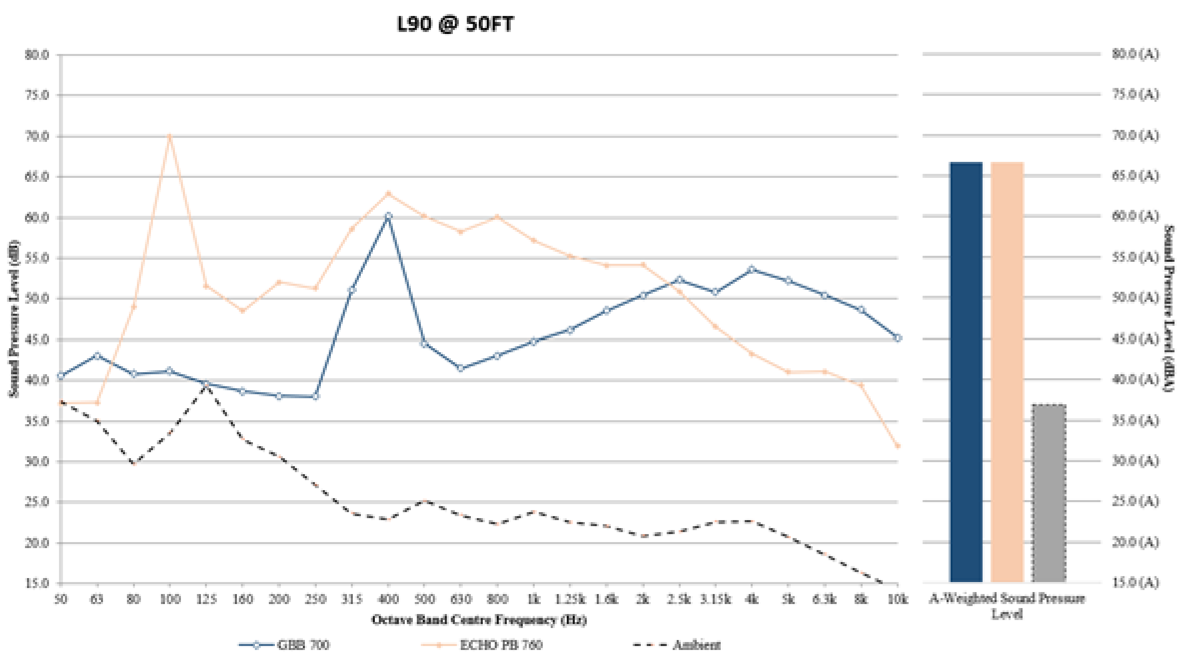
During the oral testimony of Chris Pollock on July 2, 2018, calibrated audio demonstrations of gas and battery powered leaf blowers were presented. It is important to note that the audio was played to replicate the level of the sound at the listening positions of Chairman Mendelson and Councilmember Cheh. The demonstrations were audible to members of the audience in the room and on the internet; however, the experience and levels perceived by the audience was not calibrated for their listening position.

The following three scenarios were experienced by Chairman Mendelson and Councilmember Cheh:

4.1 Demonstration 1

The first sample was a comparison of a gas and a battery blower with the same dB(A) from the manufacturers standardized testing. The important comparison is that while the overall loudness may be the same, the acoustic qualities of each and the character of the sound are totally different – the gas leaf blower generating much more low frequency noise.

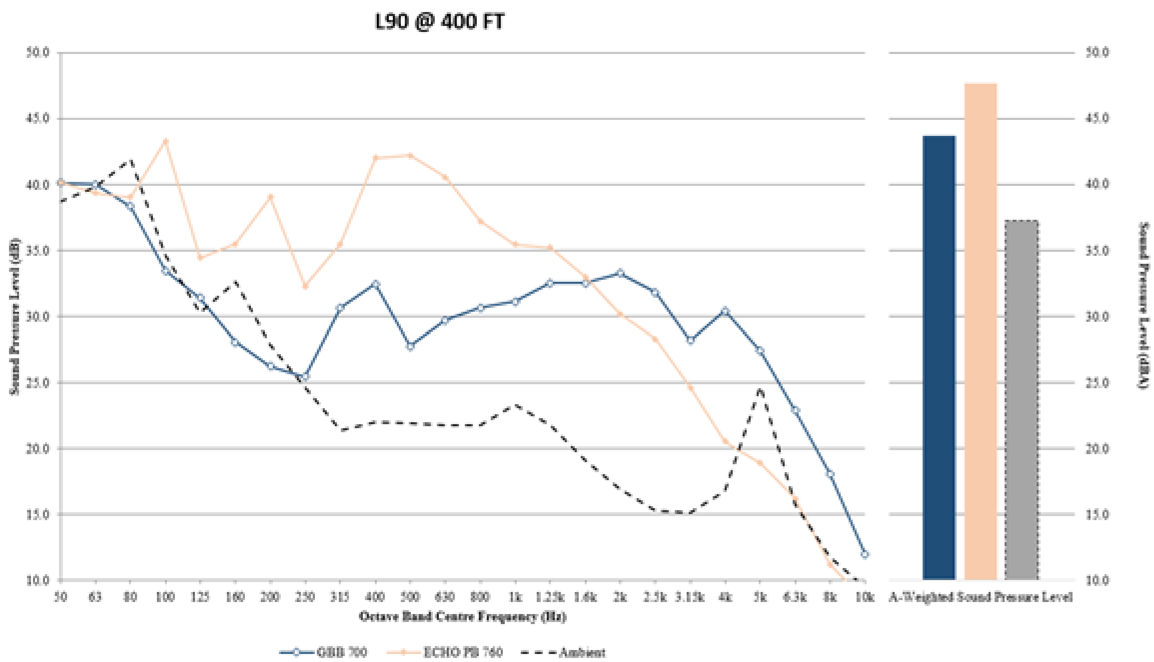
Figure 8: Audio demonstration 1 – equivalent gas and battery leaf blowers at 50 feet



4.2 Demonstration 2

The second demonstration presented in the proceedings was relative to the same two equally noise rated blowers, one gas (Echo PB 760) and one battery (Greenworks GBB 700) at 50 feet. This demonstration indicates that while rated the same overall noise level at 50 feet, the same gas blower has a significantly greater noise impact at 400 feet because the low frequency content of its noise transmits more easily over the 400 foot distance. This demonstration indicates what the community hears around operating blowers, highlighting that the low frequency components of the gas engines is part of the increased impact of gas blowers.

Figure 9: Audio demonstration 2 – equivalent gas and battery leaf blowers at 400 feet



4.3 Demonstration 3

Our third and final demonstration is three leaf blowers as measured inside an adjacent house (Greenworks GBB 700, Echo PB 760 and the Redmax EBZ 8500), with the leaf blowers operating at 50 feet from the windows, behind a typical insulated glass window. The audio results indicated that the two gas leaf blowers, the two orange lines in the graph below, were significantly above the battery blower in almost all frequency bands.

Figure 10: Audio demonstration 3 – gas and battery leaf blowers inside a house

5 Conclusions

Based on our measurements we conclude the following key points from our review of the results:

- The gas powered leaf blowers tested all generated more low frequency noise than the battery powered leaf blowers tested
- The low frequency noise of the gas leaf blowers transmitted over greater distances and was more readily audible over the longer 400 and 800 foot measurement distances
- The low frequency noise of the gas leaf blowers transmitted into a residential house more easily and were louder inside than the battery leaf blowers tested

6 Technical Glossary

L_{10}- The level of sound in deciBels that, for a given time period of interest, is exceeded 10 % of the time.

L_{EQ} – The equivalent continuous sound level. The preferred method to describe sound levels that vary over time, resulting in a single deciBel value which takes into account the total sound energy over the period of time of interest.

L_{50} - The level of sound in deciBels that, for a given time period of interest, is exceeded 50 % of the time.

L_{90} - The level of sound in deciBels that, for a given time period of interest, is exceeded 90 % of the time.

7 About Chris Pollock, PE

Chris Pollock, PE is an acoustical consultant with Arup with 20 years of experience measuring noise and designing buildings and spaces for acoustics on projects in the USA and around the world. He has an Honors degree in Mechanical Engineering from the University of Canterbury an is a Professional Engineer in the Commonwealth of Virginia. Chris has been published in articles in the field of acoustics in Architectural Record, contributed to the Architectural Graphic Standards and has been interviewed by various media outlets regarding acoustics and noise and serve on a number of panels and committee on topics related to acoustics and noise.

End of Written Statement