

Drive-Thru Sound Levels

This white paper addresses sound pressure levels (SPL) from the drive-thru communications system, which is a concern especially where municipal noise abatement rules exist. The paper includes typical measurements for a standard HME drive-thru system.

Note: Because every site is different and each municipality has its own regulations, HME is unable to make specific recommendations for compliance or give any assurance that any particular system configuration will comply with any given regulations. Statements made in this paper should be taken as general guidelines, but to ensure compliance, the site planner should retain the services of a qualified acoustic consultant equipped to make the necessary measurements.

Sound pressure levels are measured in units of dB SPL and usually include a frequency variable weight referred to as "A Weighting". For this reason, the units are frequently written as "dBA SPL" and that notation will be used throughout this paper.

In the drive-thru, the primary source of sound other than the vehicles themselves is often the drive-thru communications system. There is the sound from the speaker (outbound) which comes from the order taker or greeter. There is also the sound of the voice of the customer in the vehicle (inbound). This paper only addresses outbound sound. The outbound audio is delivered by the speaker and must be loud enough to be clearly heard by the customer over the noise of the customer's vehicle, any local traffic and other ambient background noises in the area. However, if it is too loud, the sound can be objectionable to neighbors or even violate specific regulations.

The sound pressure level from a speaker decreases as the distance away increases. However, it can be difficult to predict how much reduction will actually occur. For a single point sound source like an alarm bell hanging in air, the SPL drops approximately 6 dB every time the distance from the source doubles. Thus, if one starts one foot away, the level will be 36 dB lower when one is 64 feet away. Unfortunately, speakers are neither single point sources nor are they hanging in air. Rather, speakers are mounted in a variety of different type enclosures. Further, surrounding buildings, and cars in proximity all effect the sound's direction and energy. All of this tends to make the sound more directional and the SPL at distance less predictable.

HME base stations are equipped with a feature known as Automatic Volume Control or "AVC" which can be used to reduce the outbound sound pressure level based on ambient noise. When AVC is active, the microphone in the speaker post is used to measure the ambient noise level and the outbound level is reduced to a level that is approximately 14 - 15 dB above the ambient noise, but it **never** increases the level above what would be heard with AVC turned off. This feature can considerably reduce the SPL during quiet periods and may help in satisfying local requirements. Another feature of the EOS HD system is "Scheduled Outbound" volume settings. With this feature, the outbound volume can be programmed to lower levels at night or other known quiet periods.

This paper provides some typical measurements taken in a hemi-anechoic chamber that simulates an outdoor environment under specific circumstances. Measurements in the chamber allow us to simulate an open parking lot with any level of ambient noise we choose. These measurements can be used as a guide for what levels might occur in a drive-thru installation. SPL levels at distances greater than 16 ft from the speaker post are calculated based on projected SPL decreases at distance. Additionally, these results were compared with previous outdoor measurements with the same model of speaker and speaker post to verify the validity of the calculated results.

Drive-Thru Sound Levels

All measurements provided here were taken using the following drive-thru equipment:

- Base station: HME EOS HD set to factory default level (outbound volume “15”).
- Communicator: HME COM6200
- Speaker: HME SP10
- Microphone: HME DM5 (required for AVC operation)
- Speaker post: Texas Digital model 107150

SPL Measurements were taken with:

- NTI Minilizer ML1 with Mini SPL microphone set to A-weight, slow response
- Ambient background noise level: ~32 dBA SPL (room noise floor)

These measurements were taken using “pink noise”, a type of noise frequently used for acoustic testing, at levels simulating the loudest speech expected from an order taker. Initial measurements were taken with AVC off and no obstructions or reflecting surfaces in front of the speaker. These are not “normal” conditions for a drive-thru, but they do yield one worst-case measurement. Measurement accuracy for any SPL measurement can be taken to be ± 1 dB. The speaker in the test speaker post is centered 1.5 feet (18 inches) from the floor and the microphone is centered at 46 inches from the floor. All measurements are taken directly in front of the speaker post.

SPL tests without AVC are made with continuous pink noise supplied to a backpack communicator at a level comparable to that of an order taker speaking into the microphone. Measurements are then taken with the measurement microphone on a stand. These measurements were taken at various heights above the floor and distances from the speaker post in order to have a good picture of the way that SPL changes with distance.

Measurements are taken at heights of 1.5 feet, 3 feet, 6 feet, and 9 feet above the floor and at linear distances of 1 foot, 2 feet, 4 feet, 8 feet, and 16 feet in front of the post. From this data, we are able to extrapolate projected SPL at greater distances (assuming no obstructions).

To verify the validity of these measurements, they have been checked for self-consistency and they have been checked against measurements taken outdoors in 2010 with the same model speaker and post. In all cases, the SPLs check within ± 1 dB.

SPL tests with AVC are made at a single position with different ambient noise levels in order to demonstrate and measure AVC function. This single position approximates the position of the drive-thru customer while placing an order. These measurements are made with continuous pink noise supplied to large speakers at the back of the room to simulate ambient noise. Pulsed pink noise is used to simulate order taker speech. These measurements are taken 46 inches above the floor and 48 inches from the post. Correction factors are then calculated to allow the SPL to be estimated at other positions and distances.

Changing the outbound volume from its default setting of “15” (on a scale of 0 – 20) will change both the outbound SPL and the effect that AVC has on the outbound level. A table of correction factors is provided at the end of this paper for different volume settings.

Figure 1 is a graph showing plots of measured (out to 16 feet) and extrapolated (32 and 64 feet) SPL at various distances from the speaker post and at four different heights above the ground. Since the speaker is mounted 1.5 feet above the ground, the top curve represents the SPL directly in line with the speaker axis. From these plots, it is easy to see that the SPL falls off approximately 5 dB every time the distance doubles when on axis. When off axis, the SPL curves are initially shallower but ultimately approach the 5 dB curve as the distance increases. If the speaker were mounted at a different height in a similar enclosure, the top curve would represent the SPL at that height. For example, if the speaker were mounted at a height of 3 feet, this curve would represent the SPL at a height of 3 feet.

Drive-Thru Sound Levels

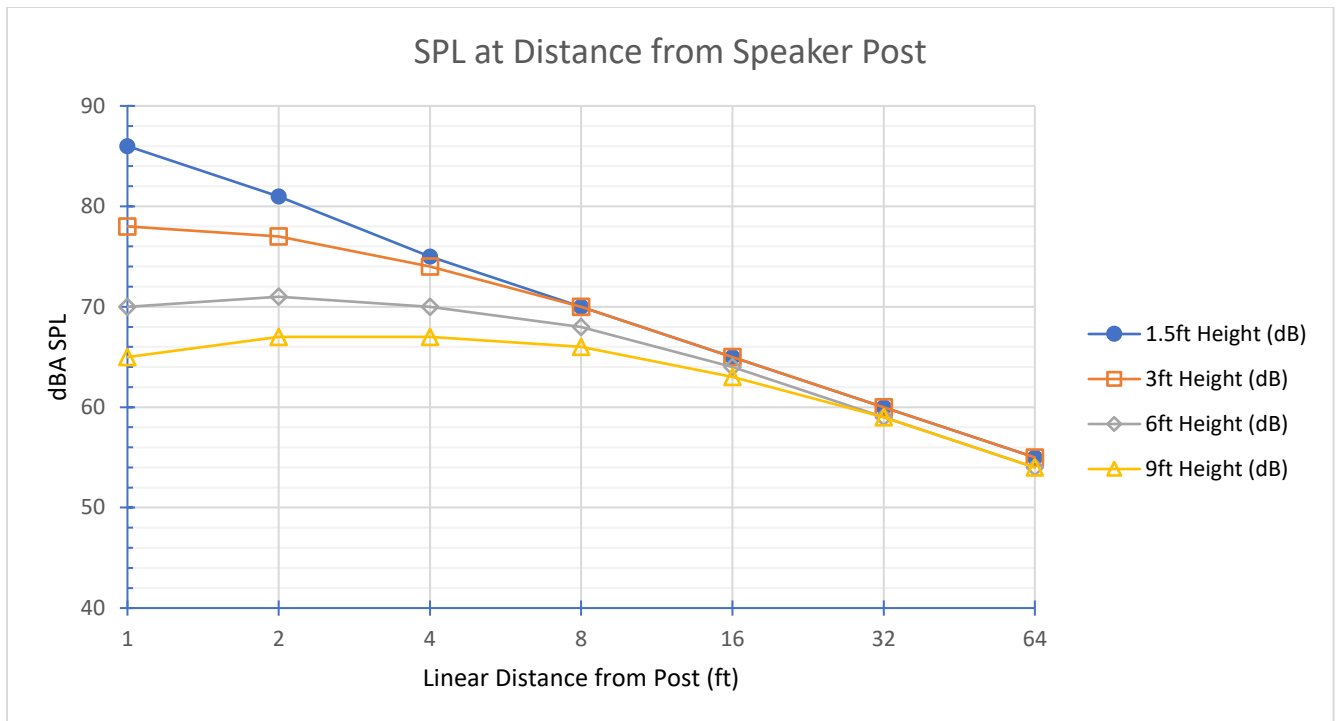


Figure 1 – Plots of SPL vs Distance at Various Heights

Figure 2 is a graph showing plots of measured SPL (at the 1.5-foot level) taken outdoors at specific distances up to 55 feet compared with measurements and extrapolations from the acoustic chamber. This graph shows the very close agreement between the outdoor measurements and the chamber measurements.

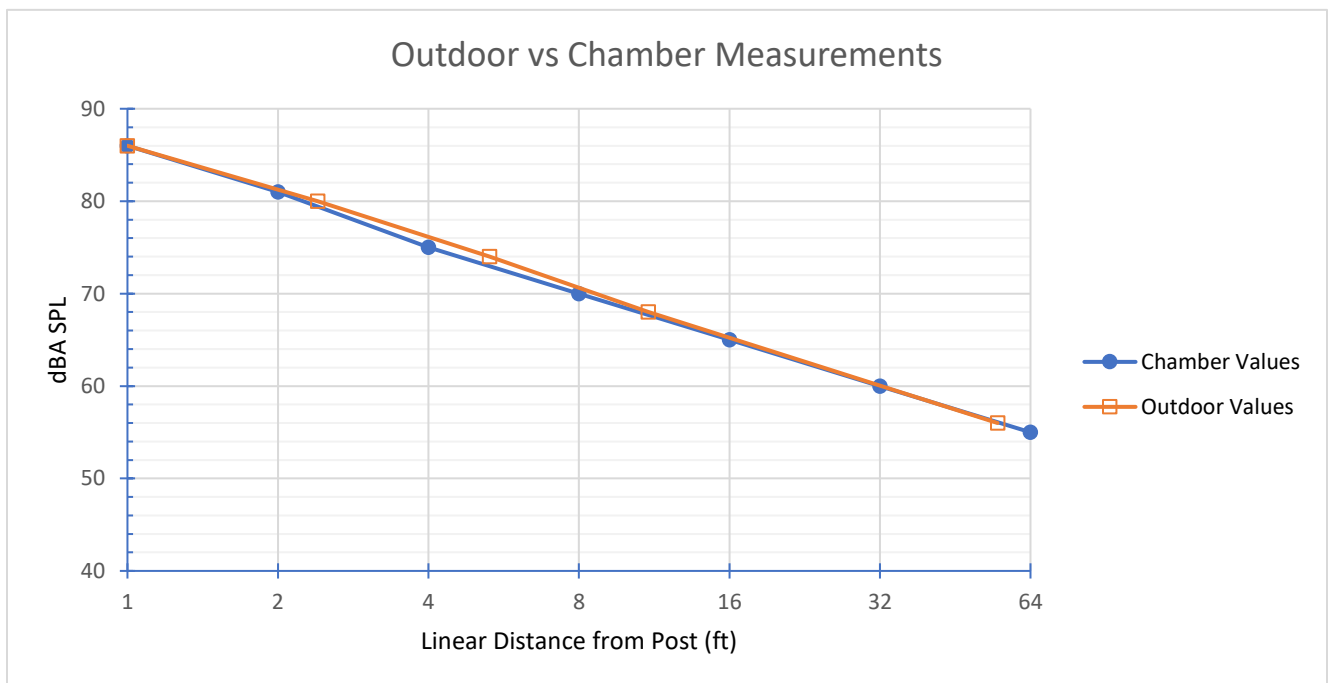


Figure 2 – Plots of SPL Measured Outdoors and in Anechoic Chamber

Drive-Thru Sound Levels

AVC Operation

AVC uses the inbound microphone to measure the ambient noise level in the drive-thru and adjust the outbound level down so that it is never more than 15 dB above the ambient noise level. This is particularly useful at night when there is less traffic on surrounding streets and fewer cars in the drive-thru. It may also be useful in situations where the regulations do not specify specific sound pressure levels but use terms like “reasonable” or “sufficient”. Because AVC adjusts continuously, it ensures that the outbound level changes as the conditions change.

AVC is calibrated to adjust the SPL as measured at a point near the microphone. SPL measurements have been taken at a point 46 inches above the ground and 48 inches in front of the post. Figures 4-6 are based on these measurements.

Since AVC adjusts based on the noise level measured at the speaker post, a noisy vehicle will drive the outbound level up. Thus, the use of AVC will not guarantee that the SPL is below any particular level for all vehicles or conditions. However, it will keep the outbound level from becoming excessively loud. If absolute limits are needed, Scheduled Outbound volume should be used instead of AVC.

Figure 3 is a graph of the amount of attenuation that is applied to the outbound signal for various ambient noise levels. This represents the difference in outbound level between AVC off and AVC on. Attenuation only occurs when the ambient noise level is below 60 dBA SPL. The attenuation amounts shown on this graph may be used in conjunction with SPL measurements to estimate the SPL at various locations for given ambient noise levels.

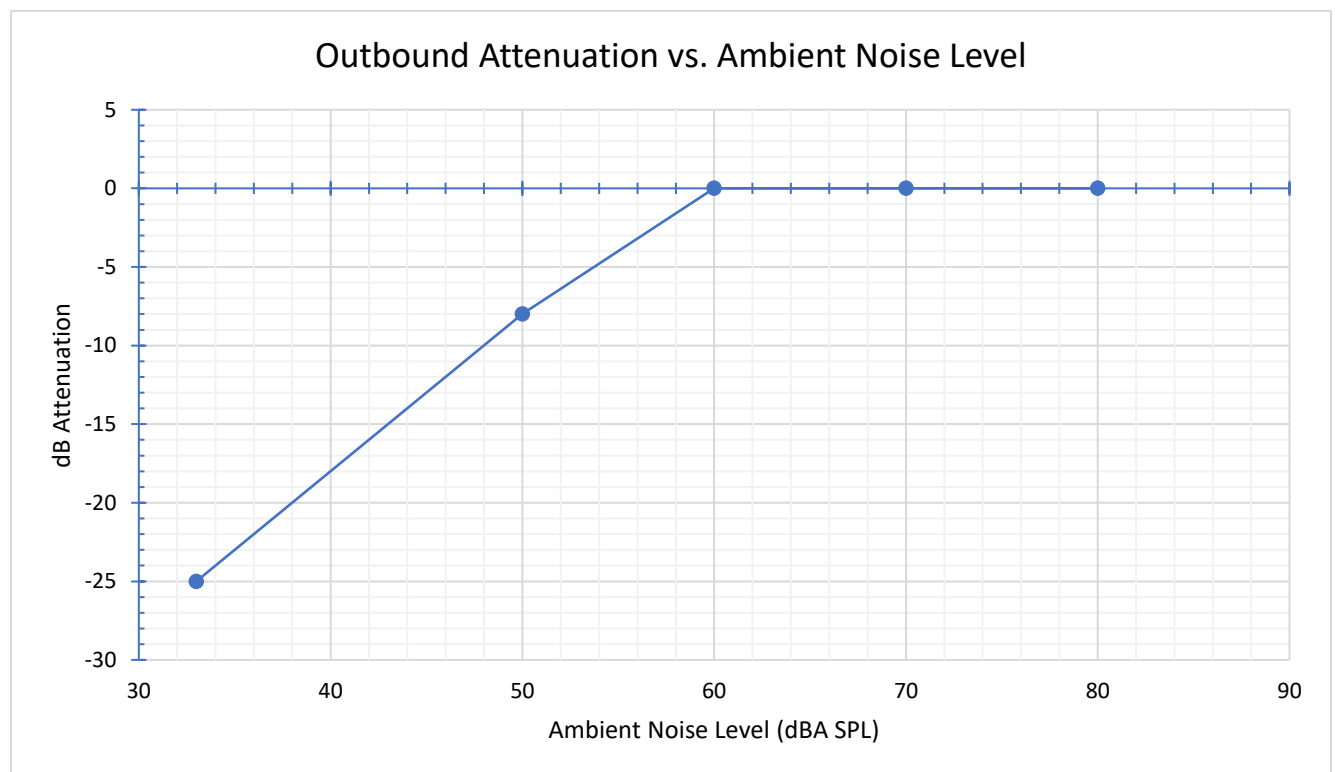


Figure 3 – AVC Outbound Attenuation for Various Ambient Noise Levels

Drive-Thru Sound Levels

Figure 4 is a graph of the total SPL (ambient noise plus outbound audio) measured at the approximate position of the customer (46 inches above the ground and 48 inches in front of the post). From this graph it can be seen that at ambient levels below 60 dBA SPL, the total SPL is approximately 14 dB above the ambient noise as expected with AVC on. Above 60 dBA ambient, the total level is less than 14 dB louder than the ambient level. Once the ambient noise level reaches approximately 80 dBA SPL, there is little contribution from the outbound audio.

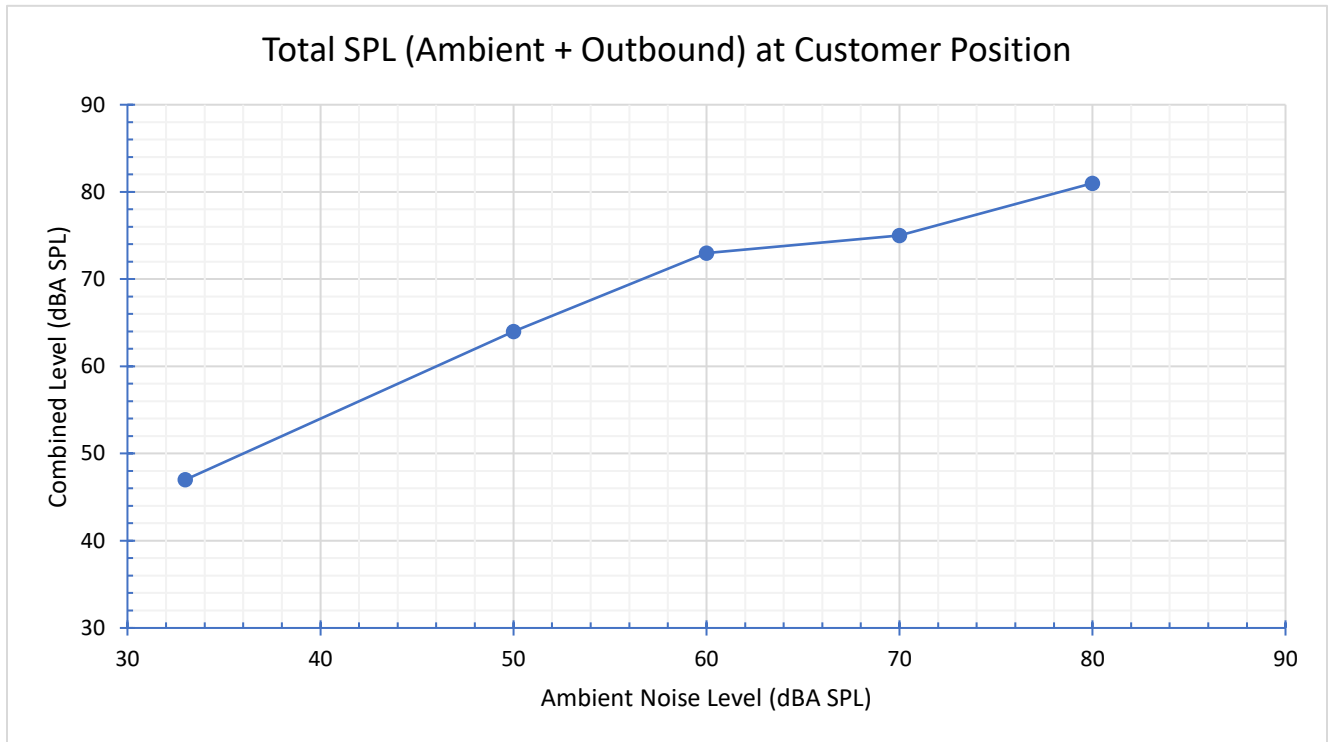


Figure 4 – Total Sound Pressure Level at Customer Position

Drive-Thru Sound Levels

Figure 5 is a graph showing the total SPL (ambient plus outbound) plotted over distance for various ambient noise levels. This assumes that the ambient noise level does not vary with distance from the post. This assumption is likely valid in a large city where the noise is general and widespread. In an installation where the majority of the ambient noise comes from a nearby street or highway, there will be variation in the ambient noise level. At higher ambient noise levels, there is little or no contribution from the outbound audio at far distances from the post.

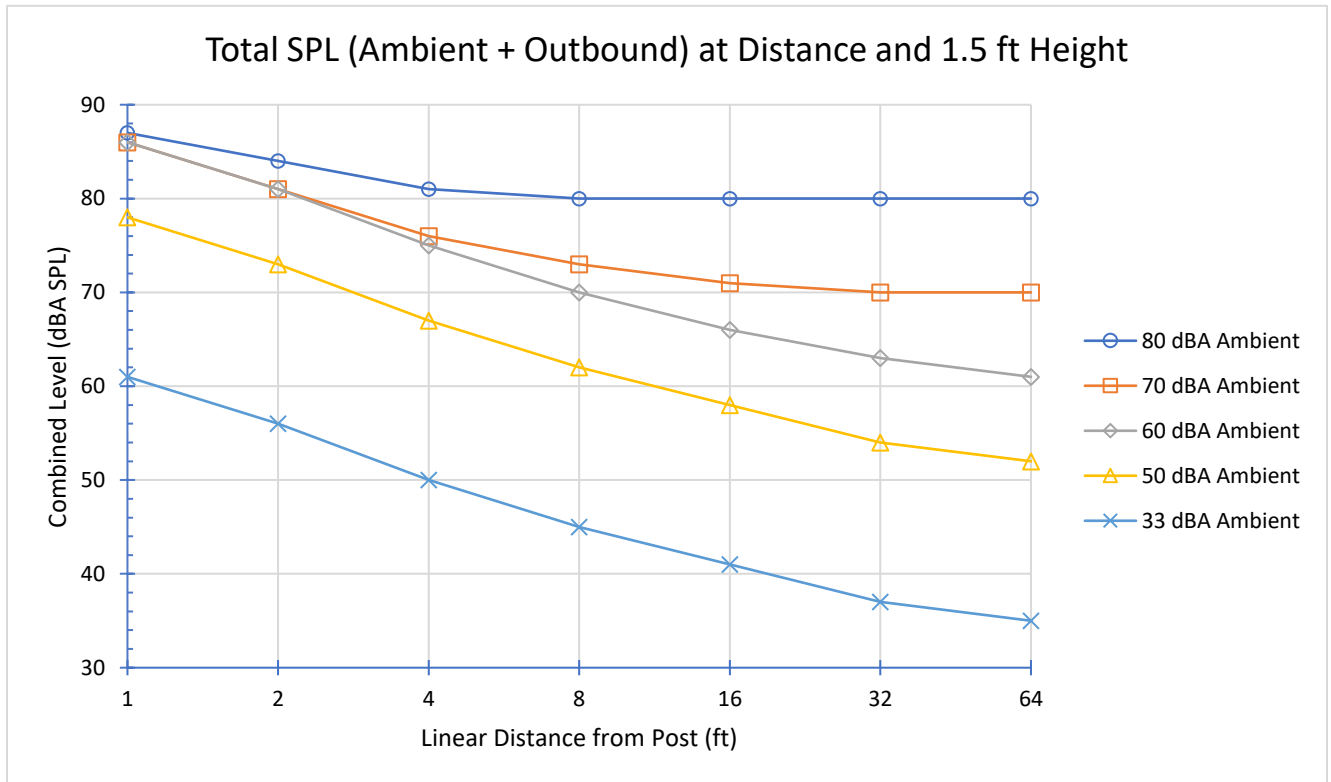


Figure 5 – Total Sound Pressure Level at Distances from Post

SPL Estimation Guidelines

HME cannot provide guarantees of SPL in specific situations. Only on-site measurements can confirm sound pressure levels at any particular location. However, these measurements can help predict general values. When there are cars in the vicinity of the speaker post, they will block and reflect sound in various ways and while they will change the direction that the sound travels, they will not increase the SPL higher than it would be on the main axis of the speaker. Echoes from surrounding buildings can cause sounds to reinforce each other in unpredictable ways. It is beyond the scope of this paper to make any predictions of SPL when there are buildings closer than 100 feet or so.

The equations presented here can be used along with the graphs to make estimations of SPL at other distances and under other ambient noise conditions. They depend on various assumptions and should only be used for making estimates.

Drive-Thru Sound Levels

EOS Volume Correction

All measurements have been taken with the outbound volume set to the default setting of 15. The table below gives correction factors for the outbound SPL given different volume settings. The correction factor should be added to the outbound SPL to get the expected SPL for that volume setting. Note that these factors can be used when setting Scheduled Outbound levels as well. For example, if the outbound level needs to be 10 dB lower at night, the nighttime volume would be set to “9”.

Volume Setting	8	9	10	11	12	13	14	15	16	17	18	19	20
Correction Factor	-15	-10	-7	-4	-3dB	-2dB	-1dB	0	1dB	2dB	3dB	4dB	5dB

Table 1 – SPL Correction Factors

Estimating SPL (no AVC)

When AVC is off, the outbound level from the speaker will be constant. Using the graph of Figure 1, it is possible to estimate the SPL at various heights and distances within a few dB. At distances less than 16 ft, it is best to approximate the level by estimating where the point would be on the graph. It is important to remember that the distance scale is logarithmic in base 2. That means that each division represents a doubling of distance. For distances greater than 16 ft, it is reasonable to assume that the level will decrease by 5 dB each time the distance doubles. The predicted SPL at some distance beyond 64 ft would be given by this equation:

$$SPL = 55 - \left(5 \times \frac{\log\left(\frac{d}{64}\right)}{\log 2}\right) \quad \text{where } d \text{ is the distance in ft}$$

Thus, the estimated SPL at 100 ft is $55 - \left(5 \times \frac{\log\left(\frac{100}{64}\right)}{\log 2}\right) = 52$ dBA.

Estimating Outbound AVC Attenuation

When AVC is on, the outbound level will adjust based on the ambient noise level as measured by the inbound microphone. The amount of attenuation can be calculated for situations where the ambient noise level is 50 dBA SPL or lower. Given a configuration where the microphone is located approximately 28 inches above the speaker, the approximate attenuation will be given by this equation (as shown in Figure 3):

$$Attn = (Nl + 14) - 72 \quad \text{where } Nl \text{ is the noise level}$$

Thus, the attenuation for an ambient noise level of 47 dBA is -11 dB. If we combine this with the earlier example and ask for the estimated SPL at 100 ft with AVC on and an ambient noise level of 47 dBA, we simply add the attenuation number to the estimated SPL. In this case, the estimated outbound SPL would be 52 - 11 or 41 dBA. Since this level is below the ambient noise level, it is unlikely to be heard. However, the total combined SPL can also be calculated.

Calculating Total Combined SPL

The ambient noise level and the outbound level will add as RMS values. This equation is used to calculate the total:

$$SPL_{tot} = 20 \times \log \sqrt{10^{\frac{Nl}{10}} + 10^{\frac{SPL}{10}}} \quad \text{where } Nl \text{ is the noise level and } SPL \text{ is the outbound SPL}$$

For the previous example this is $20 \times \log \sqrt{10^{\frac{47}{10}} + 10^{\frac{41}{10}}}$ or 48 dBA SPL.

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