WAREHOUSE LOUDSPEAKER APPLICATION DESIGN GUIDE

Loudspeaker audio systems are becoming vital for most, if not all warehouse and manufacturing facilities. Selecting the correct warehouse paging horn or loudspeaker combination is essential for efficient and effective communication in these challenging spaces. Whether the need is for paging, signaling, background music, or the combination of all three, this guide provides recommendations on choosing the correct Biamp loudspeaker device and some industry best practices to ensure that the deployment of your design achieves adequate coverage and system intelligibility for the space and its application.

AMBIENT NOISE LEVELS

It is important to first establish the ambient noise level of the space before designing a paging (or any) sound system. The ambient noise level is the average dBSPL that exists in the environment or around the perimeter of where the loudspeakers will be placed.

The ambient noise level can be measured using a sound level (SPL) meter, or a computerized and calibrated real-time spectrum analyzer. This will allow you to identify the dominant frequencies of noise where the greatest amount of energy lies (within the frequency range) and the average SPL across all frequencies.

If the sound system is being designed for an existing space where the acoustic environment and background noise conditions already exist, take your SPL measurement device to the site and take multiple readings at the average listening height (4′ [1.2m] for seated listeners or 5′ [1.5m] for standing listeners) during a typical day. **Note: Your SPL measurement device should be set on the A-Weighted scale (dBA)**

If the SPL readings cannot be taken because the building is under construction or the building is not yet "active" then an educated guess is required. Some judgement on your part will be required to adjust your SPL design goal depending upon your specific application.

The target SPL for a paging audio system is a minimum of 10 dBSPL above the ambient noise level.

Below is a list of recommended SPL Levels based on common application environments. These are the (+10 dB) SPL levels that the paging system must be able to produce for the sound system to be considered intelligible and effective:

VENUE	APPLICATION ENVIRONMENT	SPL / DB
Office	Quiet Office - No active sound masking Quiet Office - With active sound masking Noisy Office - With significant levels of background noise	50 - 60 dB 60 - 70 dB 70 - 80 dB
Warehouse	Quiet Warehouse - Storage only, no machinery Loud Warehouse - Storage and material handling, forklifts, conveyers	70 - 80 dB 80 - 90 dB
Factory	Quiet Factory - Light manufacturing, small machinery Loud Factory - Heavy manufacturing, large machinery	90 - 100 dB 100 - 105 dB
Gym, Arena, Stadium, Live Event	College and professional level sports environments with large crowds and ambient noise levels exceeding 96 dB	105+ dB

THROW DISTANCE, MOUNTING HEIGHT, AND DEVICE SPACING

THROW DISTANCE

Once we know the required SPL for the space, we then need to determine the correct loudspeaker, tap setting and layout to achieve the required SPL level. The following table shows the maximum SPL at a given distance for each power tap for the Biamp H10-G, H20-G, H30LT-G, and MPLT62-G paging horns:

Throw Distance (Feet / Meters)				3.2′ / 1m	6.5′ / 2m	13′ / 4m	26.2′ / 8m	52.5′ / 16m	105′ / 32m	210′ / 64m
H10-G 10W @ 8 Ohms SPL 113 dB 530Hz-6.5kHz	70V/100V	10W	0 dB	113	107	101	95	89	83	77
	70V/100V	5W	-3 dB	110	104	98	92	86	80	74
	70V/100V	2.5W	-6 dB	107	101	95	89	83	77	71
	70V/100V	1.25W	-9 dB	104	98	92	86	80	74	68
	70V	.625W	-12 dB	101	95	89	83	77	71	65

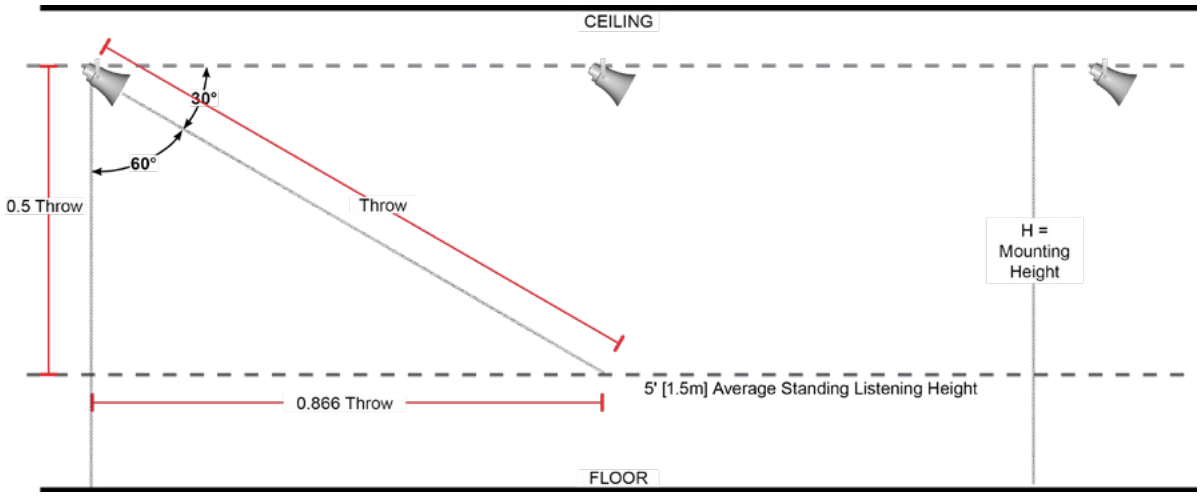
Throw Distance (Feet / Meters)				3.2′ / 1m	6.5′ / 2m	13′ / 4m	26.2′ / 8m	52.5′ / 16m	105′ / 32m	210′ / 64m
H20-G 20W @ 8 Ohms SPL 118 dB 490Hz - 6.7kHz	70V/100V	20W	0 dB	118	112	106	100	94	88	82
	70V/100V	10W	-3 dB	115	109	103	97	91	85	79
	70V/100V	5W	-6 dB	112	106	100	94	88	82	76
	70V/100V	2.5W	-9 dB	109	103	97	91	85	79	73
	70V	1.25W	-12 dB	106	100	94	88	82	76	70

Throw Distance (Feet / Meters)				3.2′ / 1m	6.5′ / 2m	13′ / 4m	26.2′ / 8m	52.5′ / 16m	105′ / 32m	210′ / 64m
H30LT-G 30W @ 8 Ohms SPL 118 dB 450Hz - 9.6kHz	70V/100V	30W	0 dB	118	112	106	100	94	88	82
	70V/100V	15W	-3 dB	115	109	103	97	91	85	79
	70V/100V	7.5W	-6 dB	112	106	100	94	88	82	76
	70V/100V	25W	-9 dB	109	103	97	91	85	79	73
	70V	12.5W	-12 dB	106	100	94	88	82	76	70

Throw Distance (Feet / Meters)				3.2′ / 1m	6.5′ / 2m	13′ / 4m	26.2′ / 8m	52.5′ / 16m	105′ / 32m	210′ / 64m
MPLT62-G 62W @ 70/100V SPL 112 dB 150Hz - 20kHz	70V/100V	62W	0 dB	112	106	100	94	88	82	76
	70V/100V	32W	-3 dB	109	103	97	91	85	79	73
	70V/100V	16W	-6 dB	106	100	94	88	82	76	70
	70V/100V	8W	-9 dB	103	97	91	85	79	73	67
	70V	4W	-12 dB	100	94	88	82	76	70	64

As a reference, the throw distance chart establishes an SPL at the listener position for each device in the product offering based on the Nominal Maximum Continuous SPL rating for each device at 1 meter.

We will then calculate the specific throw distance relative to the proposed mounting height of the loudspeakers.



IMPORTANT: Loudspeakers for this design approach are aimed at a 30-degree down angle

MOUNTING HEIGHT

Horn paging systems can be installed at various heights to achieve uniform sound pressure levels throughout the listening area. The design goal is that listeners do not experience any hot spots and can hear the audio message clearly from their position.

As best practice defines, the Throw Distance is typically twice the Mounting Height, therefore if we know the mounting height (or what would be the preferred mounting height) we can calculate the Throw Distance based on:

Mounting Height x 2 = Throw Distance

- In our example the preferred mounting height from the client is 20 feet (6.1 m)
- 20 feet x 2 = 40 feet

Throw distance would be **40 feet (12.2 m)**.

DEVICE SPACING

With the throw distance now defined we are then able to calculate the device spacing based on the following:

Throw Distance x .866 = Device Spacing

- The calculated throw distance is **40 feet (12.2 m)**
- 40 feet x .866 = 34.64 or 35 feet

Device Spacing would be **35 feet (10.7 m)**.

From our calculations we now have the following criteria for our loudspeaker / paging system layout:

Mounting Height: **20 feet (6.1 m)**

Device Spacing: **35 feet (10.7 m)**

Throw Distance: (SPL) **40 feet (12.2 m)**

LOUDSPEAKER SELECTION, TAP SETTING, AND REQUIRED SPL

The client has informed us that the required SPL level for this space is 90 dBA (80 dBA ambient noise) as it's a relatively noisy warehouse and there are some shifts that do light manufacturing, so **90 dBA** is the minimum target.

Based on our earlier calculations we can now reference the chart below which is an expanded SPL chart, based on the original device "Throw Distance" but now labeled according to, **Mounting Height**, and **Device Spacing**.

SPL REFERENCE CHART: BIAMP MODEL H10-G, H20-G, H30LT-G, MPL62-G PAGING HORNS

Mounting height (Feet / Meters)				7.5′ / 2m	10′ / 3m	13′ / 4m	20′ / 6m	26′ / 8m	40′ / 12m	52′ / 16m
H10-G 10W @ 8 Ohms SPL 113 dB 530Hz-6.5kHz	70V/100V	10W	0 dB	101	98	95	92	89	86	83
	70V/100V	5W	-3 dB	98	95	92	89	86	83	80
	70V/100V	2.5W	-6 dB	95	92	89	86	83	80	77
	70V/100V	1.25W	-9 dB	92	89	86	83	80	77	74
	70V	.625W	-12 dB	89	86	83	80	77	74	71
H20-G 20W @ 8 Ohms SPL 118 dB 490Hz - 6.7kHz	70V/100V	20W	0 dB	106	103	100	97	94	91	88
	70V/100V	10W	-3 dB	103	100	97	94	91	88	85
	70V/100V	5W	-6 dB	100	97	94	91	88	85	82
	70V/100V	2.5W	-9 dB	97	94	91	88	85	82	79
	70V	1.25W	-12 dB	94	91	88	85	82	79	76
H30LT-G 30W @ 8 Ohms SPL 118 dB 450Hz - 9.6kHz	70V/100V	30W	0 dB	106	103	100	97	94	91	88
	70V/100V	15W	-3 dB	103	100	97	94	91	88	85
	70V/100V	7.5W	-6 dB	100	97	94	91	88	85	82
	70V/100V	25W	-9 dB	97	94	91	88	85	82	79
	70V	12.5W	-12 dB	94	91	88	85	82	79	76
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	70V/100V	32W	-3 dB	97	94	91	88	85	82	79
	70V/100V	16W	-6 dB	94	91	88	85	82	79	76
	70V/100V	8W	-9 dB	91	88	85	82	79	76	73
	70V	4W	-12 dB	88	85	82	79	76	73	70
Distance Between Devices (Feet / Meters)				13′ / 4m	17′ / 5m	23′ / 7m	35′ / 11m	45′ / 14m	69′ / 21m	90′ / 27m

With the information we know:

Mounting Height:	**20 feet (6.1 m)**
Device Spacing:	**35 feet (10.7 m)**
Throw Distance (SPL):	**40 feet (12.2 m)**
Required SPL level:	**90dBA**

The customer likes the frequency response and form factor of the **H20-G** model paging horn

- At 20' (6m) the H20-G will produce **91 dBA** at the **5W** tap setting.

System Headroom is never a bad idea (and the overall system volume can always be turned down)

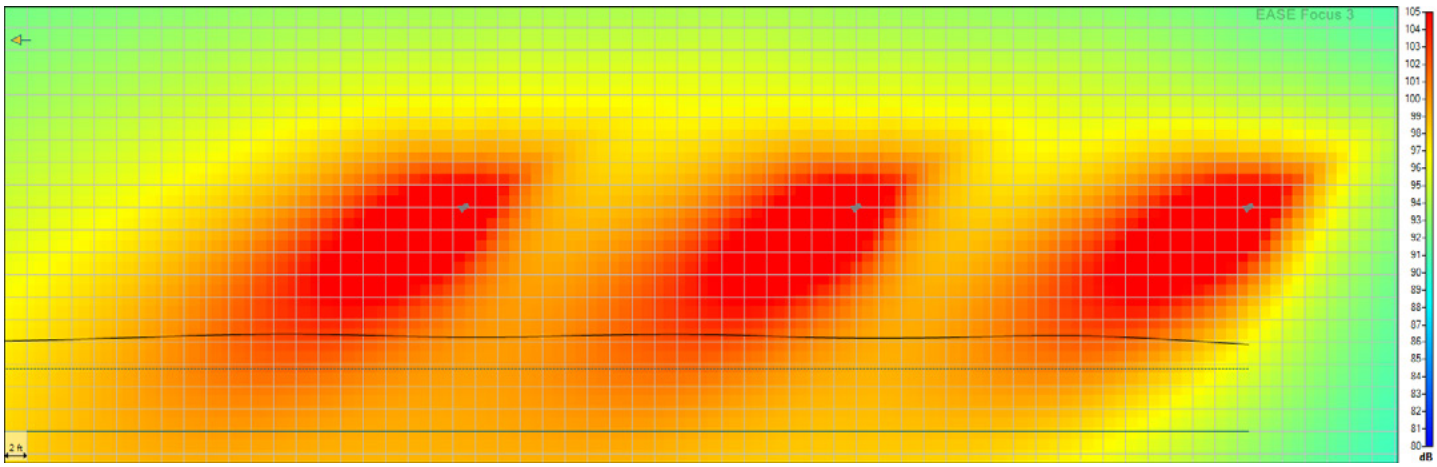
- You advise that the H20-G at the **10W** tap producing **94 dB** would be the appropriate choice.

You've now established:

- This space will use the **H20-G** mounted at **20 feet high**, spaced every **35 feet**.
- Each device will have a down angle of 30-degrees.
- Each device will be taped at **10W**, yielding **94 dBA** at the listing position.

ROW SPACING:

Here's what a side view of our 20-foot (6m) high / 35-foot (7.6m) device spacing looks like:



But this is just for a single row of loudspeakers. We now need to apply what we've calculated to the total area of the space that needs audio coverage.

You can also use the device spacing calculation we used earlier (Throw Distance x.866 = Device Spacing) to establish a guideline for the distance between rows:

How many loudspeakers are in each row?

- Length of the space / divided by Device Spacing

How many rows of loudspeakers are needed?

- Width of the space / divided by Device Spacing

Note: This calculation gives you a good starting point but the row spacing is often dictated by the layout of the warehouse and it's often required to place the loudspeakers in rows covering the aisles between racks or shelving where workers are likely to be. A good rule of thumb to follow is that if you can't SEE the loudspeaker, it's likely that you won't be able to HEAR the loudspeaker.

In our warehouse example the total space requiring audio coverage is: **335′ x 125′ or 41,875 sq. ft.**

How many loudspeakers are in each row?

- Length of the Space ÷ Device Spacing (35 feet)
- **335-feet / divided by 35-feet = 9.6**

This would suggest 9 to 10 loudspeakers in each row.

- We decide to specify **9 Devices** per row.

How many rows of loudspeakers are needed?

- Width of the space ÷ Device Spacing (35 feet)
- **125-feet / divided by 35-feet = 3.5**

This would suggest 3 to 4 rows.

- We decide to specify **4 Rows** of loudspeakers.

THE FINAL COUNTDOWN

The total number of loudspeakers calculated for this (335’ x 125’) space would be: **36 loudspeakers**.

- 9 Devices x 4 Rows **(9 x 4) = 36**

Referencing the acoustic simulation model below: We see that the calculation does effectively estimate the total number of loudspeakers required for this 41,875 sq. ft. warehouse space. It achieves the minimum required SPL of 90dB, the actual average broadband SPL of the model is 92.6 dBA, if we take a SPL measurement down each aisles we are getting a broadband SPL average of **94 dBA**.

We are now able to provide (with a high degree of confidence) the following information to the client:

Warehouse space: 335′ x 125′ (41,875 sq. ft) / Minimum Required SPL Level: 90 dB.

- Mounting Height: 20 feet AFF (Above Finished Floor)
- Down Angle: - 30 degrees
- Device Spacing / Row Spacing: 35 feet.
- Loudspeaker Layout: 4 Rows x 9 Devices
- **Total QTY: 36 H20-G loudspeakers, 70V/100V, tapped at 10W, resulting in 94 dBA.**

Summary:

Step 1: Establish the Minimum Required SPL Level for the Space.

Step 2: Determine what the available (or preferred) mounting height is for each device.

Step 3: Calculate Throw Distance: **Mounting Height x 2 = Throw Distance**

Step 4: Calculate Device Spacing: **Throw Distance x .866 = Device Spacing**

Step 5: Use SPL Reference Chart, select loudspeaker model and tap setting that achieves required SPL.

Step 6: If Row Spacing needs to be defined use **Throw Distance x.866 = Device Spacing** as a reference.

Step 7: Establish the **Length** and **Width** of the space requiring audio coverage. (Sq. Ft.)

Step 8: Calculate Devices Per Row: **Length of the Space ÷ Device Spacing**

Step 9: Calculate Number of Rows: **Width of the Space ÷ Device Spacing**

Step 10: Warehouse Loudspeaker System Design Worksheet, **Loudspeaker Proposal**

WAREHOUSE LOUDSPEAKER SYSTEM DESIGN WORKSHEET:

Step 1: Minimum Required SPL Level for the Space: _____ dBA

Step 2: Available (or preferred) mounting height for each device: _____ Feet/Meters

Step 3: Calculate Throw Distance: **Mounting Height x 2 = Throw Distance** _____ Feet/Meters

Step 4: Calculate Device Spacing: **Throw Distance x .866 = Device Spacing** _____ Feet/Meters

Step 5: Calculate Row Spacing: (if not defined use Device Spacing as reference)_____ Feet/Meters

Step 6: Select loudspeaker model and tap setting that achieves required SPL relative to mounting height:

Loudspeaker Model: _____

70V/100V Transformer Tap: _____

Step 7: Dimensions of the space requiring audio coverage:

Length: _____ Feet/Meters **Width:** _____ Feet/Meters

Step 8: Calculate Devices Per Row: **Length ÷ Device Spacing:** _____ Devices/Row

Step 9: Calculate Number of Rows: **Width ÷ Device Spacing:** _____ # of Rows

STEP 10: LOUDSPEAKER PROPOSAL:

Loudspeaker Model: _____ 70V/100V Transformer Tap: _____

Mounting Height: _____ Down Angle: (- 30 degrees) _____

Device Spacing: _____ Row spacing: _____

Loudspeaker Layout: _____ Rows X _____ Devices

Total QTY: _____

Tap Setting: _____

System SPL: _____

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Distance Between Devices (Feet / Meters)				**13′ / 4m**	**17′ / 5m**	**23′ / 7m**	**35′ / 11m**	**45′ / 14m**	**69′ / 21m**	**90′ / 27m**

Note: If the actual mounting height of the device falls between two rows, choose the higher of the two mounting heights for additional system headroom. Additionally, if the required SPL value falls between two columns, choose the higher of the two SPL values for additional system headroom.