

**Appendix E3**

**Football Field Acoustics Final**

**Memo**

Prepared by The Greenbusch Group, Inc.

November 11, 2021



**DATE:** November 24, 2021  
**TO:** Jean Stolzman AIA, LEED AP BC+C  
**FROM:** Ellie Myers – The Greenbusch Group, Inc.  
Justin Morgan, INCE  
**RE:** Issaquah High School #4 and Elementary School #17 – Football Field Acoustics Memo

Transmitted by:  Mail  Delivery  Fax  E-mail

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## INTRODUCTION

The intent of this memorandum is to provide an update to the memorandum issued in October 2019 summarizing sound levels associated with the football field at the new Issaquah High School #4 and Elementary School #17, which is being designed for the Issaquah School District.

## REGULATORY CRITERIA

Noise generated by the football field will include, but is not limited to, unamplified human voices from the audience and players on the field and amplified human voices through the PA system. Unamplified human voices from the audience and players on the field are exempt from the provisions of the Washington Administrative Code (WAC) 173.60.040, per WAC 173.60.050. However, voices amplified by the PA system will need to comply with codified sound limits, which prohibits sound levels at neighboring properties from exceeding 57 dBA between 7:00 am and 10:00 pm.

## ACOUSTICAL MODEL

The primary tool used to predict sound levels at neighboring properties was a 3-D computer noise model using the acoustic modeling software environment Cadna/A. Cadna/A utilizes the CADNA (Control of Accuracy and Debugging for Numerical Applications) computation engine developed by the Pierre et Marie Curie University of Paris. The model used for this Project utilized the International Organization for Standardization 9613 Part II algorithms, implemented in the Cadna/A software, which accounted for the effects of distance, topography, and surface reflections on sound levels.

Locations of structures, information about the PA system, and topographic information was provided by Bassetti Architects and Travis Fitzmaurice Wartelle Balangue Engineers Inc. (TFWB). Structures located at the field include one grandstand (GS), one visitor stand, and a noise barrier on the back of the GS. The GS upper-level seating is approximately 16 feet above grade and will have an angled canopy 33 feet above grade.

The PA system contains four groups of speakers, which include two large speakers, two sets of 10 medium speakers, and two small speakers mounted to the front and sides of the GS canopy.

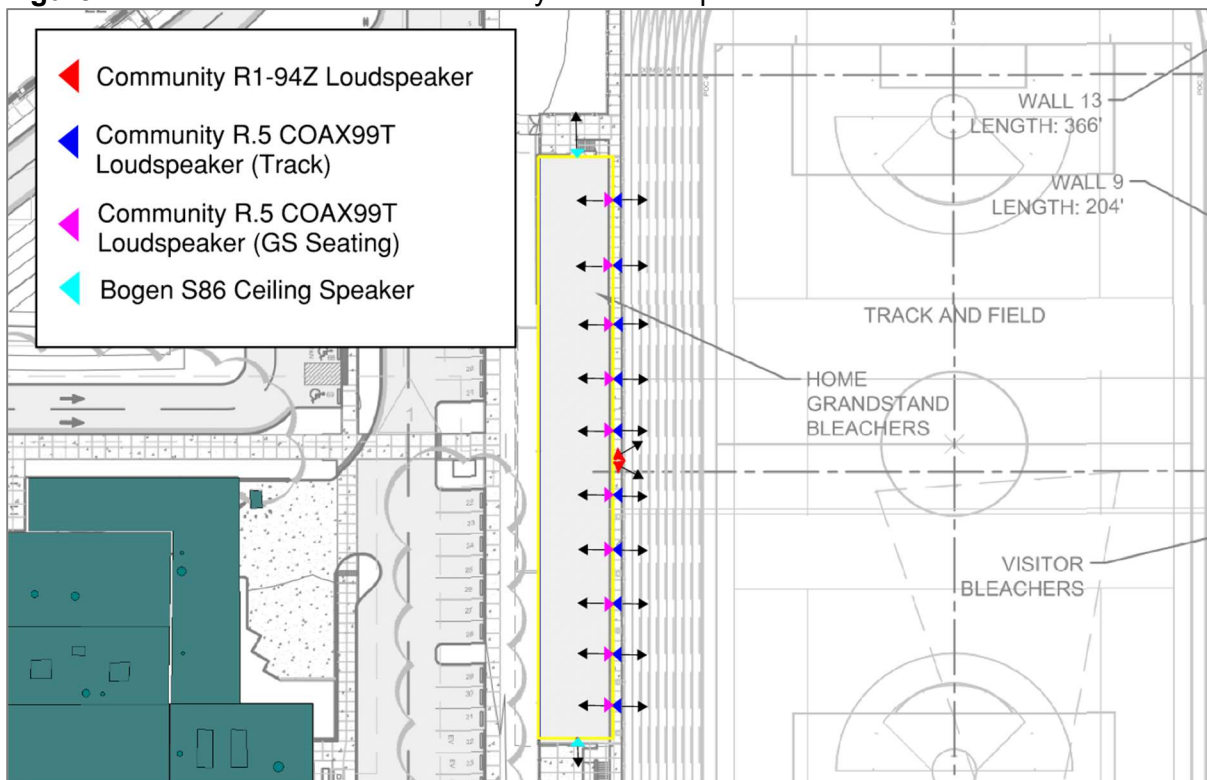
## PA System

Four types of speakers will be used for the football field and GS. Speakers do not radiate sound equally in all directions, but rather focus mid and high frequency sound in front of the speaker. This directivity was included in our analysis based on technical information

published by the manufacture and is presented in the Appendix. The speakers used for this project were selected by TFWB and include the following:

- Two Community R1-94Z 2-way horn loaded weather-resistant loudspeakers mounted approximately 33-feet-above grade, directed towards the football field, and operating at a nominal power of 200 Watts (W).
- Ten Community R.5 COAX99T 2-way coaxial weather-resistant full-range loudspeakers mounted approximately 33-feet-above grade, directed towards the track, and operating at a nominal power of 100W.
- Ten Community R.5 COAX99T 2-way coaxial weather-resistant full-range loudspeakers mounted approximately 33-feet-above grade, directed towards the GS seating, and operating at a nominal power of 100W.
- Two Bogen S86 ceiling speaker grille assemblies mounted approximately 30-feet-above grade, directed towards the ticket booth and concessions, and operating at a nominal power of 4W.

**Figure 1.** Location and Direction of PA System Loudspeakers



## ANALYSIS

The speakers were modeled at locations shown in the 2020 100% CD specification documents. The two Community R1-94Z speakers were modeled as being mounted front and center on the underside of the canopy. Each speaker was oriented to cover one half of the football field. The 20 Community R.5 COAX99T speakers were mounted in pairs, approximately 26 feet apart, along the front underside of the canopy. Ten of the Community R.5 COAX99T speakers were directed towards the GS seating and the other 10 were directed towards the track area west of the football field. One Bogen S86 ceiling speaker was directed towards the ticket booth, and the other was pointed towards the concessions.

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All speakers were modeled at the proposed operating power and sound levels were predicted at neighboring properties.

## **RESULTS**

With all 24 loudspeakers operating at the same time, sound levels at neighboring property lines are expected to exceed code limits by up to 21 dB. To meet code at neighboring property lines the operating power of the Community R1-94Z and Community R.5 COAX99T loudspeakers may be limited to 1W. The Bogen S86 Speaker can likely operate at the proposed 4W. We recommend sound level measurements of the PA system be made after it's installation to adjust the speaker sound levels until they meet code at neighboring property lines. A limiter should be set for the speakers once the appropriate sound levels are determined.

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## **Appendix**

## SPECIFICATIONS

<b>Loudspeaker Type:</b>	2-way horn loaded coaxial, weather-resistant
<b>Operating Range:</b>	90 Hz to 16 kHz 110 Hz to 10 kHz (±4 dB)
<b>Max Input Ratings:</b>	200W continuous, 500W program 40 volts RMS, 89 volts momentary peak
<b>Recommended Power Amplifier:</b>	420W to 600W @ 8 ohms
<b>Sensitivity (1W/1m):</b>	104 dB SPL (100 Hz to 16 kHz 1/3 octave bands) 105 dB SPL (250 Hz to 4 kHz speech range)
<b>Maximum Output:</b>	127 dB SPL / 134 dB SPL (peak)
<b>Nominal Impedance:</b>	8 ohms
<b>Minimum Impedance:</b>	5.7 ohms @ 230 Hz
<b>Nominal -6dB Beamwidth:</b>	80° H (+0° / -49°, 1 kHz to 16 kHz) 35° V (+4° / -10°, 1 kHz to 16 kHz) 100° H x 100° V (400 Hz)
<b>Axial Q / DI:</b>	29.7 / 14.7, 1 kHz to 16 kHz
<b>Crossover Frequency:</b>	1.2 kHz
<b>Recommended Signal Processing:</b>	90 Hz high pass filter
<b>Drivers:</b>	LF 1 x 12" weather-treated, Ferrofluid-cooled HF 1 x 1" exit, titanium diaphragm
<b>Driver Protection:</b>	PowerSense™ DDP
<b>Input Connection:</b>	12 foot (4 m) SJOW #16 gauge
<b>Controls:</b>	None
<b>Enclosure:</b>	Hand-laminated fiberglass, light grey gelcoat
<b>Mounting/Rigging Provisions:</b>	(5) 1/2-13 rigging points
<b>Grille:</b>	3-layer WeatherStop™, light grey (Zinc-rich epoxy dual-layer powder coated perforated steel grille, foam, woven poly mesh)
<b>Environmental Performance:</b>	IEC529 IP55W rating with a minimum 5-degree downward aiming angle
<b>Required Accessories:</b>	90 Hz high pass filter
<b>Supplied Accessories:</b>	SSYR1 yoke bracket, light grey
<b>Optional Accessories:</b>	TRC400 400-watt 70/100/140-volt transformer
<b>Dimensions—Height:</b>	24.75 inches (629 mm)
<b>Width:</b>	24.75 inches (629 mm)
<b>Depth:</b>	29.75 inches (756 mm)
<b>Weight (without yoke):</b>	47.5 lbs (21.5 kg)
<b>Weight (with yoke):</b>	55.5 lbs (25.2 kg)
<b>Shipping Weight:</b>	75 lbs (34 kg)

### NOTES:

1. Sensitivity: Free field pink noise measurement at 40 ft (12.2 m) at 25% power; extrapolated to 1 meter and an input of 2.83 volts RMS.
2. Watts: All wattage figures are calculated using the rated nominal impedance.



## APPLICATIONS

- Convention centers, ballrooms, arenas, malls
- Athletic fields, small arenas, athletic field houses
- Theme and amusement parks
- Fairgrounds, rodeos, air shows
- Racing tracks, skating rinks, swimming pools
- Electronic carillons
- Cruise ships
- Portable sound systems

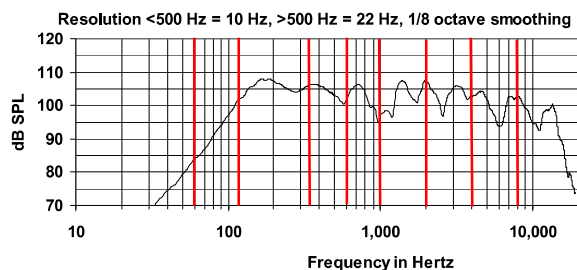
## FEATURES

- Weather-resistant, all-fiberglass enclosure
- Weather-treated drivers and crossovers
- Corrosion-resistant zinc-rich epoxy dual-layer powder coated steel grille and yoke
- Pattern control to below 500 Hz
- High efficiency
- Integral mounting points
- High power passive crossover
- High-fidelity, full-range reproduction of music and speech
- Application-specific coverage pattern
- Optional "indoor" version available with a black enclosure and no grille (model R1-64BNG)
- Five-year product warranty / Fifteen-year enclosure warranty

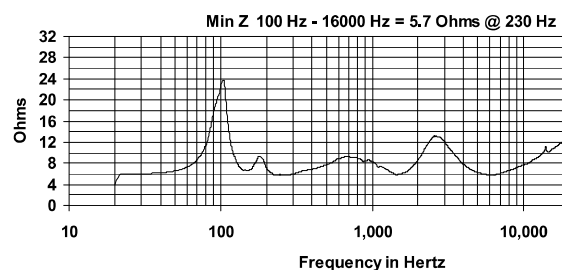
## DESCRIPTION

The R1-94Z two-way full-range loudspeaker system is engineered to provide quality full-range sound projection in a variety of outdoor and indoor applications. Its wide range, smooth frequency response and high efficiency ensures both high fidelity music reproduction and superb projection of clear intelligible speech with very low distortion. The R1 loudspeakers are available in two versions. The standard version is weather-ready, with a WeatherStop™ grille and light grey finish. The BNG version, with black exterior and no grille, is more suitable for indoor applications. A weather-resistant mounting yoke is included.

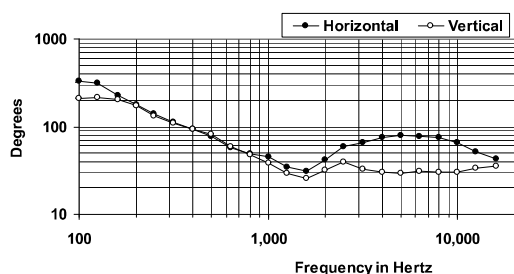
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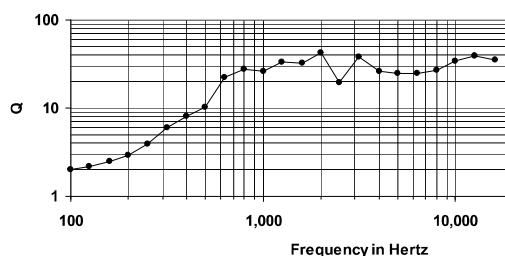
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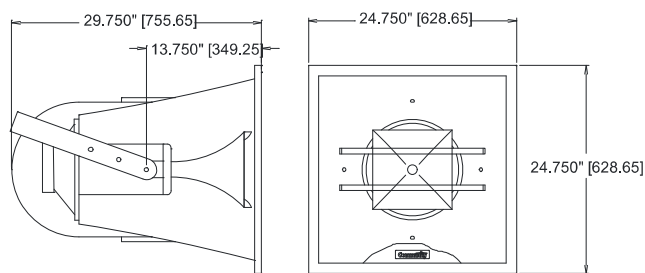
## BEAMWIDTH



## AXIAL Q

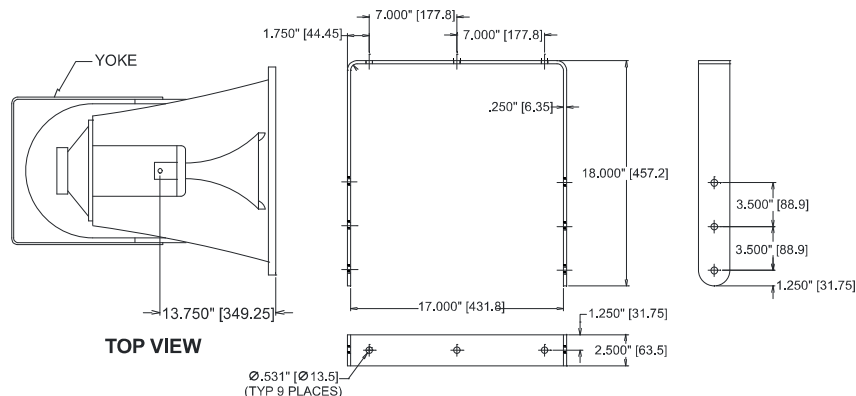


## DIMENSIONS



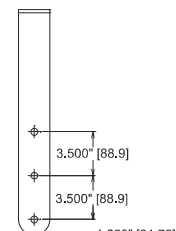
SIDE VIEW

FRONT VIEW



TOP VIEW

## R1 YOKE



## ARCHITECTURAL SPECIFICATIONS

The loudspeaker system shall be a horn-loaded, two-way, full-range co-axial design with one 12" Ferrofluid-cooled woofer treated with moisture repellant on a bass horn and one 1" exit HF driver with a titanium diaphragm mounted on a fiberglass horn built within the bass horn. Drivers shall be connected to an integral crossover with a crossover frequency of 1200 Hz and integral over-current protection circuitry using high positive current coefficient resistors. The input connection shall be one 16-2 12-foot (4m) SJOW cable with stripped ends. The loudspeaker enclosure shall be an integral double-wall weather-sealed light grey fiberglass bell with a three-layer weather-resistant grille. The steel grille shall be powder coated with a proprietary zinc-rich epoxy dual-layer powder coating process in light grey to color match the enclosure. The system shall have an IEC529 IP rating of IP55W with a minimum 5-degree downward aiming angle. There shall be five 1/2 - 13 threaded mounting points. The system shall have an amplitude response of 110 Hz to 10 kHz (+/- 4 dB), input capability of 40V RMS, 105 dB sensitivity at one meter / 2.83 V and 8 ohms nominal impedance. The nominal dispersion shall be 80°H x 35°V from 1 kHz to 16 kHz. The loudspeaker shall be 24.75 in. (629 mm) H x 24.75 in. (629 mm) W x 29.75 in. (756 mm) D and weigh 47.5 lbs. (21.5 kg).

Community strives to improve its products on a continual basis. Specifications are therefore subject to change without notice.

## SPECIFICATIONS

<b>Loudspeaker Type:</b>	2-way, coaxial, weather-resistant, full-range
<b>Operating Range:</b>	80 Hz to 18 kHz 90 Hz to 12.5 kHz ( $\pm 3.5$ dB)
<b>Max Input Ratings:</b>	200W continuous, 500W program 40 volts RMS, 89 volts momentary peak
<b>Recommended Power Amplifier:</b>	420W to 600W @ 8 ohms
<b>Sensitivity (1W/1m):</b>	96 dB SPL (100 Hz to 13 kHz 1/3 octave bands) 96 dB SPL (250 Hz to 4 kHz speech range)
<b>Maximum Output:</b>	119 dB SPL / 126 dB SPL (peak)
<b>Nominal Impedance:</b>	8 ohms
<b>Minimum Impedance:</b>	3.8 ohms @ 9.9 kHz
<b>Nominal -6dB Beamwidth:</b>	90°H (+10° / -23°, 1.6 kHz to 12.5 kHz) 90°V (+4° / -30°, 1.6 kHz to 12.5 kHz)
<b>Axial Q / DI:</b>	10.7 / 10.3, 1.6 kHz to 12.5 kHz
<b>Crossover Frequency:</b>	2 kHz
<b>Recommended Signal Processing:</b>	60 Hz high pass filter
<b>Drivers:</b>	LF 1 x 12" HF 1 x 1" exit titanium free, Ferrofluid-cooled
<b>Driver Protection:</b>	DYNA-TECH protection circuitry
<b>Input Connection:</b>	12 foot (4 m) SJOW #16 gauge
<b>Controls:</b>	None
<b>Enclosure:</b>	Rotomolded LLDPE, light grey
<b>Mounting/Rigging Provisions:</b>	(5) 3/8-16 rigging points
<b>Grille:</b>	3-layer WeatherStop™, light grey (Zinc-rich epoxy dual-layer powder coated perforated steel grille, foam, woven poly mesh)
<b>Environmental Performance:</b>	IEC529 IP54W rating with a minimum 5-degree downward aiming angle
<b>Required Accessories:</b>	24 dB/Oct high pass filter
<b>Supplied Accessories:</b>	(1) Yoke bracket, light grey (1) Aiming strap
<b>Optional Accessories:</b>	PMB Series pole mount brackets
<b>Dimensions—Height:</b>	16 inches (406.4 mm)
<b>Width:</b>	16 inches (406.4 mm)
<b>Depth:</b>	15.94 inches (404.88 mm)
<b>Weight:</b>	35 lbs (15.9 kg)
<b>Shipping Weight:</b>	42 lbs ( 19.1 kg)

### NOTES:

1. Sensitivity: Free field pink noise measurement at 20 ft (6.1 m) at 50% power; extrapolated to 1 meter and an input of 2.83 volts RMS.
2. Watts: All wattage figures are calculated using the rated nominal impedance.



## APPLICATIONS

- Convention centers
- Fill speaker for stadia, athletic fields, arenas and race tracks
- Outdoor background music / paging systems
- Theme and amusement parks
- Fairgrounds, rodeos, air shows
- Malls, cruise ships, skating rinks
- Swimming pools
- Portable sound systems

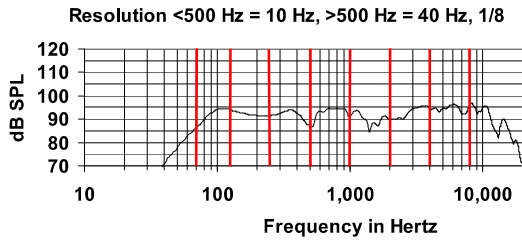
## FEATURES

- Weather-resistant, rotomolded UV enclosure
- Weather-treated drivers and crossovers
- Corrosion-resistant zinc-rich epoxy dual-layer powder coated steel grille and yoke
- High fidelity
- High efficiency
- Integral mounting points
- High power passive crossover
- Optional 200W, 70V autoformer
- Five-year product warranty / Fifteen-year enclosure warranty

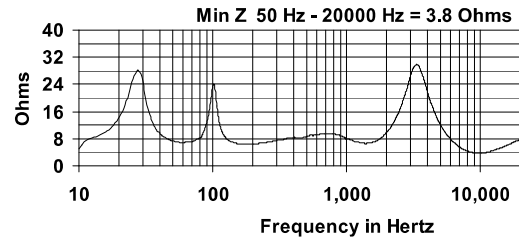
## DESCRIPTION

The R.5COAX99 high fidelity, two-way, full-range loudspeaker system is engineered to provide quality full-range sound in a variety of outdoor and indoor applications. Its wide range, smooth frequency response and high efficiency ensure both high fidelity music reproduction and superb projection of clear intelligible speech with very low distortion. Five-year limited product warranty; fifteen-year enclosure warranty.

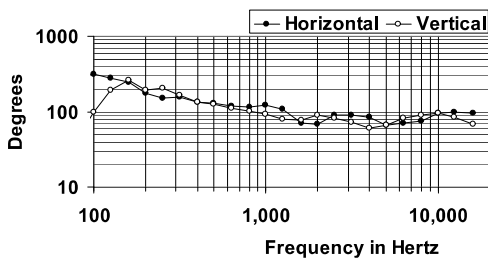
## FREQUENCY RESPONSE



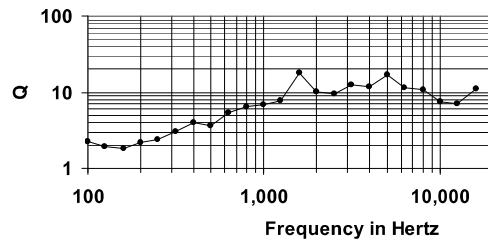
## IMPEDANCE



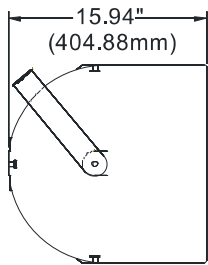
## BEAMWIDTH



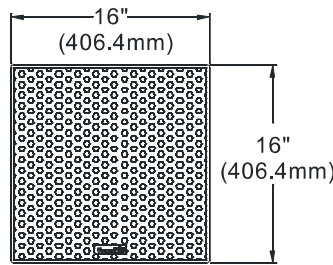
## AXIAL Q



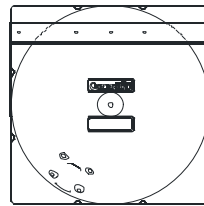
## DIMENSIONS



SIDE VIEW

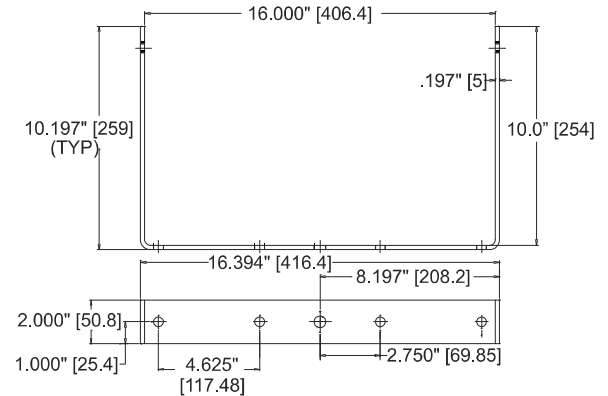


FRONT VIEW



REAR VIEW

## R.5 YOKE



## ARCHITECTURAL SPECIFICATIONS

The loudspeaker system shall be a two-way, full-range bass reflex design with a single cast 12" and one 1" exit HF driver coaxially mounted on a 90° x 90° horn. Drivers shall be connected to an integral crossover with a crossover frequency of 2 kHz and integral over-current protection circuitry. The cabinet shall be a roto-molded linear low density polyethylene enclosure providing weather and UV resistance with a three-layer weather resistant grille. The steel grille shall be powder coated with a proprietary zinc-rich epoxy dual-layer powder coating process in light grey to color match the enclosure. The system shall have an IEC529 IP rating of IP54W with a minimum 5-degree downward aiming angle. The input connection shall be one 12' (4m) SJOW #16-gauge cable with stripped ends. The enclosure shall incorporate five 3/8-16 rigging points for multiple mounting options. In addition, the loudspeaker will be supplied with one zinc-rich epoxy dual-layer powder coated steel yoke bracket. The system shall have an amplitude response of 90 Hz to 12.5 kHz (+/-3.5dB), input capability of 40 V RMS, 96 dB Sensitivity at one meter and 2.83 V, 8 Ohm nominal impedance. The nominal dispersion shall be 90° H x 90° V from 1.6 kHz to 12.5 kHz. The dimensions of the enclosure are defined as 16" x 16" x 16" (HWD) at a weight of 35 lbs. (38.5 lbs for the optional 70V version).

Community strives to improve its products on a continual basis. Specifications are therefore subject to change without notice.

# Ceiling Speaker Grille Assemblies



S86T725PG8WBR



S86T725PG8WVK

## Description

Bogen's Ceiling Speaker Assemblies consist of an 8" Cone Speaker (S86 or S810) pre-assembled onto a 13" steel ceiling grille painted with off-white (PG8W) or bright white (PG8U) enamel. Options for these assemblies are recessed volume control (VR), volume control with knob (VK), and rear-mounted screw terminal strip for power taps (BR).

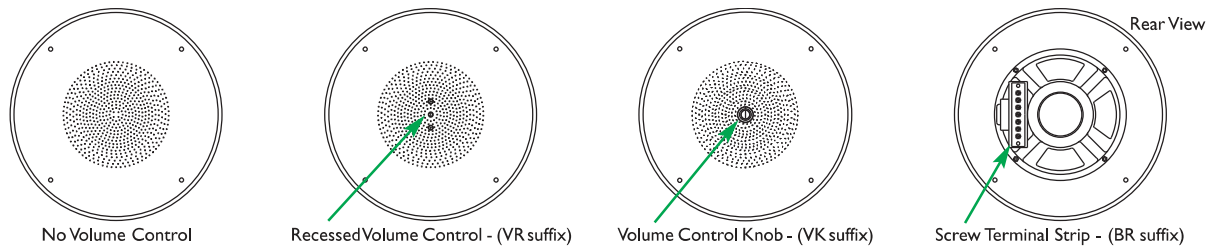
## Features

- 4-watt capacity
- 8" cone speaker for excellent audio quality
- 6 different power taps available (4, 2, 1, 1/2, 1/4, 1/8W)
- T725 4-watt transformer
- Off-white enamel over steel grille ("W" versions)
- Bright white enamel over steel grille ("U" versions)
- Pre-assembled for faster installation
- Works with both 70V and 25V amplifier outputs
- Available with volume control – recessed or with knob (VR and VK models only)
- Screw terminals (BR models only)
- 6 oz. or 10 oz. magnet weights

## Technical Specifications

Model	Power Taps (in Watts)	Frequency Response	Sensitivity (4 ft./1W)	Magnet Weight	No Volume Control	Recessed Volume Control (VR)	Volume Control w/Knob (VK)	Screw Terminals (BR)	Off-White (W)	Bright White (U)	Shipping Weight (6/Carton)	Dimensions				
S86T725PG8W	4, 2, 1, 1/2, 1/4, 1/8 @ 25 & 70V	50 Hz- 12 kHz	95 dBspl	6 oz.	●				●		27 lb. / carton	13" Dia x 3-1/4" D				
S86T725PG8WVR						●				●						
S86T725PG8WVK							●			●						
S86T725PG8WBR					●			●	●				28 lb. / carton			
S86T725PG8WBRVR						●		●	●							
S86T725PG8WBRVK							●	●	●							
S86T725PG8U									●				●	27 lb. / carton		
S86T725PG8UVR									●				●			
S86T725PG8UVK										●			●			
S86T725PG8UBR									●		●		●	28 lb. / carton		
S86T725PG8UBRVR										●	●		●			
S86T725PG8UBRVK											●		●			
S810T725PG8W						70 Hz- 15 kHz	96 dBspl	10 oz.	●					●		30 lb. / carton
S810T725PG8WVR									●					●		
S810T725PG8WVK			●						●							
S810T725PG8U	●									●						
S810T725PG8UVR					●					●						
S810T725PG8UVK									●	●						

## Ceiling Speaker Assembly Variations



No Volume Control

Recessed Volume Control - (VR suffix)

Volume Control Knob - (VK suffix)

Screw Terminal Strip - (BR suffix)

## Architect and Engineer Specifications

**S86T725PG8W & Variations** The loudspeaker assembly shall be a Bogen model **S86T725PG8W** (or **S86T725PG8WVR**, **S86T725PG8WVK**, **S86T725PG8WBR**, **S86T725PG8WBRVR**, or **S86T725PG8WBRVK**), or equivalent, 8" cone-type loudspeaker, having a frequency response of at least 50 Hz to 12 kHz. Axial sensitivity shall be 95 dB, measured at 1-watt/4 feet. The loudspeaker shall have a 6 oz. ceramic magnet and a 3/4" voice coil. A transformer, capable of matching an 8-ohm loudspeaker to a 25-volt or 70-volt line, and providing power taps of 4, 2, 1, 1/2, 1/4, and 1/8 watts shall be included. The loudspeaker shall be assembled on a 13" steel ceiling grille, finished in off-white semi-gloss enamel. Assembly depth shall be 3-1/4". (For **S86T725PG8WVR** add) A recessed volume control shall be included.

(For **S86T725PG8WVK** add) A volume control knob shall be accessible from the front of the grille.

(For **S86T725PG8WBR** add) A terminal strip shall be included for connection of the audio line.

(For **S86T725PG8WBRVR** add) A terminal strip shall be included for connection of the audio line. A recessed volume control shall be included.

(For **S86T725PG8WBRVK** add) A terminal strip shall be included for connection of the audio line. A volume control knob shall be accessible from the front of the grille.

**S86T725PG8U & Variations** The loudspeaker assembly shall be a Bogen model **S86T725PG8U** (or **S86T725PG8UVR**, **S86T725PG8UVK**, **S86T725PG8UBR**, **S86T725PG8UBRVR**, or **S86T725PG8UBRVK**), or equivalent, 8" cone-type loudspeaker, having a frequency response of at least 50 Hz to 12 kHz. Axial sensitivity shall be 95 dB, measured at 1-watt/4 feet. The loudspeaker shall have a 6 oz. ceramic magnet and a 3/4" voice coil. A transformer, capable of matching an 8-ohm loudspeaker to a 25-volt or 70-volt line, and providing power taps of 4, 2, 1, 1/2, 1/4, and 1/8 watts shall be included. The loudspeaker shall be assembled on a 13" steel ceiling grille, finished in bright white semi-gloss enamel. Assembly depth shall be 3-1/4".

(For **S86T725PG8UVR** add) A recessed volume control shall be included.

(For **S86T725PG8UVK** add) A volume control knob shall be accessible from the front of the grille.

(For **S86T725PG8UBR** add) A terminal strip shall be included for connection of the audio line.

(For **S86T725PG8UBRVR** add) A terminal strip shall be included for connection of the audio line. A recessed volume control shall be included.

(For **S86T725PG8UBRVK** add) A terminal strip shall be included for connection of the audio line. A volume control knob shall be accessible from the front of the grille.

**S810T725PG8W & Variations** The loudspeaker shall be a Bogen model **S810T725PG8W** (or **S810T725PG8WVR**, or **S810T725PG8WVK**), or equivalent, 8" cone-type loudspeaker, having a frequency response of at least 70 Hz to 15 kHz. Axial sensitivity shall be 96 dB, measured at 1-watt/4 feet. The loudspeaker shall have a 10 oz. ceramic magnet and a 1" voice coil. A transformer, capable of matching an 8-ohm loudspeaker to a 25-volt or 70-volt line, and providing power taps of 4, 2, 1, 1/2, 1/4, and 1/8 watts shall be included. The loudspeaker shall be assembled on a 13" steel ceiling grille, finished in off-white semi-gloss enamel. Assembly depth shall be 3-1/4".

(For **S810T725PG8WVR** add) A recessed volume control shall be included.

(For **S810T725PG8WVK** add) A volume control knob shall be accessible from the front of the grille.

**S810T725PG8U & Variations** The loudspeaker shall be a Bogen model **S810T725PG8U** (or **S810T725PG8UVR**, or **S810T725PG8UVK**), or equivalent, 8" cone-type loudspeaker, having a frequency response of at least 70 Hz to 15 kHz. Axial sensitivity shall be 96 dB, measured at 1-watt/4 feet. The loudspeaker shall have a 10 oz. ceramic magnet and a 1" voice coil. A transformer, capable of matching an 8-ohm loudspeaker to a 25-volt or 70-volt line, and providing power taps of 4, 2, 1, 1/2, 1/4, and 1/8 watts shall be included. The loudspeaker shall be assembled on a 13" steel ceiling grille, finished in bright white semi-gloss enamel. Assembly depth shall be 3-1/4".

(For **S810T725PG8UVR** add) A recessed volume control shall be included.

(For **S810T725PG8UVK** add) A volume control knob shall be accessible from the front of the grille.

**BOGEN**<sup>®</sup>  
**COMMUNICATIONS, INC.**

www.bogen.com