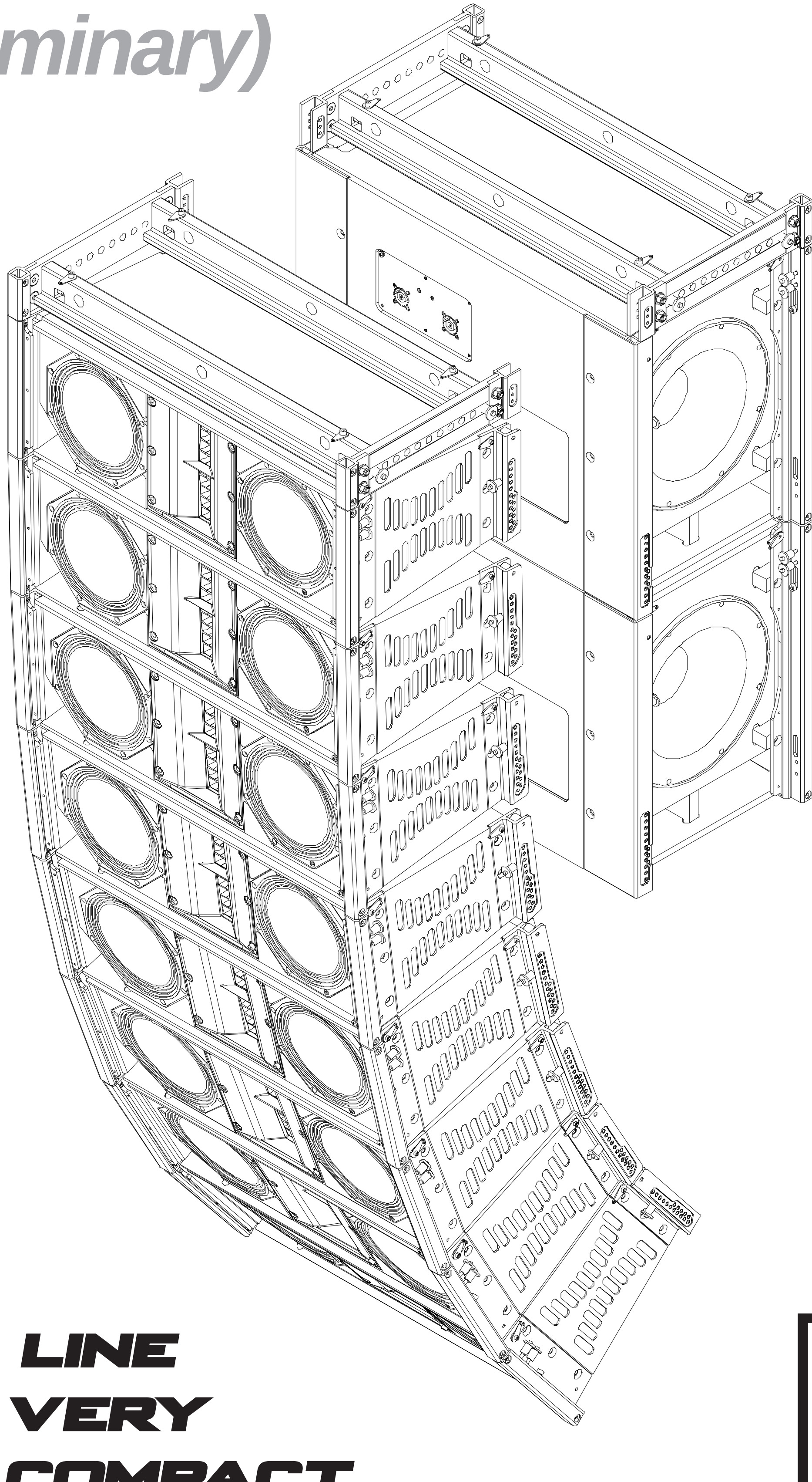
X-Line Very Compact Rigging Manual

(Preliminary)



LINE
VERY
COMPACT™

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Rigging-Safety Warning

This document details general rigging practices appropriate to the entertainment industry, as they would apply to the rigging of Electro-Voice X-Line Very Compact (XLVC) loudspeaker systems. It is intended to familiarize the reader with standard rigging hardware and techniques for suspending XLVC loudspeaker systems overhead. Only persons with the knowledge of proper hardware and safe rigging techniques should attempt to suspend any sound systems overhead. Prior to suspending any Electro-Voice XLVC loudspeaker systems overhead, it is essential that the user be familiar with the strength ratings, rigging techniques and special safety considerations outlined in this manual. The rigging techniques and practices recommended in this manual are, of necessity, in general terms to accommodate the many variations in loudspeaker arrays and rigging configurations. As such, the user is expressly responsible for the safety of all specific XLVC loudspeaker array designs and rigging configurations as implemented in practice.

All the general rigging material contained in this manual is based on the best available engineering information concerning materials and practices, as commonly recognized in the United States, and is believed to be accurate at the time of the original printing. As such, the information may not be directly applicable in other countries. Furthermore, the regulations and requirements governing rigging hardware and practices may be superseded by local regulations. It is the responsibility of the user to ensure that any Electro-Voice loudspeaker system is suspended overhead in accordance with all current federal, state and local regulations.

All specific material concerning the strength ratings, rigging techniques and safety considerations for the XLVC loudspeaker systems is based on the best available engineering information concerning the use and limitations of the products. Electro-Voice continually engages in testing, research and development of its loudspeaker products. As a result, the specifications are subject to change without notice. It is the responsibility of the user to ensure that any Electro-Voice loudspeaker system is suspended overhead in accordance with the strength ratings, rigging techniques and safety considerations given in this document and any manual update notices. All non-Electro-Voice associated hardware items necessary to rig a complete XLVC loudspeaker array (grids, chain hoists, building or tower supports and miscellaneous mechanical components) are the responsibility of others.

Electro-Voice
February, 2005

0. Introduction

The X-Line Very Compact (XLVC) loudspeaker systems represent an important step in line-array technology for small- and medium-scale sound reinforcement. The individual loudspeaker drivers, acoustic lenses, acoustic waveguides, enclosures and rigging hardware were all designed specifically for the XLVC product line to not only achieve the highest acoustic output with the highest fidelity, but also to produce a precise wavefront from each element to achieve state-of-the-art line-array performance. A brief description of the product line is included below. The XLVC loudspeaker systems are shown in Figure 1 with key dimensions and weights.

XLD281: Three-way, LF1/LF2/HF loudspeaker system with a 120°H x 10°V coverage pattern. The system includes two DVN2080 8-inch (203-mm) LF drivers and two ND2S-16 2-inch (51-mm) HF drivers. The XLD281 has a switchable crossover that allows either biamp or triamp operation. The XLD281 utilizes an enclosure that is trapezoidal in the vertical plane (with an 10° total included angle) and has XLVC 10° rigging tube and channel modules secured to the left and right enclosure sides.

XLE181: Two-way, LF/HF loudspeaker system with a 120°H x 10°V coverage pattern. The system includes one DVN2080 8-inch (203-mm) LF driver and two ND2S-16 2-inch (51-mm) HF drivers. The XLE181 has a switchable crossover that allows either biamp or passive operation. The XLE181 utilizes a narrower 10° trapezoidal enclosure than the XLD281 and has XLVC 10° rigging tube and channel modules secured to the left and right enclosure sides.

XS212: Dual Side-Firing Bass System with two DVX3120 12-inch (305-mm) woofers. The XS212 utilizes an enclosure that is rectangular in shape and has XLVC elongated 20° rigging tube and channel modules secured to the left and right enclosure sides.

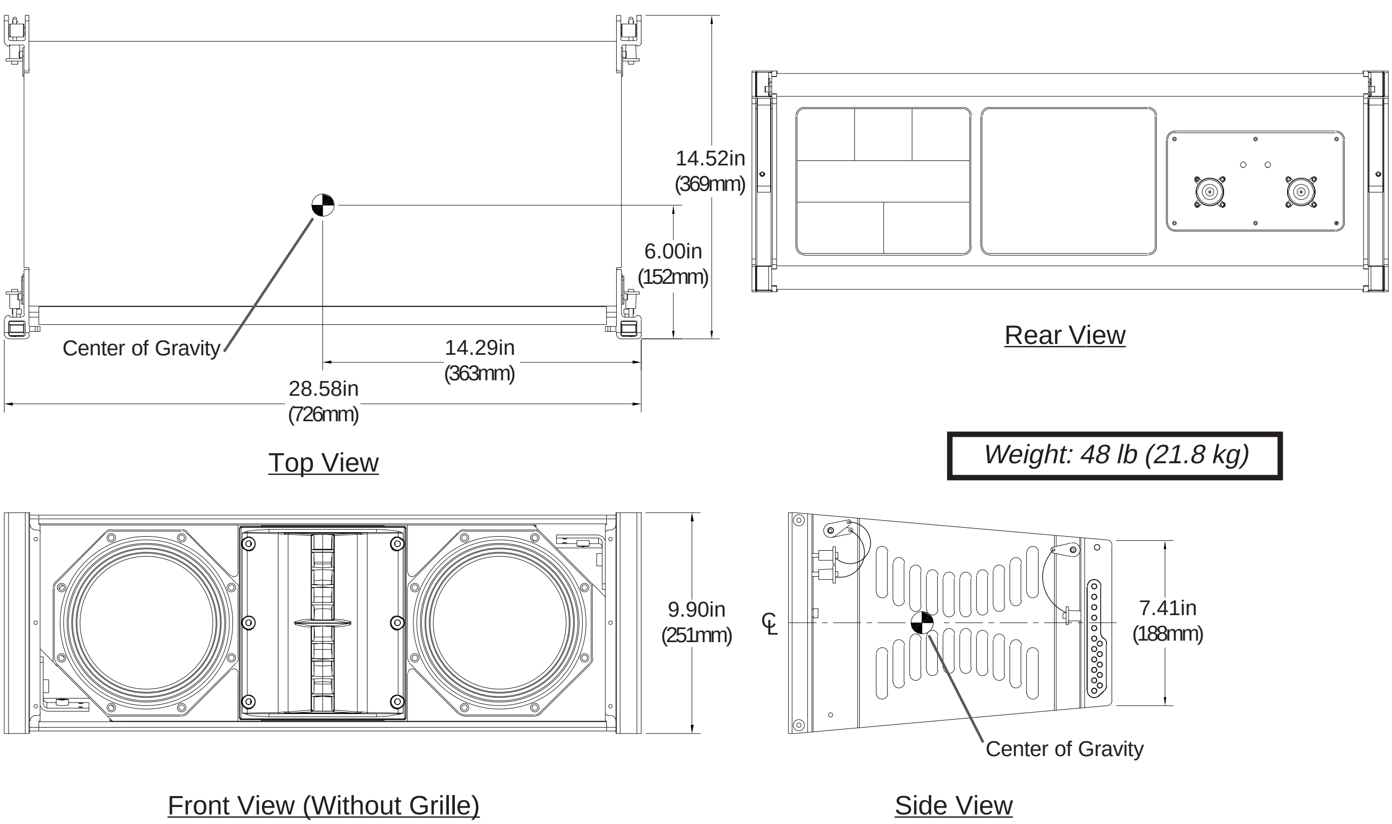


Figure 1a: *XLD281 Loudspeaker System*

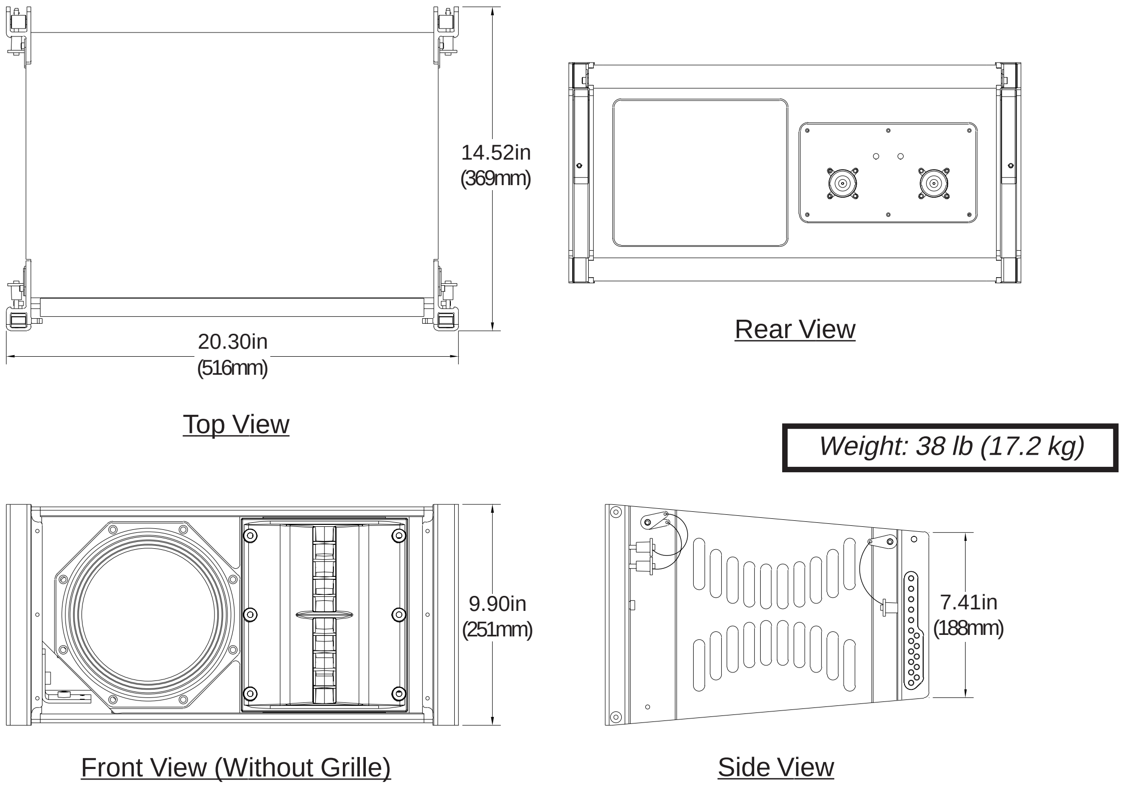


Figure 1b: *XLE181 Loudspeaker System*

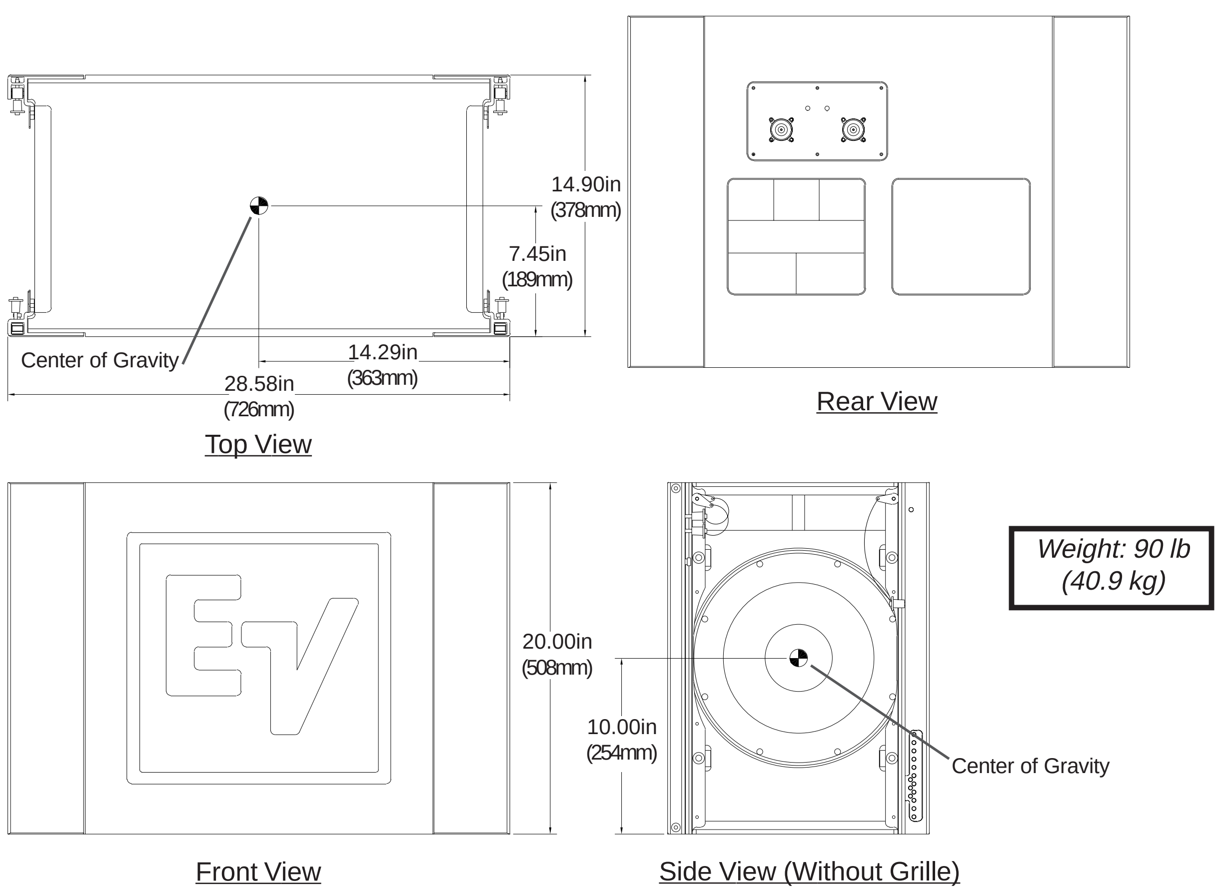


Figure 1c: *XS212 Loudspeaker System*

1. X-Line Very Compact Rigging System

1.1 Overview of the XLVC Flying System

The XLVC loudspeaker systems have been designed to construct correct acoustic line arrays. Acoustic line arrays typically consist of independent columns of loudspeaker systems that acoustically and coherently sum to radiate cylindrical wavefronts. This simplifies the rigging system.

The XLVC loudspeaker enclosures utilize a hinged rigging system that makes constructing arrays easy, predictable and repeatable. This front-hinging rigging concept allows arrays to be accurately constructed with the least possible spacing between enclosures. The front and back rigging hardware for linking two enclosures together are captured as an integral part of the side rigging tube and channel modules.

A basic array is shown in Figure 2 that illustrates the integral components that make up a typical XLVC flying system. The XLD281 and XLE181 enclosures are vertically trapezoidal - taller at the front than at the back. The enclosures are hinged at the front corners using rigging hardware specially designed for the XLVC system. The enclosures are linked at the rear using rigging arms that have multiple attachment positions. The different positions adjust how close the back corners of the enclosures are pulled together; hence, adjusting the vertical angle of the bottom enclosure.

1.2 XLVC Enclosure Rigging Hardware Details

On each side of the enclosure are XLVC rigging tube and channel modules. All the rigging hardware needed to fly a column of XLVC enclosures is an integral part of the high-strength aluminum-alloy rigging tube and channel modules. The structural load is transmitted through the modules minimizing the load on the loudspeaker enclosure shell. Figures 3a and 3b illustrate the XLVC enclosure rigging hardware components. Figures 4a and 4b show key dimensions for the rigging hardware.

At the front rigging module is a rectangular rigging tube. Captured inside the rigging tube is a rigging connector called the hinge bar. The hinge bar is constructed from a high-strength aluminum alloy. The hinge bar can slide out the top of the tube and be locked into position as shown in Figure 2. The portion of the hinge bar sticking out the top would be inserted into the front rigging tube of an enclosure above and pinned into place, linking the two enclosures together and forming a hinging point between the two enclosures. The hinge bar can also be fully retracted inside the tube for transportation.

Each hinge bar has two holes in the bar for rigging box-to-box or securing pins for transport. The front rigging tube has two holes for pinning the bar in place to construct arrays or for transport. As shown in Figures 3a and 3b, the bottom hole and pin on the bar locks the hinge bar in place at the top of the tube. The exposed top hole and pin is then used to lock the hinge bar in the tube of an enclosure above. For transportation, the hinge bar would be slid down inside the tube and would be locked in the tube module using the two “transport holes” on the rear of the front rigging tube.

At the rear is a channel module with a vertical rigging slot. Captured inside the rigging slot is a rigging connector called the swing arm. The swing arm is constructed from a high-strength aluminum alloy. The swing arm can be pivoted to stick out the top as shown in Figures 3a and 3b. At the bottom of the channel from the enclosure above, the rear rigging slot has a series of holes.

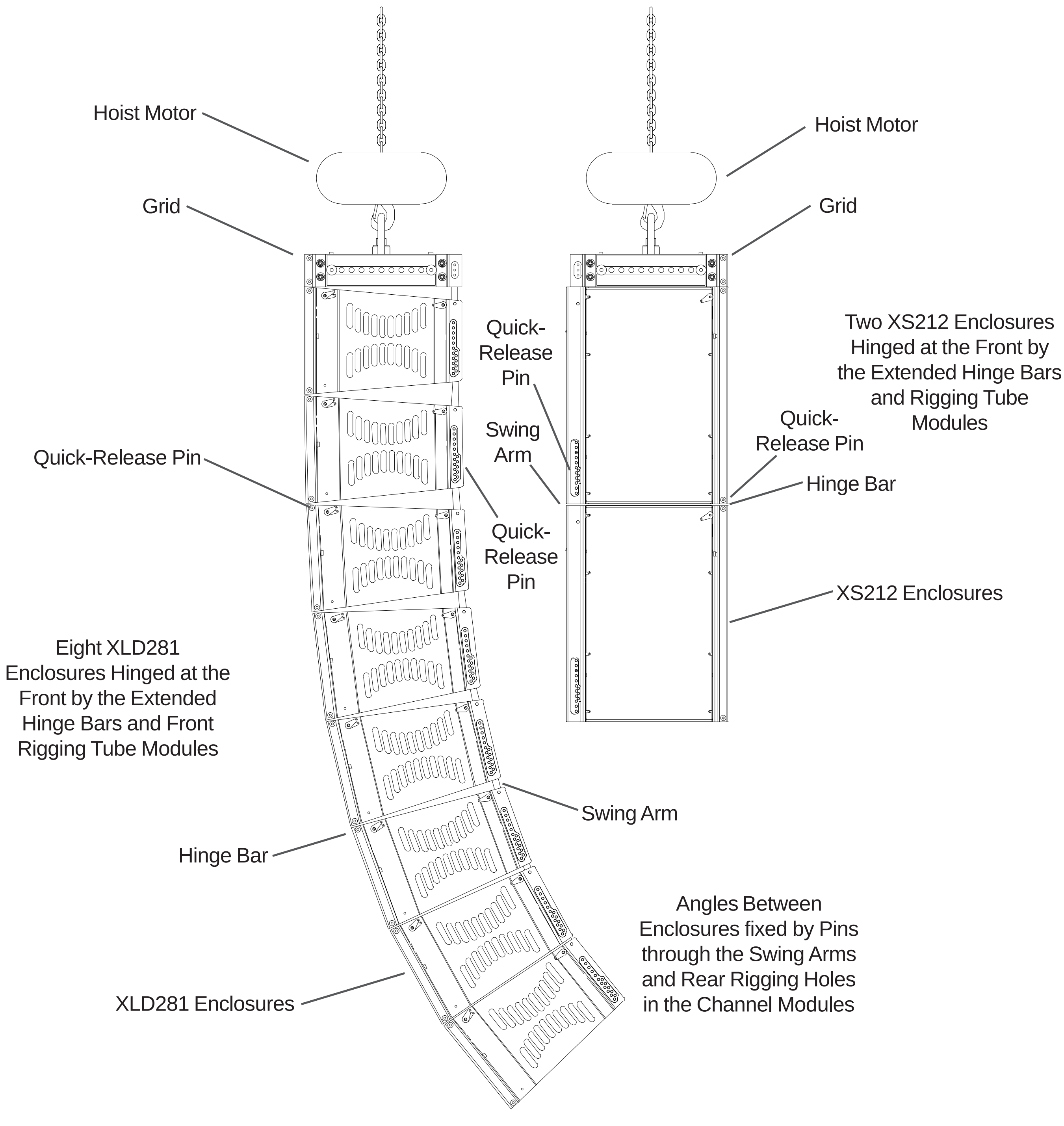


Figure 2:

Typical XLVC Flying System (without Coupler Beam)

The swing arm from an enclosure below can be pivoted up so that the quick-release pin from the enclosure below may be inserted through a hole in the rigging slot on the channel module above, linking the two enclosures together. The vertical tilt angle of the bottom enclosure is then determined by the hole in which the swing arm is pinned. The XLD281 and XLE181 enclosures may be angled from 0° to 10° in 1° increments, while the XS212 enclosure may be angled from 0° to 20° in 2° increments. The angle adjustment holes are detailed in figures 4a and 4b. This pin fixes the maximum distance the back corners of the enclosures may be separated.

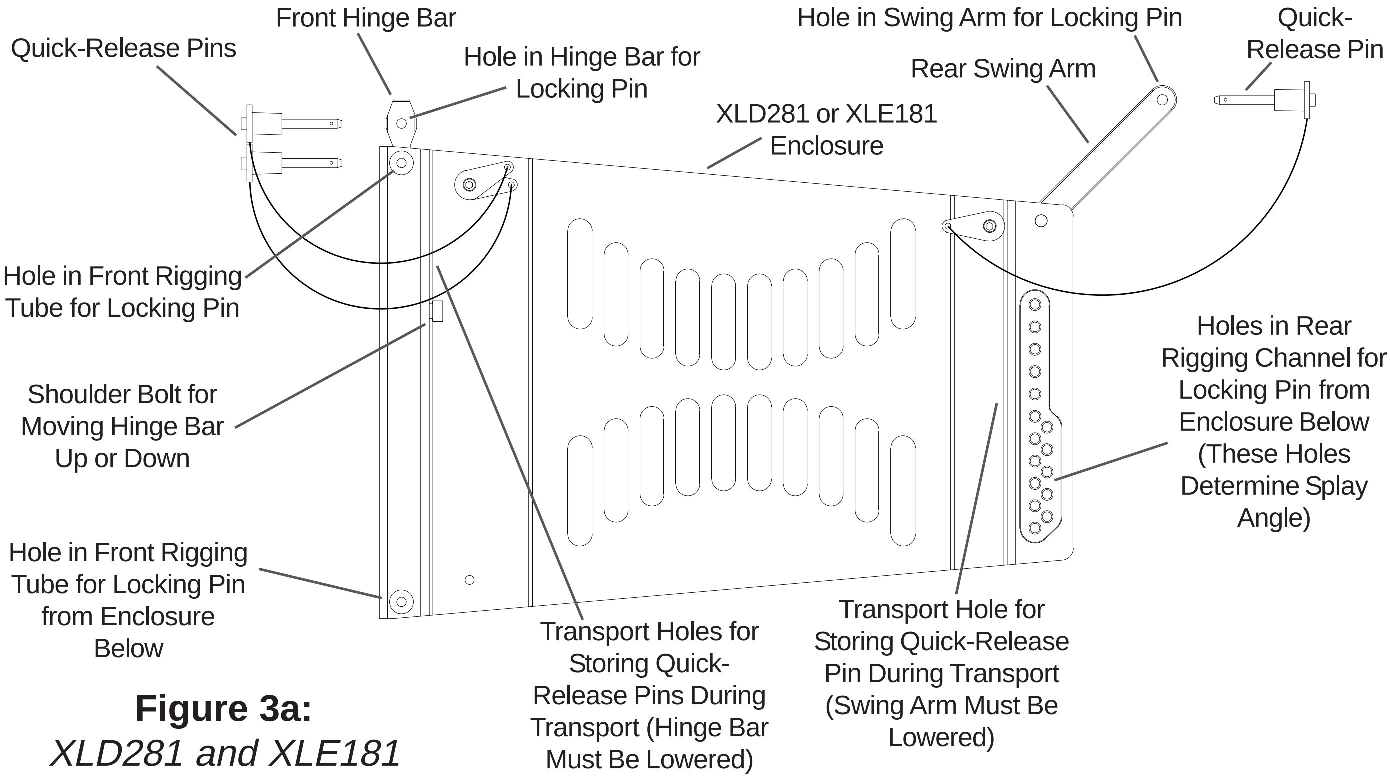


Figure 3a:
XLD281 and XLE181 Rigging Hardware

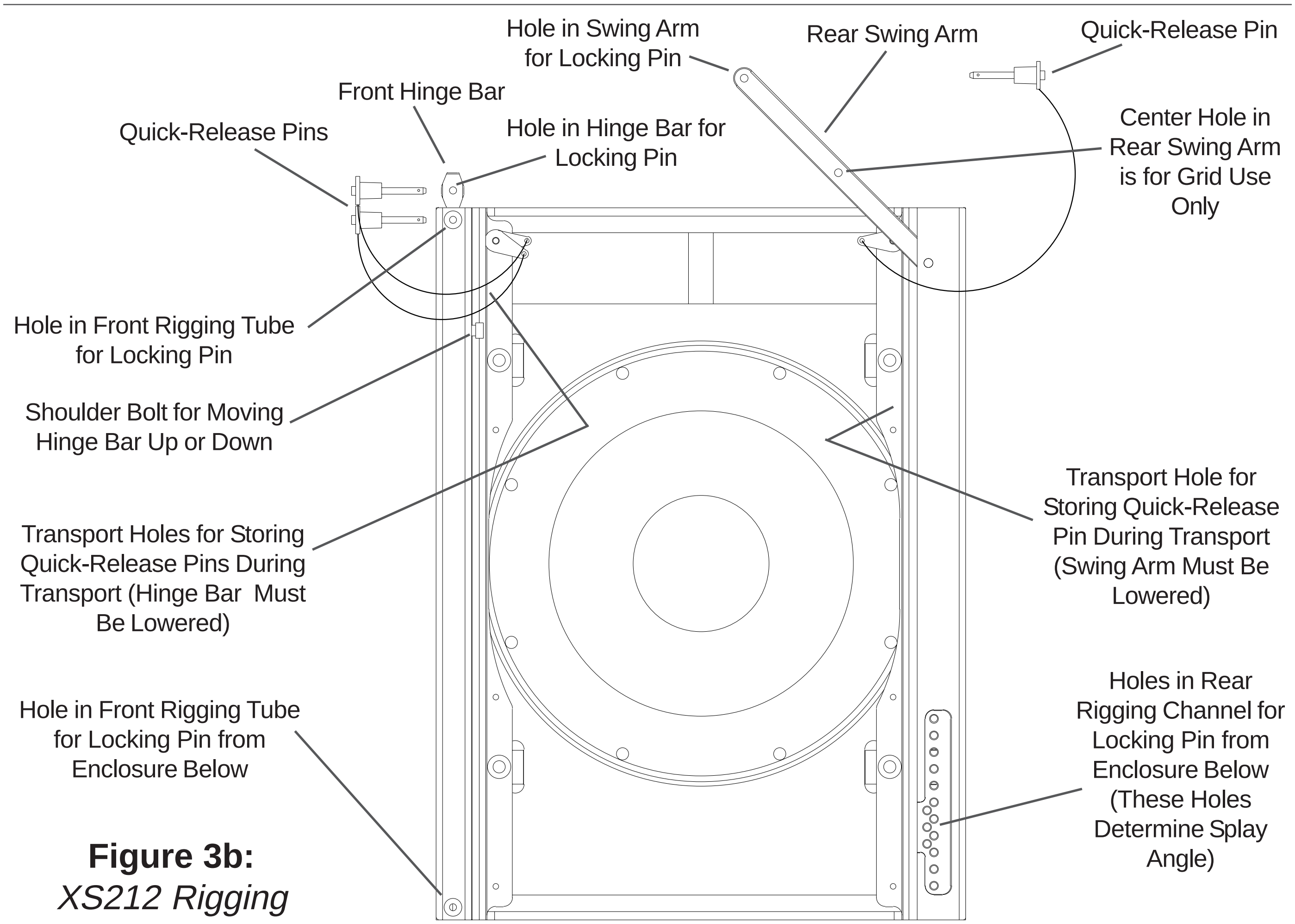


Figure 3b:
XS212 Rigging Hardware

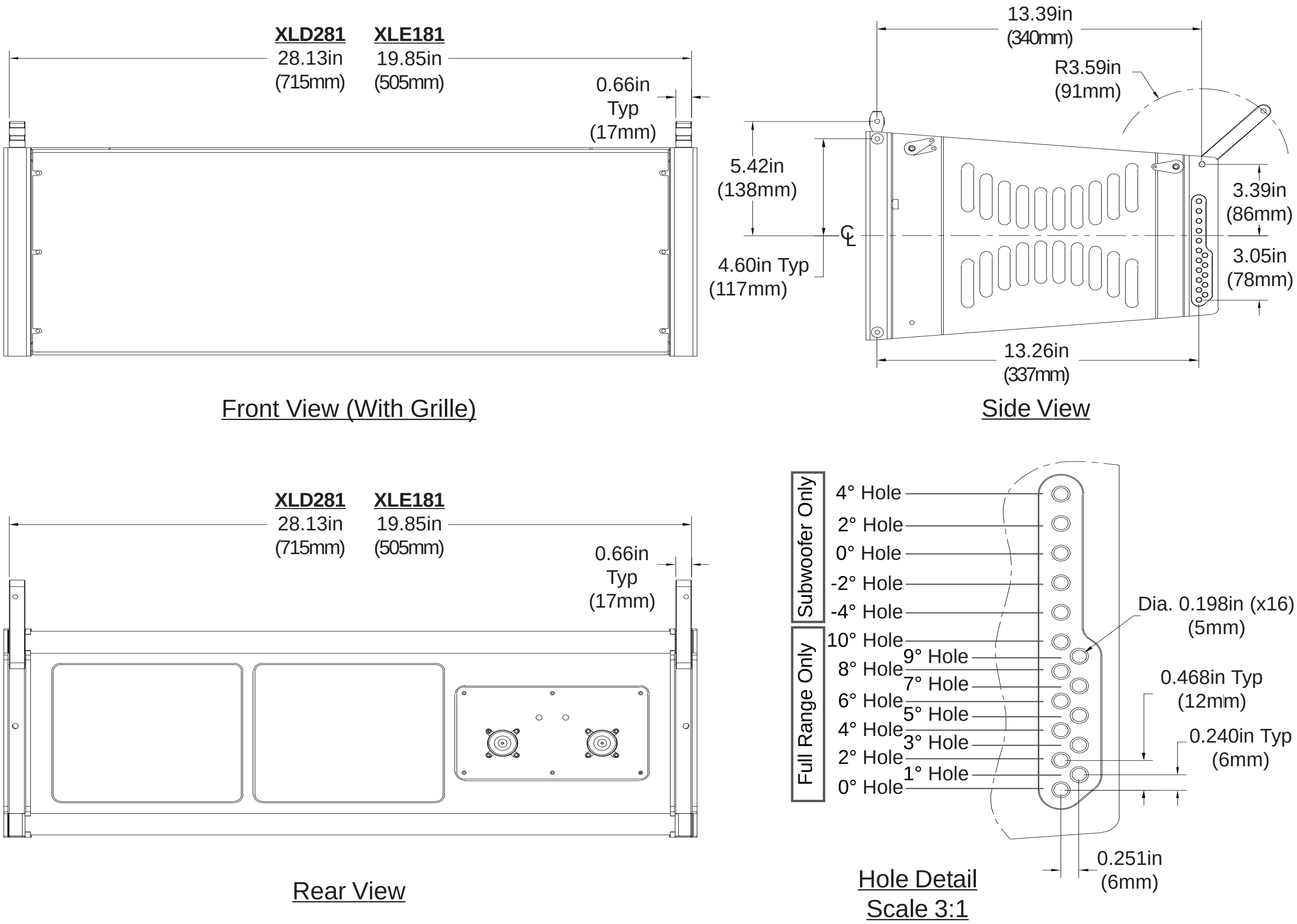


Figure 4a:

XLD281 and XLE181 Rigging Dimensions

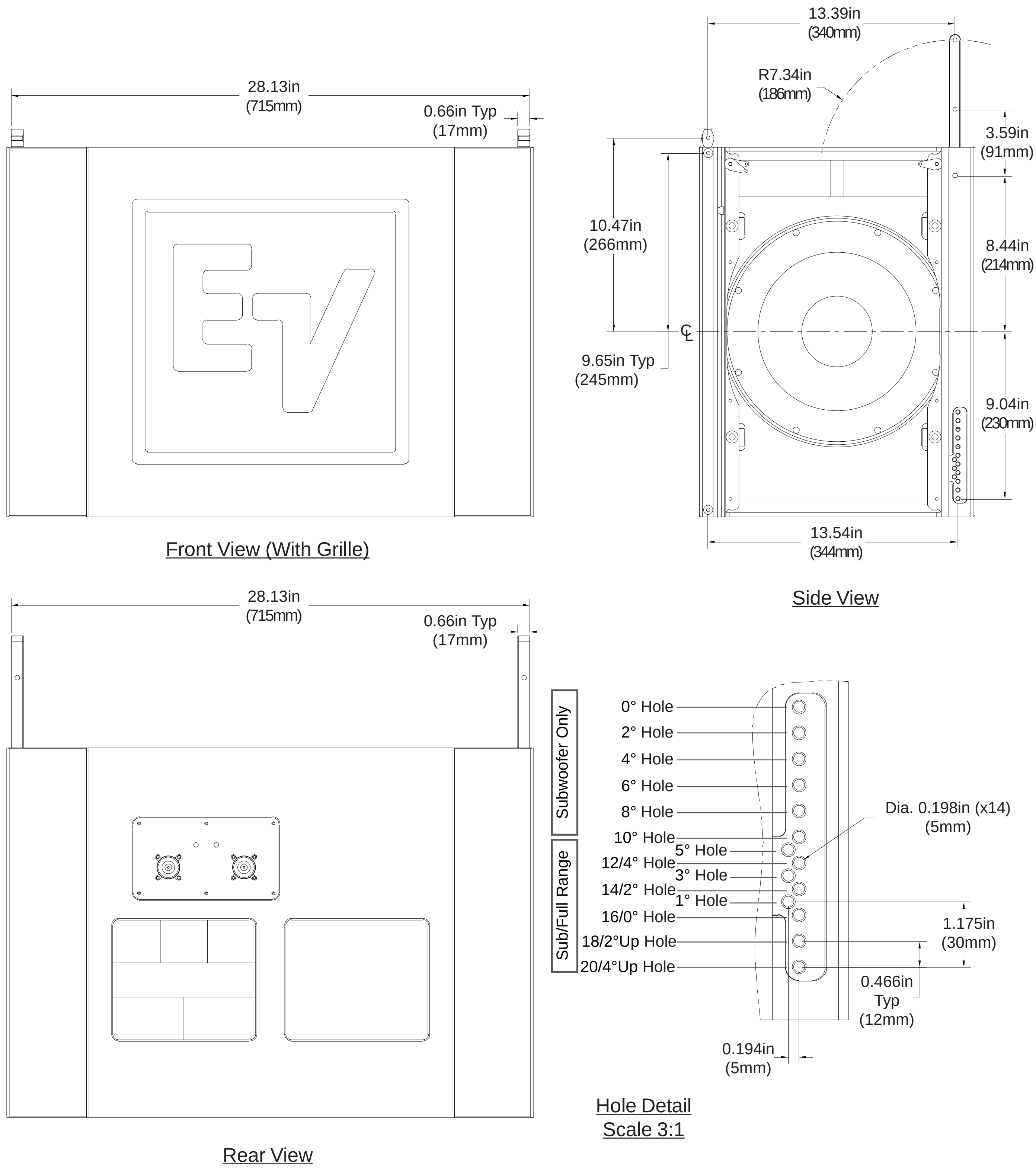


Figure 4b:
XS212 Rigging Dimensions

2. XLVC Rigging and Flying Techniques

2.1 Array Considerations

The XLVC loudspeaker systems have been specifically designed to construct acoustically coherant line-arrays. Line-array systems typically consist of independent columns of loudspeaker enclosures. The most common implementation would be a stereo sound reinforcement system with two columns (left and right). Additional columns of loudspeakers are sometimes added to cover different seating sections of a venue – seating areas that wrap around the side or back of a stage, for example, or for applications with the requirement of a center channel for speech.

The XLVC line arrays will consist of columns of XLD281 or XLE181 120°H x 10°V full-range systems. The exact number of XLVC loudspeaker systems in a column will vary depending on the vertical acoustic coverage required for the specific venue. Furthermore, the relative vertical angles between the boxes will also depend on the venue's acoustic coverage requirements. (Acoustic design techniques are outside the scope of this document and the reader is directed to the XLVC LAPS modeling software available from the Electro-Voice website for acoustic design assistance.) It is also possible to construct subwoofer line arrays using the XS212 systems, or implement subwoofers in the same column as the XLD281 full-range elements.

Although the full-range XLVC loudspeaker systems shown in Figure 1 are not completely symmetrical, their acoustical polar responses are substantially symmetrical because the high-frequency sections (in the XLD281) are in the center of the enclosures. Thus, stereo left and right arrays, or left-center-right arrays may be constructed with the loudspeakers in their normal right-side-up orientation as shown in Figure 1.

2.2 Rigging an Array Using the XLVC Dollies

Attach the top enclosure in the array to the grid, as shown in Figure 6. (Only an XLVC compatible grid can be used with an XLVC array.) The grid has front rigging tubes similar to the enclosures. Slide the front hinge bar of the top enclosure into the front tube of the grid using the same technique that was used to link two enclosures.

MAKE SURE THAT THE QUICK-RELEASE PINS ON THE HINGE BARS FULLY LOCK INTO THE ROUND HOLES IN THE FRONT RIGGING TUBES ON BOTH THE ENCLOSURE AND THE BOTTOM HOLE OF THE GRID.

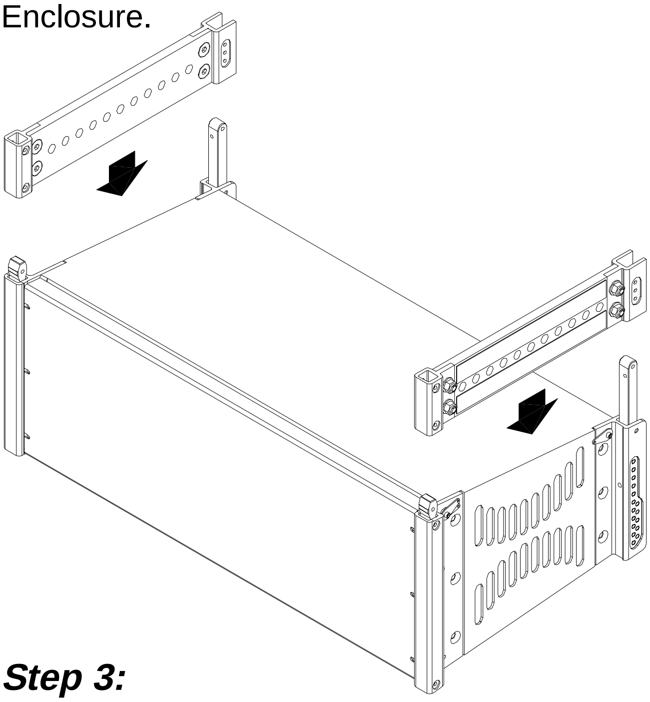
The grid also has a rear rigging channel similar to the enclosures, except that the grid only has three attachment holes available. Unlock the rear swing arm from the top enclosure by removing the quick-release pin from the rear rigging channel on the enclosure. Pivot the rear swing arm on the enclosure up into the rear rigging channel on the grid. Insert the quick-release pin from the grid through one of the three holes in the rear rigging channel on the grid (top hole is 0°, middle hole is 2° up, and bottom hole is 4° up) and through the hole in the swing arm. Repeat the process for the other side of the enclosure and grid.

MAKE SURE THAT THE QUICK-RELEASE PIN IS FULLY LOCKED IN THE REAR OF THE GRID AND THAT THE SWING ARM FROM THE ENCLOSURE IS SECURED.

ON EACH ENCLOSURE, ALWAYS MAKE SURE THAT THE LEFT AND RIGHT SWING ARMS ON THAT ENCLOSURE ARE LOCKED INTO THE SAME HOLES FOR THE SAME VERTICAL SPLAY ANGLE. THE QUICK-RELEASE LOCKING PINS ARE TETHERED TO THE REAR RIGGING FRAME WITH A LANYARD. THE QUICK-RELEASE PINS MUST ONLY BE LOCKED IN THE REAR RIGGING HOLES ON THE FRAME TO WHICH IT IS TETHERED. NEVER USE THE PINS FROM ONE ENCLOSURE TO LOCK INTO ANOTHER ENCLOSURE.

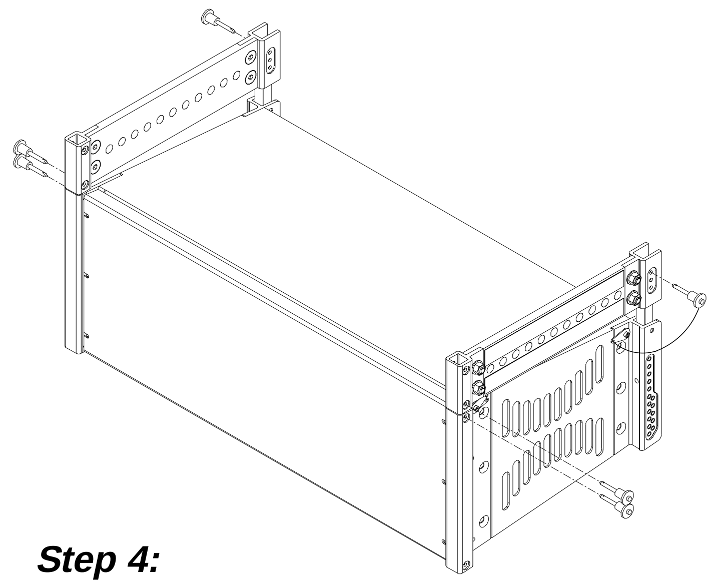
Step 1:

Assemble Sidearms to Rigging at top of the Enclosure.



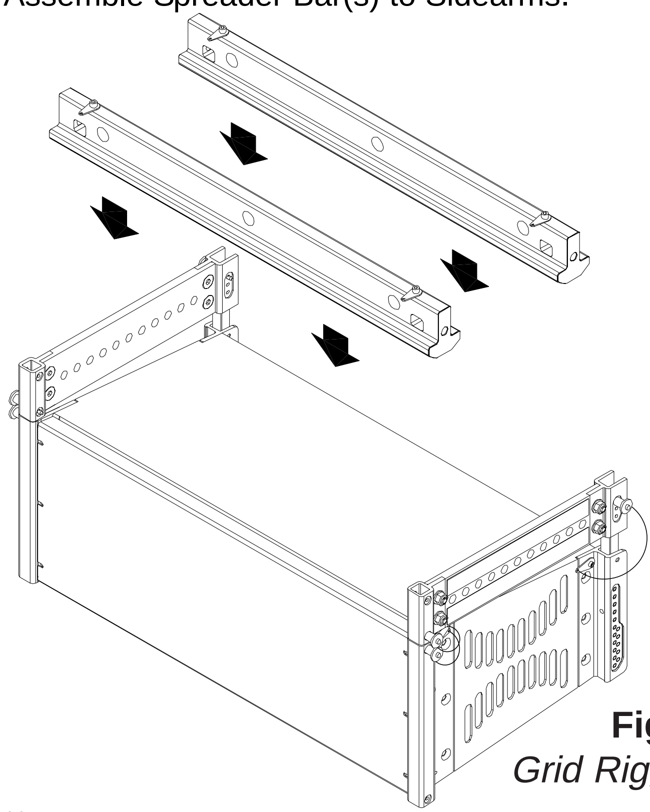
Step 2:

Insert Quick-Release Pins through Enclosure Rigging and Sidearms.



Step 3:

Assemble Spreader Bar(s) to Sidearms.



Step 4:

Insert Quick-Release Pins through Sidearms and Spreader Bar(s) using the hole locations from LAPS.

See next page for fully assembled configurations.

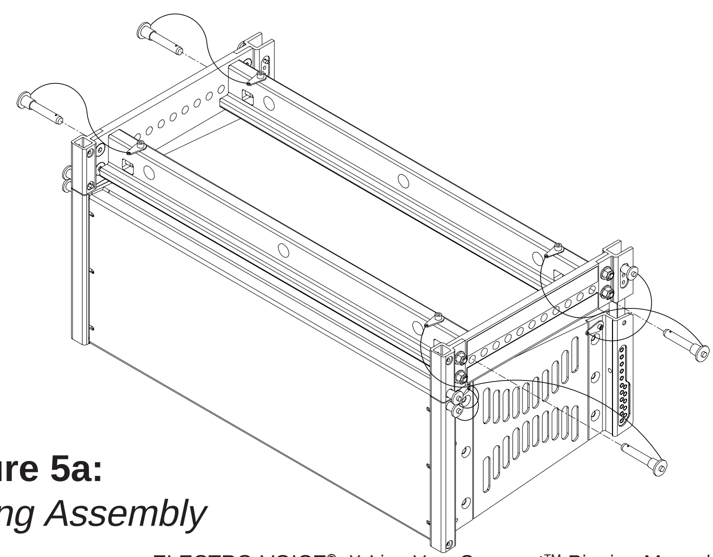


Figure 5a:

Grid Rigging Assembly

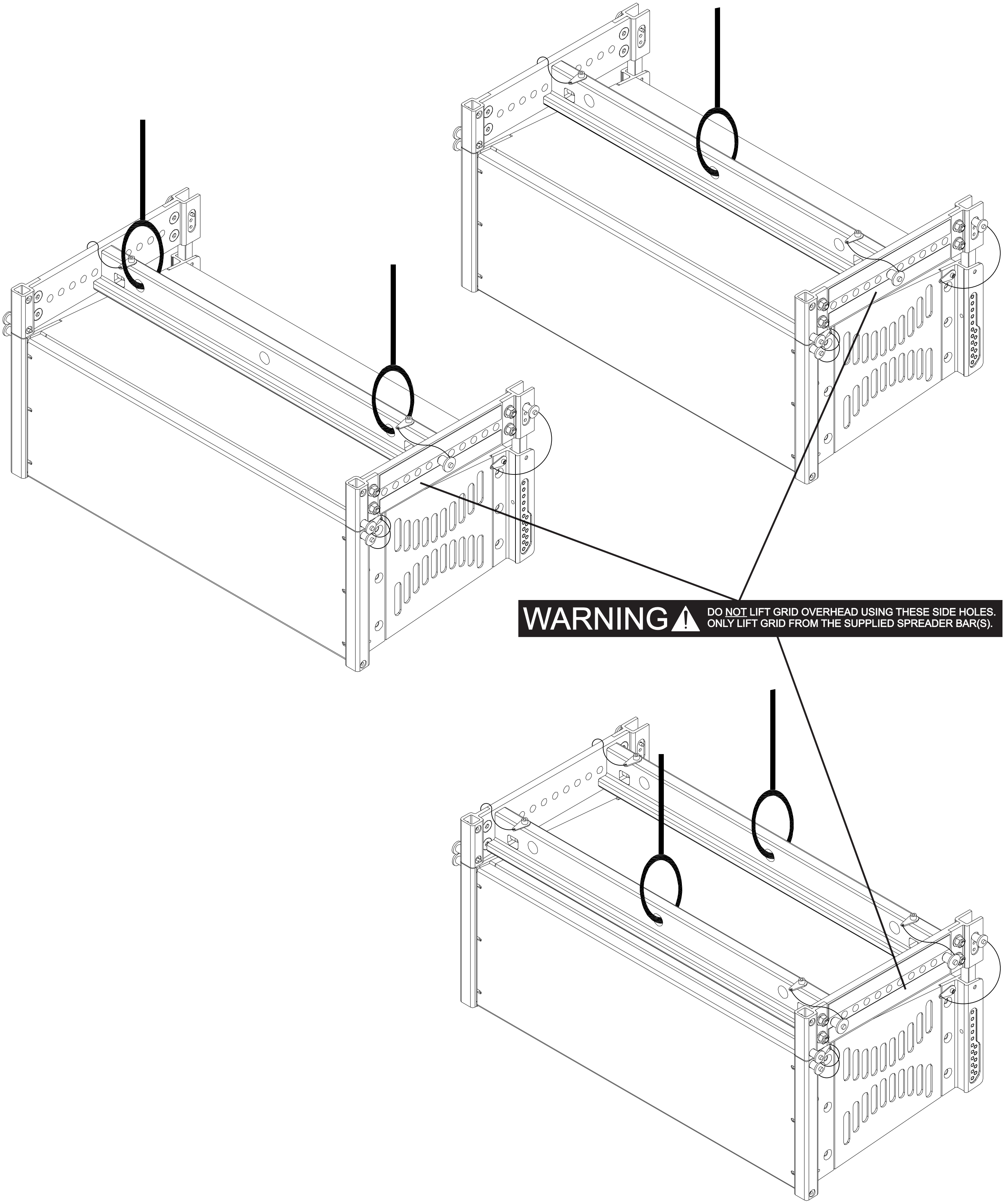


Figure 5b:
Grid Rigging Configurations

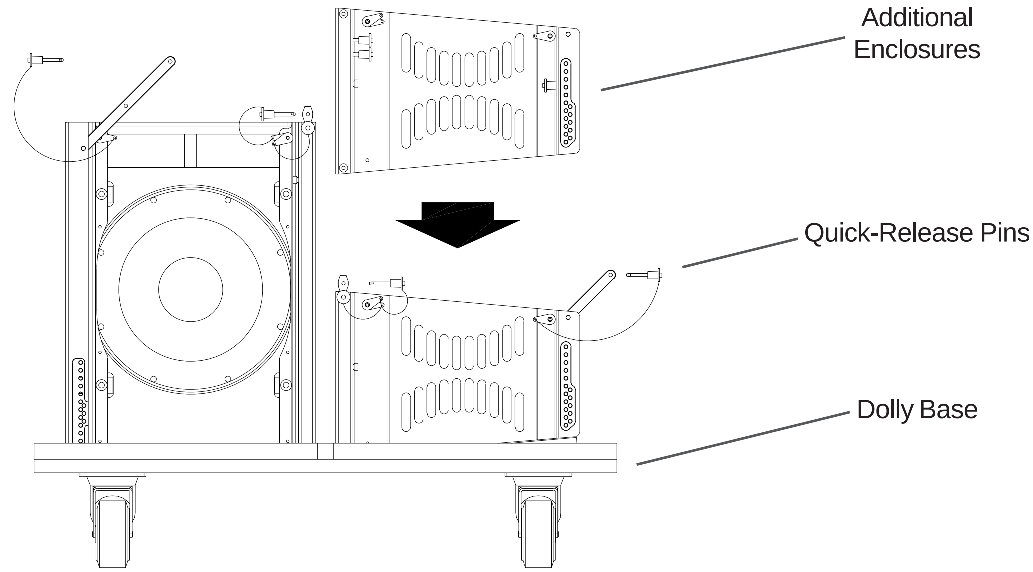


Figure 6a:

Stacking and Flying Arrays using the XLVC Dolly - Step 1

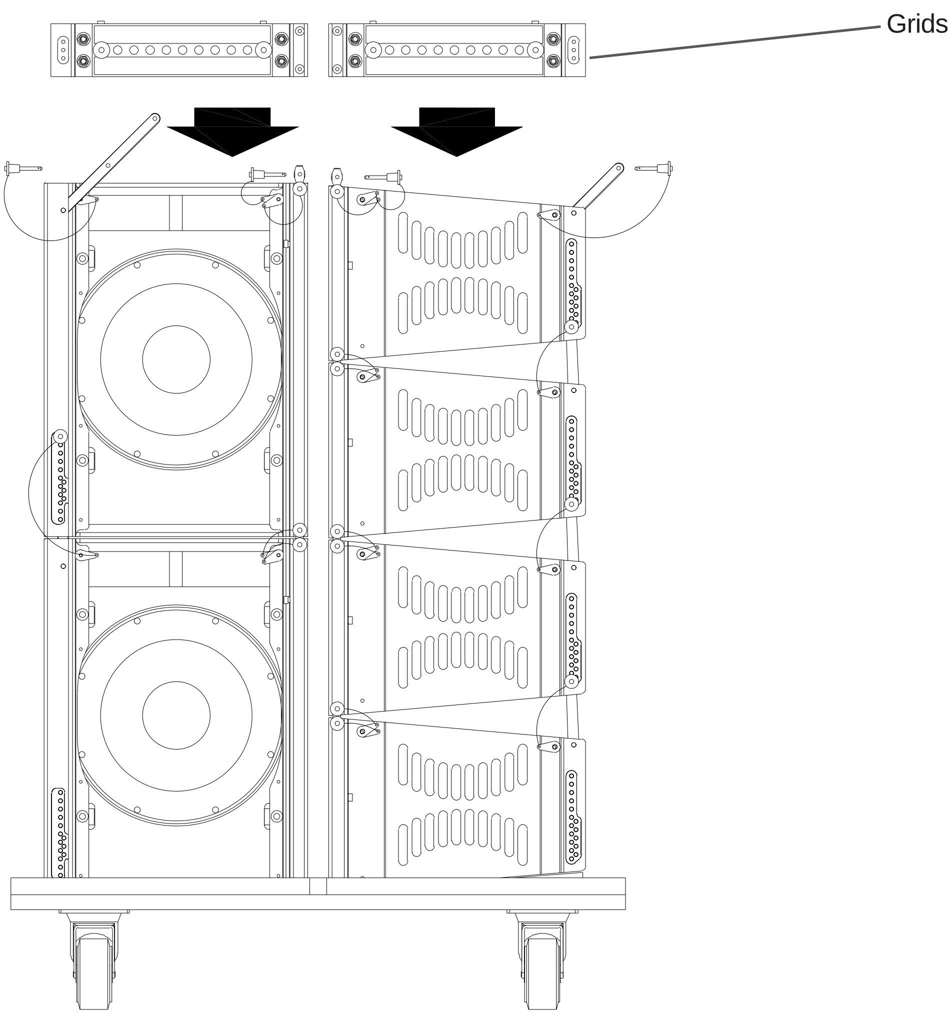


Figure 6b:

Stacking and Flying Arrays using the XLVC Dolly - Step 2

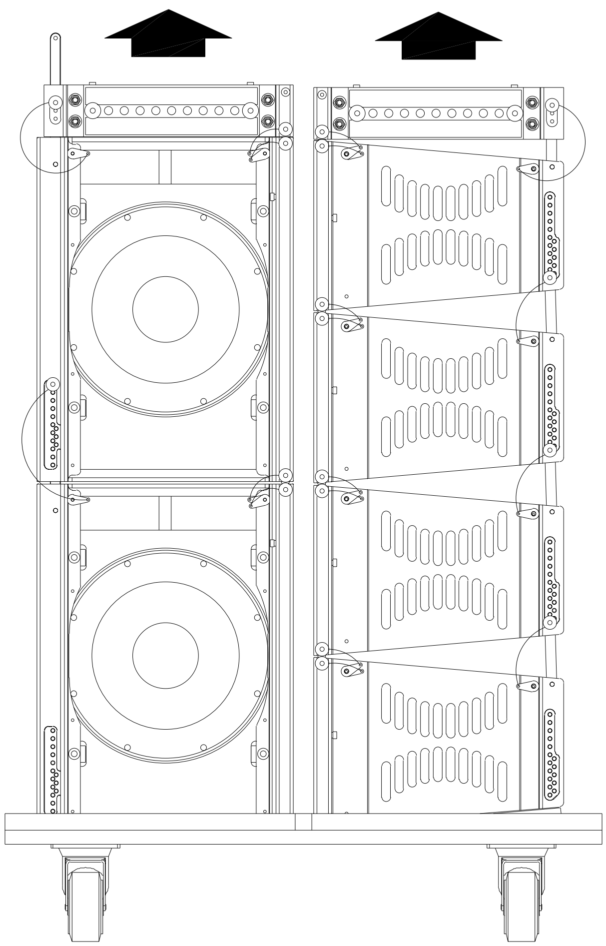


Figure 6c:
Stacking and Flying Arrays using the XLVC Dolly - Step 3

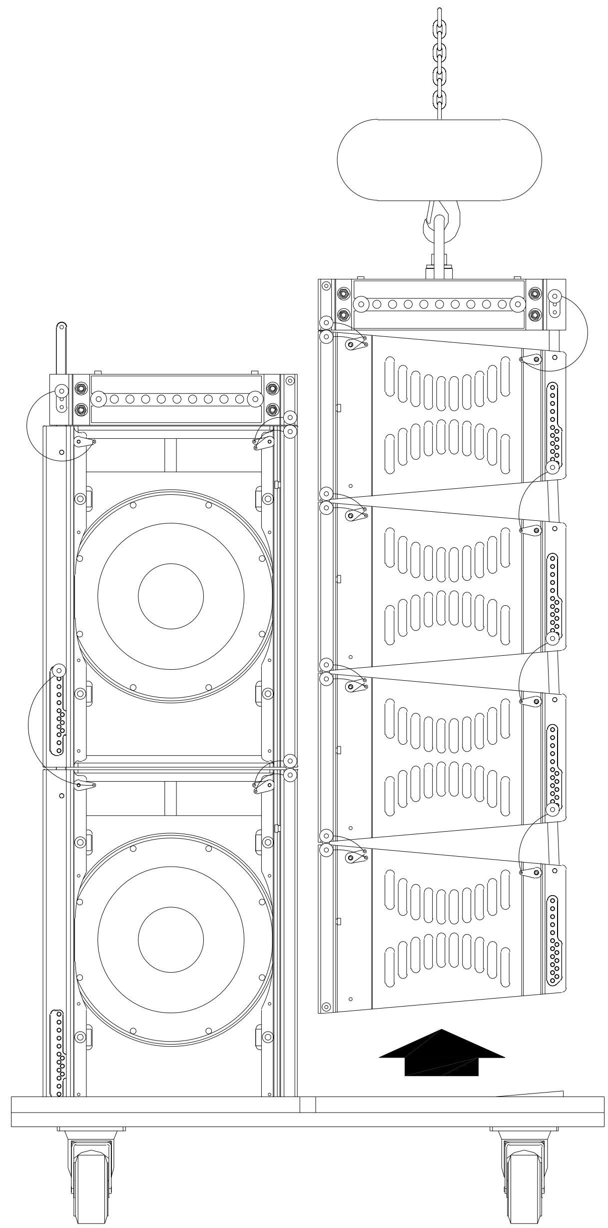


Figure 6d:
Stacking and Flying Arrays using the XLVC Dolly - Step 4

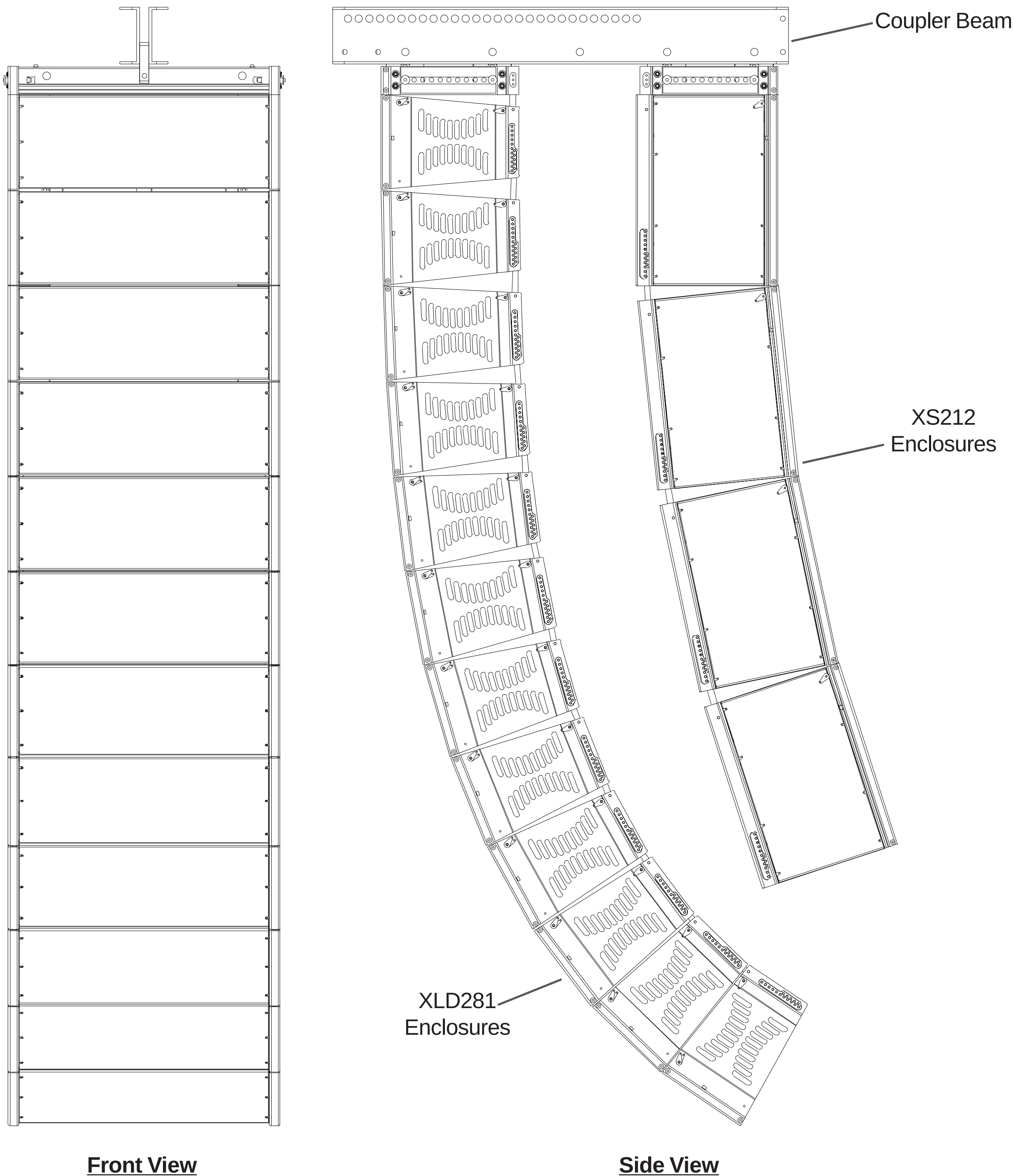


Figure 7a:

Flying an Array of XS212's behind XLD281's using the XLVC Coupler Beam (audience only sees XLD281's)

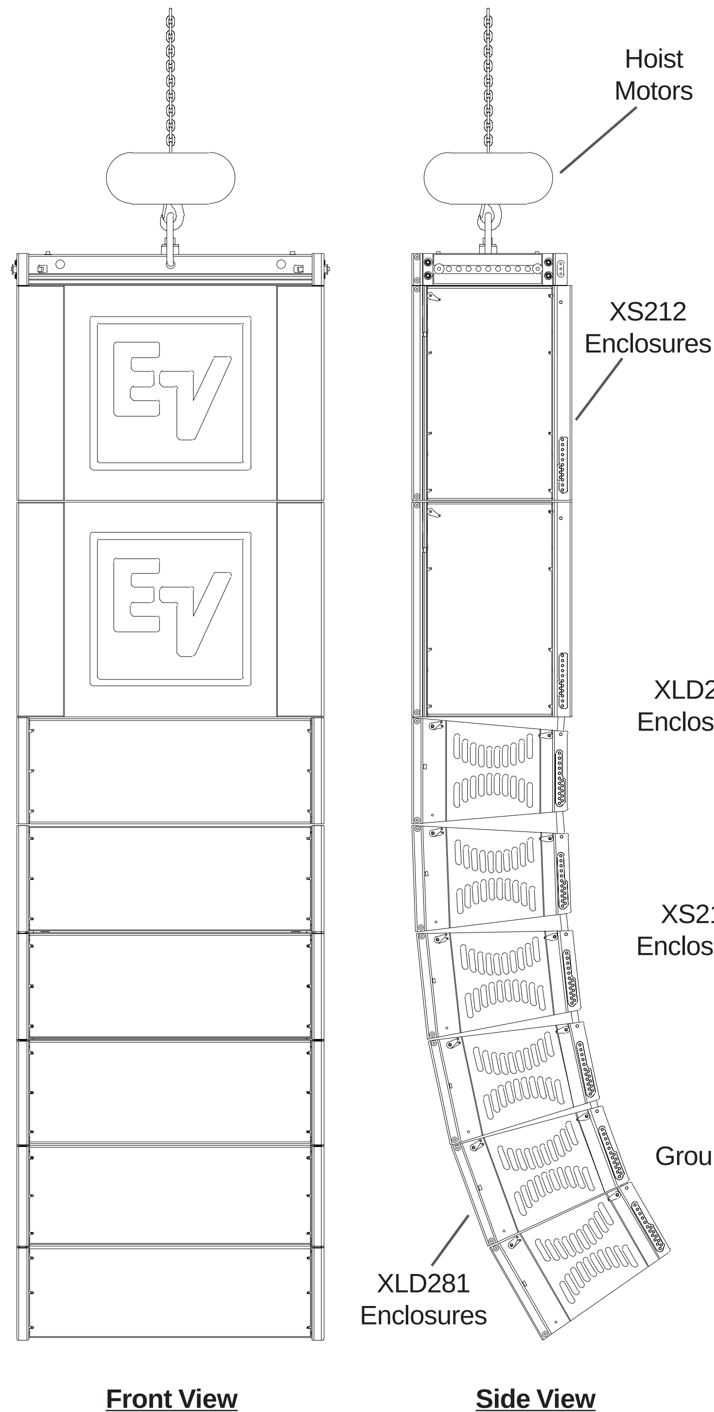


Figure 7b:
Flying an Array of XLD281's under XS212's using Interactive Rigging

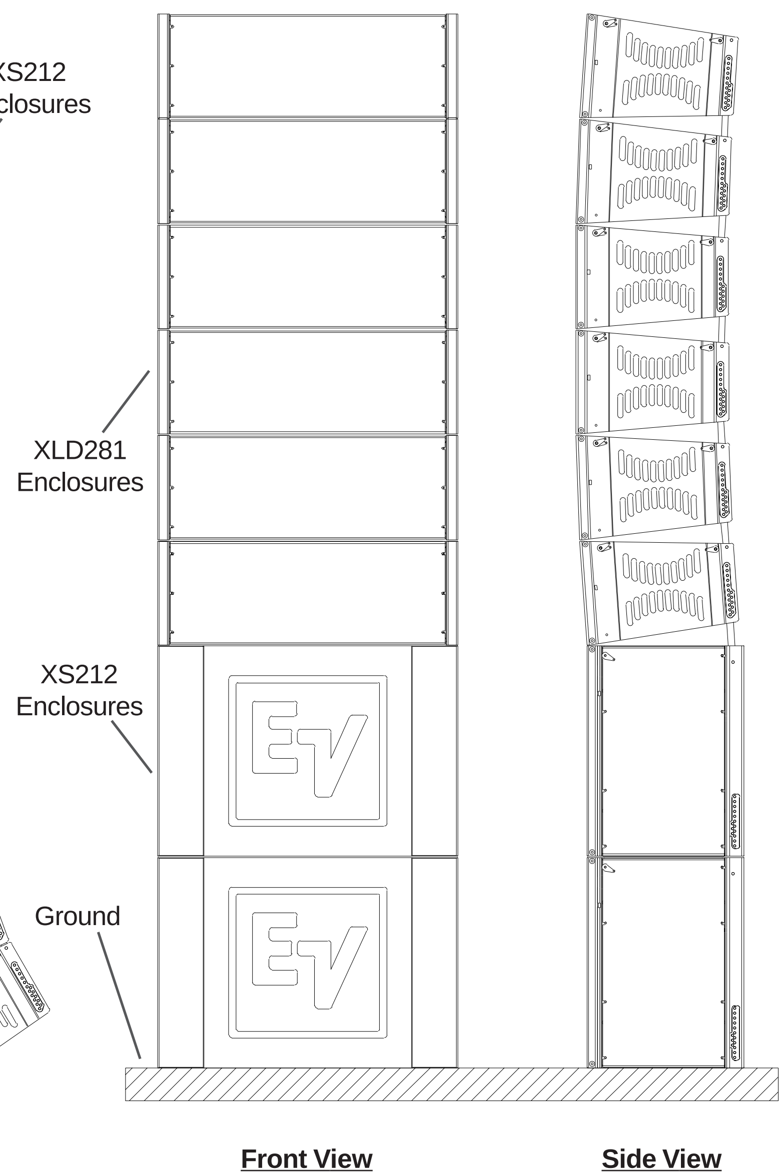


Figure 7c:
Groundstacking XLD281's over XS212's using Interactive Rigging

3. *Rigging-Strength Ratings, Safety Factors, and Special Safety Considerations*

3.1 Working-Load Limit and Safety Factor Definitions

The structural ratings for all of the XLVC rigging components and complete loudspeaker systems are based on test results in which parts were stressed to failure. Manufacturers typically present the structural-strength ratings of mechanical components or systems as either the working-load limit (WLL) or the ultimate-break strength. Electro-Voice chooses to present the structural-load ratings of the XLVC loudspeaker systems as the working-load limit. The working-load-limit rating represents the maximum load that should ever be applied to a mechanical component or system.

THE USER SHOULD NEVER APPLY A LOAD THAT EXCEEDS THE WORKING-LOAD LIMITS OF ANY OF THE RIGGING COMPONENTS OR COMPLETE LOUDSPEAKER SYSTEMS DESCRIBED IN THIS MANUAL.

The working-load limits for the XLVC rigging components and complete loudspeaker systems described in this manual are based on a minimum of an 8:1 safety factor. The safety factor is defined as the ratio of the ultimate-break strength divided by the working-load limit, where the ultimate-break strength represents the force at which a part will structurally fail. For example, if a part has working-load limit of 1,000 lb (454 kg), it would not structurally fail until a force of at least 8,000 lb (3,629 kg) was applied, based on a 8:1 safety factor. However, the user should never apply a load to that part that exceeds 1,000 lb (454 kg). The safety factor provides a margin of safety above the working-load limit to accommodate normal dynamic loading and normal wear.

CAUTIONS for Working-Load Limits and Safety Factors

The working-load limits defined by the manufacturer of any rigging component should never be exceeded. Electro-Voice bases the working-load limits of its XLVC products on a minimum of an 8:1 safety factor. Other manufacturers of rigging components may base their working-load limits on safety factors other than 8:1. For example, 5:1 safety factors are fairly common amongst rigging manufacturers because many regulatory agencies call for a minimum safety factor of 5:1.

When an XLVC loudspeaker system is installed where local regulations only require a safety factor of 5:1, Electro-Voice insists that the working-load limits of the XLVC rigging never be exceeded and that an 8:1 safety factor be maintained for the XLVC loudspeakers.

The user is cautioned that some local regulations may require safety factors higher than 8:1. In that circumstance, Electro-Voice insists that the user maintain the higher safety factor as required by the local regulations throughout the entire XLVC installation. It is the responsibility of the user to make sure that any XLVC installation meets any applicable local, state or federal safety regulations.

3.2 Structural Rating Overview

There are two independent strength ratings that, together, give a complete description of the overall structural performance capabilities of any XLVC loudspeaker system. They are defined as follows:

1. The strength of each individual rigging point; which is the combined strength of the rigging tube and channel, the rigging tube and channel components (front hinge bars, rear swing arm, quick-release pins, etc.) and the enclosure.

2. The total strength of the overall enclosure; which is a function of the combined forces from all of the rigging points acting on the rigging components and enclosure as a whole.

The array designer must be aware of the working-load-limit ratings and the loads being applied to the individual rigging points and the overall enclosure. An XLVC loudspeaker system is only as strong as its weakest link. It is usually the case that one of the working-load limits will be approached sooner that the other.

WHEN SUSPENDING ANY XLVC LOUDSPEAKER SYSTEM OVERHEAD, THE WORKING-LOAD LIMITS MUST NEVER BE EXCEEDED FOR EACH INDIVIDUAL RIGGING POINT, OR THE OVERALL ENCLOSURE.

The forces acting on each individual rigging point and on the overall enclosures in an XLVC flying system will vary with each array configuration. Determining the forces throughout an array requires complex mathematical calculations. Electro-Voice engineers have, however, defined a set of simplified structural-rating guidelines that eliminate the need for the complex calculations for most array configurations. The interaction of the complex forces throughout arrays were analyzed to develop this set of conservative guide-lines, presented below, to enable a rigger to immediately determine on site whether or not an array is safe without having to make weight-distribution calculations. The structural-strength ratings of the individual rigging points and the overall XLVC enclosures are also presented below so that a complex structural analysis can be made for any array configuration. The reader should consult an experienced structural engineer to perform the complex structural analysis.

The reader is directed to the References section of this manual for a list of rigging references (for background in general rigging practice) and mechanical engineering references (for background in structural engineering analysis).

3.3 Simplified Structural-Rating Guidelines

Electro-Voice engineers have defined a set of simplified structural-rating guidelines that will enable a rigger to immediately evaluate the safety of an XLVC system on site without having to make complex force-distribution calculations. A combination of destructive testing and computer modeling were used to analyze the complex forces throughout arrays. Conservative working-load ratings were utilized to simplify the guidelines. Therefore, array configurations other than those illustrated in these simplified guidelines may be permissible for those applications, consult section 3.4, Complex Structural-Rating Analysis for a detailed structural analysis.

The simplified structural-rating guidelines are shown in Figure 8. (Note that there is a label on the back of each flying XLVC loudspeaker enclosure that includes the graphics shown in Figure 8.)

These guidelines provide a simplified rating for typical arrays based on the:

1. Vertical angle of each enclosure
2. Total weight of that enclosure plus all of the enclosures and rigging hung below it.
3. Angles of the force components on the front hinge bars and rigging tubes relative to the enclosures.
4. Angles of the force components on the rear swing arms, quick-release pins and rigging channels relative to the enclosures.

Specifications Pending

Figure 8:
Simplified XLVC Rigging-Rating Guidelines

Figure 8 includes a graph of the working-load weight-versus-angle limit rating for the XLVC enclosures. This working-load weight limit is applicable to every enclosure in an array, and includes the weight of that enclosure plus the total weight of all enclosures, rigging hardware and cabling suspended below it. The absolute enclosure angle is the vertical angle of that enclosure, where 0° represents an upright enclosure facing straight ahead (0° elevation angle). These working-load-versus-angle limits take into account the complex forces generated in the front hinge bars, the rear swing arms, the quick-release pins, the rigging tubes and channels, the enclosures and the (optional) pull-up line, as a result of the complex weight distribution throughout the array.

Also included in the simplified structural-rating guidelines in Figure 8 are side-to-side and front-to-back angle limits for the front hinge bars and rear swing arms on the top enclosure.

WHEN APPLYING THE SIMPLIFIED STRUCTURAL RATING GUIDELINES TO ANY XLVC LOUDSPEAKER SYSTEM SUSPENDED OVERHEAD, THE USER MUST OBEY THE FOLLOWING RULES:

1. Never exceed the working-load-versus-angle limit for any enclosure in the array.
2. Never exceed the side-to-side angle limits for the front hinge bar assemblies on any enclosure.
3. Never exceed the side-to-side angle limits for the rear swing arm assemblies on any enclosure.
4. Always make sure that every front hinge bar is securely locked in the front rigging tube on every enclosure (and grid, when applicable) before lifting overhead.
5. Always make sure that every rear swing arm is securely locked in the rear rigging channel with the quick-release pins on every enclosure (and grid, when applicable) before lifting overhead.
6. If a pull-up grid is used, never exceed the side-to-side angle limits for the pull-up grid.

Discussion of Array Examples: For example, if the top enclosure in a column was angled down 30°, the enclosure working-load-versus-angle limit from the simplified structural-rating guidelines shown in Figure 8 would indicate that a total of **800 pounds (363 kg)** could be safely suspended. This would include the weight of the top enclosure plus all of the enclosures and rigging suspended below.

If, however, the top enclosure in a column was angled up 30°, the total allowable weight would then only be **764 lb (347 kg)** - including the weight of the top enclosure plus all of the enclosures and rigging suspended below. The enclosure working-load-versus-angle limit shown in Figure 8 not only applies to the top enclosure in an array column, but also applies to every enclosure in an array column. In arrays where a pull-up grid is not used, the top enclosure is always the limiting factor because it supports the most weight. However, in arrays where a pull-up grid is used to achieve substantial downward angles, it is possible that a lower enclosure could be the limiting factor.

3.4 Complex Structural-Rating Analysis

For a complete structural-rating analysis, the forces in each individual piece of attachment hardware throughout the XLVC system must be determined, as well as the forces on each enclosure. Determining these forces requires complex mathematical calculations. All of these forces must then be compared to the working-load limits detailed below for each of the rigging points and the overall enclosures.

The reader should consult an experienced structural engineer to perform the complex structural analysis.

WHEN SUSPENDING ANY XLVC LOUDSPEAKER SYSTEM OVERHEAD, THE WORKING-LOAD LIMITS MUST NEVER BE EXCEEDED FOR EACH INDIVIDUAL RIGGING POINT, AND THE OVERALL ENCLOSURE.

XLD281, XLE181 and XS212 Front Rigging Structural-Strength Ratings

The working-load limit of each of the front rigging points on the XLVC enclosures is dependent upon the hinge bar assembly, the rigging tube and channel assemblies, the enclosure and the angle of pull. The structural-strength ratings for the front rigging points are identical for the XLD281, XLE181, and XS212, and are shown in Figure 9. The enclosures have two rigging points at the front. The structural ratings shown in Figure 9 are for a single rigging attachment point. Each rigging point has the same rating.

The front-to-back structural-strength ratings for the front rigging points shown in Figure 9 cover a full 360° rotation. Although it is not possible to put the front button bars into tension over 360°, it is possible for the hinge bars to go into compression with some array configurations. Therefore, the 360° rating is necessary to accommodate both tension and compression. It also should be noted that the XLVC front rigging is only rated for use over side-to-side pull angles of a maximum of ±10°.

XLD281, XLE181 and XS212 Rear Rigging Structural-Strength Ratings

The working-load limit of each of the rear rigging points on the XLVC enclosures is dependent upon the swing arm assembly, the rigging frame assembly, the quick-release pins, the enclosure and the angle of pull. The structural-strength ratings for the rear rigging points are identical for the XLD281, XLE181, and XS212, and are shown in Figure 10. The enclosures have two rigging points at the rear. The structural ratings shown in Figure 10 are for a single rigging attachment point. Each rigging point has the same rating.

It should be noted that the front-to-back-angle range shown in Figure 10 for the XLD281 and XLE181 consists of two 10° arc segments, while the front-to-back-angle range shown in Figure 10 for the XS212 consists of two 20° arc segments. When both the front and rear rigging are installed, the front hinge bar always prevents the rear swing arm from having any kind of front-to-back force. Thus, it will always be axially loaded. For the XLD281 and XLE181, a tensile force can only be applied over an angle range of negative 0°-10°, while the XS212 can only be over a range of negative 0°-20°. The angles are negative because the boxes can only be angled downward. (Imagine two boxes facing straight ahead. The bottom enclosure can only be tilted downward because the rear rigging can only be adjusted to bring the rear corners of the enclosures together). It also should be noted that the XLVC rear rigging is only rated for use over side-to-side pull angles of a maximum of ±5°.

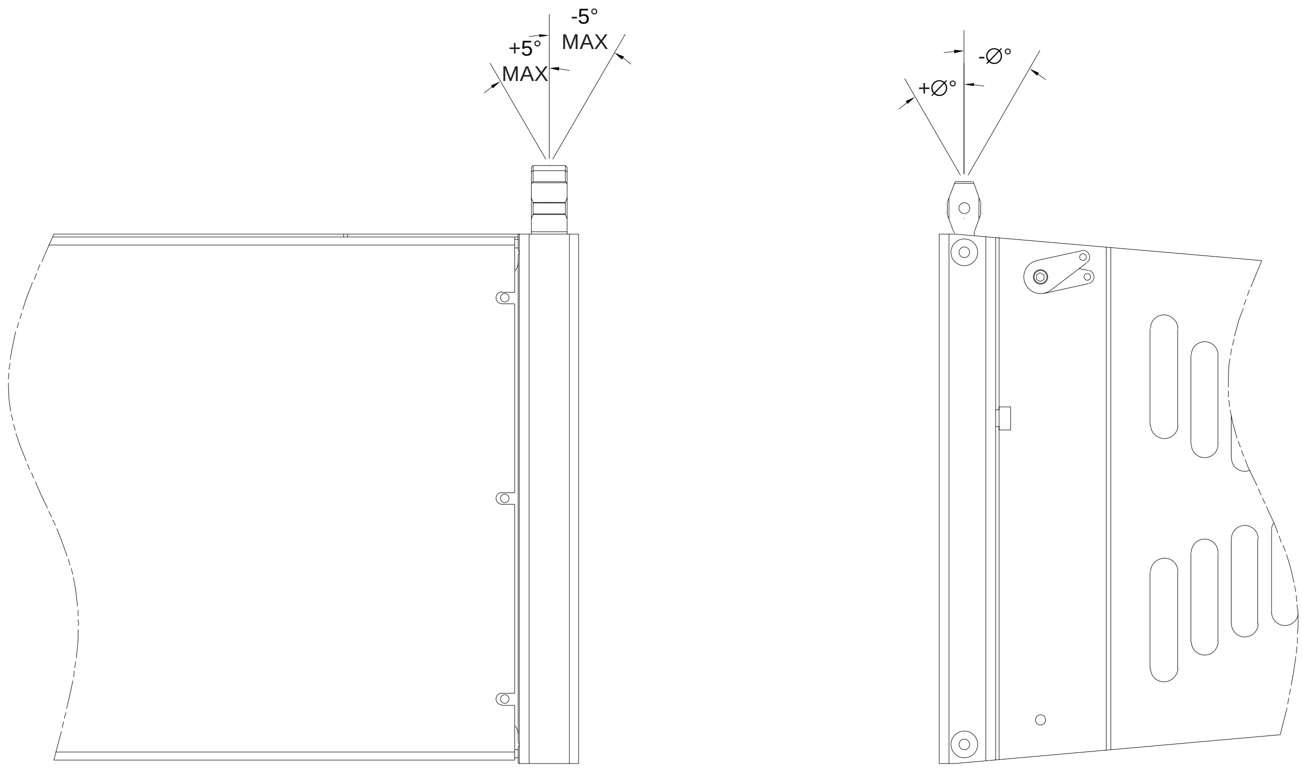
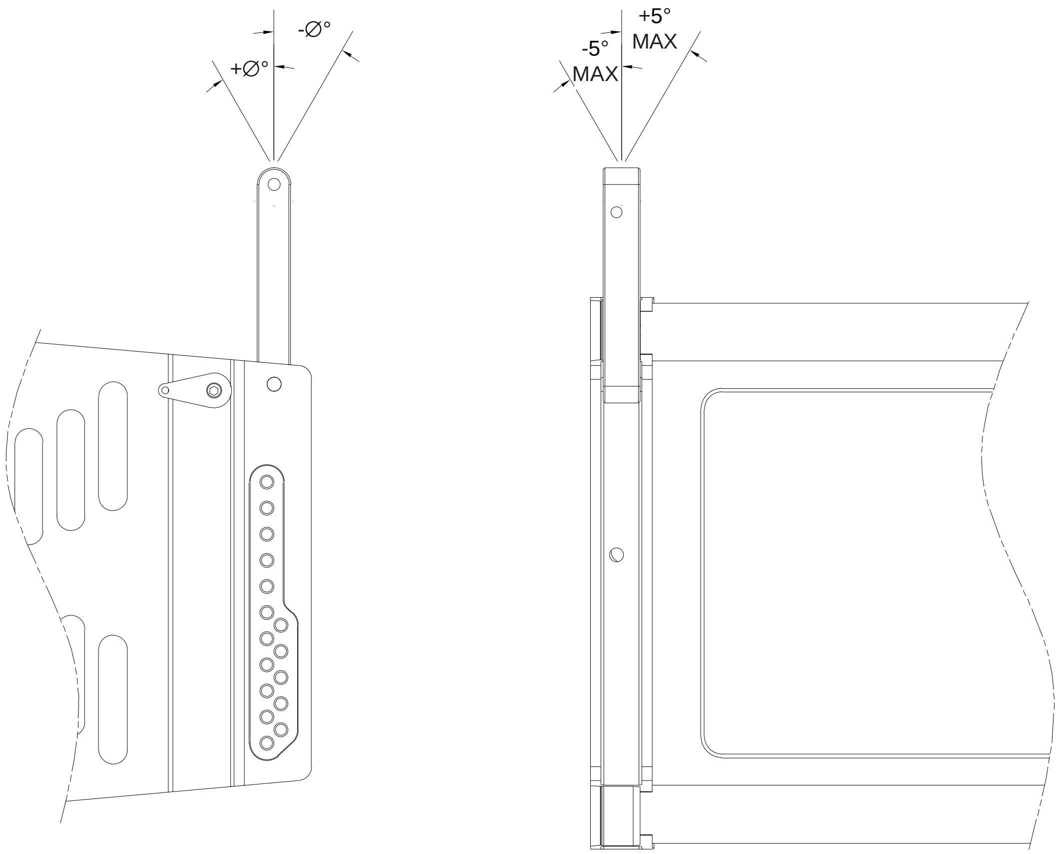
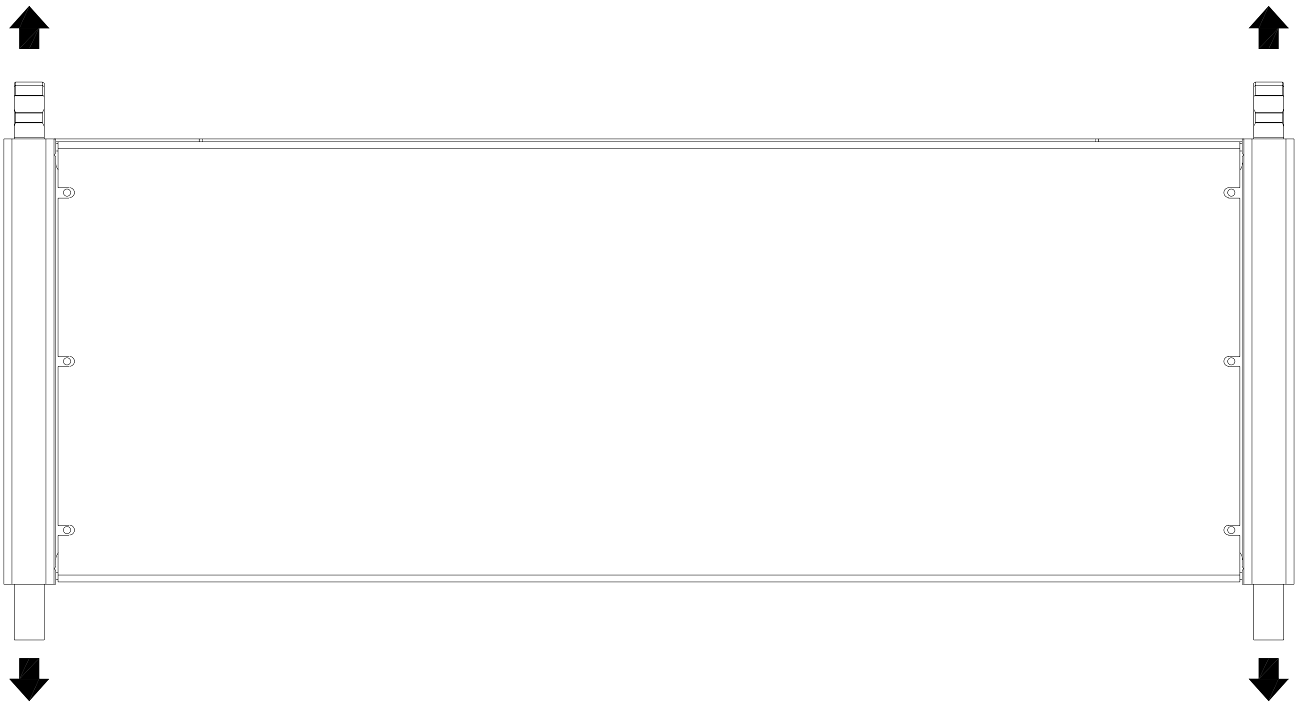


Figure 9:
XLD281, XLE181, and XS212 Front-Rigging-Point
Structural Ratings



Working-Load Limit
850 lb (386 kg)
From 0° to -10° (XLD281, XLE181 - Swing Arm in Tension)
From 0° to -20° (XS212 - Swing Arm in Tension)
From +170° to +180° (XLD281, XLE181 - Swing Arm in Compression)
From +160° to +180° (XS212 - Swing Arm in Compression)
These are the Only Possible Angle Ranges

Figure 10:
XLD281, XLE181, and XS212 Rear-Rigging-Point Structural Ratings



Total Column Weight
Working-Load Limit
850 lb (386 kg)

Figure 11:
XLD281, XLE181 and XS212 Overall Enclosure Structural Ratings

XLD281, XLE181, and XS212 Overall Enclosure Structural-Strength Ratings

The actual strength of the XLVC enclosures will depend on the complex total of the combined forces from each of the rigging points acting on the enclosure as a whole and will vary with the array configuration. However, for the sake of simplicity, Electro-Voice chooses to define the working-load limit of the overall enclosures as the sum total of the weight of that enclosure plus the weight of all of the enclosures and rigging hardware suspended below. This simplified working-load weight rating of the overall enclosures is defined as being independent of the angles of pull on the individual rigging points. The Electro-Voice engineers have chosen to define the working-load limits of the individual rigging points as a function of pull angle so that they take into account any variations in enclosure strength that might occur as a function of pull angle. This approach allows the enclosure working-load limit to be defined as independent of pull angles, making the complex structural rating analysis easier. The overall enclosure strength ratings are identical for the XLD281, XLE181, and XS212, and are shown in Figure 11.

CAUTIONS for a Complex Structural Rating Analysis

WHEN APPLYING A COMPLEX STRUCTURAL RATING ANALYSIS TO ANY XLVC LOUDSPEAKER SYSTEM SUSPENDED OVERHEAD, THE USER MUST OBEY THE FOLLOWING RULES:

1. Never exceed the front-to-back angle limits for the front hinge-bar assemblies on any enclosure. Never exceed the side-to-side angle limits for the front hinge-bar assemblies on any enclosure.
2. Never exceed the front-to-back angle limits for the rear swing-arm assemblies on any enclosure. Never exceed the side-to-side angle limits for the front swing-arm assemblies on any enclosure.
3. Always make sure that every front button bar is securely locked in the front rigging tube on every enclosure (and grid, when applicable) before lifting overhead.
4. Always make sure that every rear swing arm is securely locked in the rear rigging channel with the quick-release pins on every enclosure (and grid, when applicable) before lifting overhead.

3.5 Wind Loading

The XLVC loudspeaker systems have been designed to withstand winds of up to **60 miles per hour (96.6 kilometers per hour)** if the bottom cabinet is rigidly secured. For obvious safety reasons, Electro-Voice urges the user not to suspend any loudspeaker systems overhead outdoors when high winds are expected. When suspending XLVC loudspeaker systems outdoors, the user is strongly encouraged to rigidly tie off the bottom cabinets in all arrays as a safety precaution against unexpected high winds.

A pull-up grid with an attached strap may be used to secure the bottom cabinets. The tie-off assembly must have a working-load rating of **2,000 lb (907 kg)**. A ratchet strap with a **2,000-lb** working-load rating must be used for the pull-up assembly.

3.6 Electro-Voice Structural-Analysis Procedures

Electro-Voice maintains a structural pull-test facility in Burnsville, Minnesota USA which includes load cells with digital-electronic display and recording. The load cells are calibrated annually by an independent laboratory to a standard traceable to the United States National Bureau of Standards. This pull-test facility is capable of pulling to destruction both individual rigging components and complete loudspeaker systems.

Electro-Voice utilizes state-of-the-art computer-modeling programs for structural analysis throughout the development of loudspeaker systems. The computer modeling enables the complex forces in the rigging components and enclosures to be analyzed for loudspeakers assembled into arrays in both static and dynamic conditions.

Structural testing and computer modeling were used throughout the engineering development of all the XLVC individual rigging components and complete loudspeaker systems described in this manual. Testing and modeling involving both anticipated use and anticipated misuse were performed as part of the analysis. Engineering prototypes were stressed to failure and designs were revised based on those test results. Production systems and components were stressed to failure for verification of the final designs.

4. Rigging Inspection and Precautions

Electro-Voice XLVC Loudspeaker Systems:
Prior to each use, inspect the loudspeaker enclosures for any cracks, deformations, missing or damaged components that could reduce enclosure strength. Inspect the rigging tube and channel assemblies on the enclosures for any cracks, deformations, corrosion, missing or loose screws which could reduce the flying hardware strength. Replace any loudspeaker systems that are damaged or missing hardware. Never exceed the limitations or maximum recommended load for the XLVC systems.

Electro-Voice XLVC Front Rigging Hinge Bar Assemblies: Prior to each use, inspect the front rigging hinge bars and the front rigging tubes for any cracks, burrs, deformations, corrosion or missing or damaged components that could reduce hinge bar assembly strength. Always check to make sure that the hinge bar can move freely in the front rigging tube. Replace any hinge bars that are damaged or missing hardware. Always double check that each quick-release pin on each hinge bar is securely locked into position in the front rigging tubes on the XLVC enclosures and grids before lifting. Never exceed the limitations or maximum recommended load for the XLVC rigging hardware.

Electro-Voice XLVC Rear Swing Arm Assemblies: Prior to each use, inspect the rear rigging swing arms, the rear rigging channels and rear rigging holes for any cracks, burrs, deformations, corrosion or missing or damaged components that could reduce swing arm assembly strength. Always check to make sure that the swing arm bar can move freely in the rear rigging slots and that the quick-release locking pins can be easily inserted in the swing arm holes and rigging holes to lock the arm. Replace any swing arms that are damaged or missing hardware. Always double check that each swing arm is securely locked in the rear rigging holes with a quick-release pin. Never exceed the limitations or maximum recommended load for the XLVC rigging hardware.

Electro-Voice Quick-Release Pins: Prior to each use, inspect the quick-release pins on the rigging frame assemblies any for cracks, burrs, deformations, corrosion or missing or damaged components that could reduce the pin strength. Replace any quick-release pins that are damaged. Always double check that each quick-release pin is securely locked to the front hinge bar and rear swing arm assemblies on the XLVC enclosures before lifting. Never exceed the limitations or maximum recommended load for the XLVC rigging hardware.

Grid Assemblies: Prior to each use, inspect each grid assembly any for cracks, burrs, deformations, corrosion or missing or damaged components that could reduce the grid assembly strength. Replace any grids that are damaged or missing hardware. Always double check that each grid is securely locked to the front hinge bar assemblies and the rear swing arm assemblies on the XLVC enclosures before lifting. Always double check that each quick-release pin attaching the sidearms to the spreader bar(s) are securely locked into place. Never exceed the limitations or maximum recommended load for the grids.

Coupler Beam (CBeam) Assemblies: Prior to each use, inspect the CBeam assemblies for any cracks, burrs, deformations, corrosion or missing or damaged components that could reduce the CBeam assembly strength. Replace any CBeam assemblies that are damaged or missing hardware. Always double check that each CBeam assembly is securely locked to the spreader bar(s) on the grids below. Never exceed the limitations or maximum recommended load for the CBeam assemblies.

Chain Hoists: Prior to each use, inspect the chain hoist and associated hardware (including motor, if applicable) for any cracks, deformation. Broken welds, corrosion, missing or damaged components that could reduce the hoist strength. Replace any damaged chain hoists. Never exceed the limitations or maximum recommended load specified by the hoist manufacturer. Always follow manufacturers' recommendations for operation, inspection, and certification. Always raise and lower the load slowly and evenly, avoiding any rapid changes in speed or shifting loads that could result in a sudden jolt to the suspended system.

Building, Tower or Scaffold Supports: Prior to each use, the strength and load-bearing capabilities of the building, tower or scaffold structural supports should be evaluated and certified by a professional engineer as being adequate for supporting the intended rigging system (including the loudspeakers, grids, chain hoists and all associated hardware). Prior to each use, inspect the building, tower or scaffold structural supports for any cracks, deformation, broken welds, corrosion, missing or damaged components that could reduce the structural strength. Damaged structural supports should be replaced or repaired and recertified by a professional engineer. Never exceed the limitations or maximum recommended load for the supports.

Miscellaneous Mechanical Components: Prior to each use, inspect all mechanical components (chain, wire ropes, slings, shackles, hooks, fittings, ratchet straps, etc.) for any cracks, deformation, broken welds, slipping crimps, fraying, abrasion, knots, corrosion, chemical damage, loose screws, missing or damaged components that could reduce the maximum strength specified by the component manufacturer. Replace any damaged mechanical components. Never exceed the limitations or maximum recommended load for the mechanical components.

References

Rigging References

[1] W.E. Rossnagel, L.R. Higgins & J.A. MacDonald, Handbook of Rigging for Construction and Industrial Operations, McGraw-Hill Book Company, New York, NY, USA (1988).

[2] J.O. Glerum, Stage Rigging Handbook, Southern Illinois University Press, Carbondale, IL, USA (1987).

[3] P. Carter, Backstage Handbook, Broadway Press, New York, NY, USA (1988).

[4] ATM Fly-Ware™, Riggermeister Production Rigging Guide, ATM Fly-Ware™, Carson, CA, USA (1995).

[5] Wire Rope Technical Board, Wire Rope Users Manual, American Iron and Steel Institute, Stevensville, MD, USA (1985).

[6] Broderick & Bascom Rope Company, Rigger's Handbook, Sedalia, MO, USA (1993).

[7] MacWhite Wire Rope Company, Catalog of Tables, Data and Helpful Information, Kenosha, WI, USA (1991).

[8] Acco Chain & Lifting Division, Chain Sling User's Manual, Acco Corporation, York, PA, USA (1992).

[9] Newberry, W.G., Handbook for Riggers, Newberry Investments Company, Calgary, Alberta, Canada (1989).

Mechanical Engineering References

[10] J.L. Meriam & L.G. Kraige, Engineering Mechanics, Volume One - Statics, John Wiley & Sons, Inc., New York, NY, USA (1992).

[11] J.L. Meriam & L.G. Kraige, Engineering Mechanics, Volume Two - Dynamics, John Wiley & Sons, Inc., New York, NY, USA (1992).

[12] J.E. Shigley & C.R. Mischke, Mechanical Engineering Design, McGraw-Hill Book Company, New York, NY, USA (1989).

[13] A. Jensen & H.H. Chenoweth, Applied Engineering Mechanics, McGraw-Hill Book Com-pany, New York, NY, USA (1983).

Websites

[14] http://www.cmworks.com/

[15] http://catalog.thecrosbygroup.com/maininterface.htm

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Printed in U.S.A

Part Number 38110-429 Rev 1