



**Electro-Voice<sup>®</sup>**  
**THE X-ARRAY<sup>™</sup> INSTALL SYSTEM**

**X-Array Install<sup>™</sup> - Xi**  
**LOUDSPEAKER**  
**SYSTEM**

**FLYING MANUAL**

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## WARNING

This manual details general rigging practices appropriate to the sound industry, as they would apply to the rigging of Electro-Voice X-Array Install™ Xi loudspeaker systems. It is intended to familiarize the reader with standard rigging hardware and techniques for suspending those 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 Xi 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 Xi loudspeaker-array designs and rigging configurations as implemented in practice.

All of 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 Furthermore the regulations and requirements governing rigging hardware and practices may be superseded by local regulations.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 Xi loudspeaker systems is based on the best available engineering information concerning the use and limitations of the products. Electro-Voice continually engages in testing and 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 applications manual and any manual update notices. All associated non-Electro-Voice rigging hardware used for suspending any X-Array Install™ Xi loudspeaker systems overhead is expressly the responsibility of others.

### I. INTRODUCTION

#### 1.1 The Flying Xi Loudspeaker Systems

The flying versions of the X-Array Install™ loudspeaker systems all incorporate a unique two-point flying system that consists of two lengths of heavy-duty, L-track, aircraft-type rigging hardware on the top and bottom of each enclosure. The design allows arrays to be assembled very quickly, and offers such flexibility in the vertical angling of the cabinets that pull-up points are usually unnecessary. Furthermore, the cabinets may be oriented with the rigging track on the top and bottom of the enclosure or on the sides of the enclosure. For fire safety and additional structural strength in both flying orientations, top-to-bottom and side-to-side metal straps link the rigging track assemblies inside the enclosure. In addition, a line of flying hardware accessories is available for use with the Xi loudspeaker systems from Sound Manufacturing, Inc. (See Appendix A for available rigging accessories.)

### II. BASIC XI RIGGING PRIMER

#### 2.1 Anatomy of an Xi Flying System

A basic two-cabinet flying system is shown in Figure 2.1a, illustrating the integral components that make up a typical Xi loudspeaker array, where the enclosures are oriented with the rigging hardware on the top and bottom of the enclosures. A similar two-cabinet system is shown in Figure 2.1b where the enclosures are oriented with the rigging hardware on the sides of the enclosures. The top cabinets are the starting points for constructing the arrays in both examples. These cabinets are first secured to a grid through the use of two grid straps per cabinet. (The GS-1B grid straps are recommended.) The Xi enclosures are equipped with two pieces of track, which have multiple positions where the grid straps may be attached. The linear positioning of the attachment points along the track (front-to-back) determines the vertical angling of the enclosure. The remaining ends of the grid straps are then secured to cross members of a grid. The relative positioning of the straps along the cross members of the grid (front to back) determine the relative horizontal splay angle between two adjacent columns of enclosures.

A second row of enclosures may be added below the original two by utilizing linking straps that attach from the lower track pieces of the top enclosures to the upper track pieces of the bottom enclosures. (LS-1B, LS-2B and LS-3B linking straps, each a different length, are recommended.) Additional cabinets may be hung in succession in this fashion, as long as the load on any of the enclosures or rigging straps does not exceed their working-load-limit rating. The loudspeaker/array/grid assembly is then raised into position by a motorized chain hoist (or hoists) of sufficient load rating. Note that the weight of such an array can be quite substantial and the building structural sup-

ports to which the hoists are attached must be capable of supporting such a load with a sufficient safety factor. In permanent installations, the chain hoists are often eliminated, with the grid assembly being secured directly to the building structure. The reader is referred to Chapters IV and V of this manual for a detailed discussion of the structural strength ratings of the Xi loudspeakers and L-track rigging accessories, and information on how to safely suspend Xi loudspeaker systems overhead.

#### 2.2 The Rigging Hardware

The Xi flying system utilizes the highest-tech aircraft-type hardware available for securing heavy loads. Four pieces of heavy-duty, aircraft-type, “L-Track” rigging hardware, specially machined extrusions of very-high-strength, aluminum-alloy material, are mounted in each enclosure. The track pieces are secured to high-strength, aluminum-alloy brackets that are an integral part of the Xi flying enclosure. Enclosure dimensions and rigging track locations are shown in Figure 2.2 for all of the Xi loudspeaker systems.

For attachment to the track, the GS-1B grid-strap assembly, the LS-1B, LS-2B and LS-3B linking strap assemblies, the RS-1B double-stud, swivel-ring fitting assembly and the RS-2B single-stud, swivel-ring fitting assembly are available from Sound Manufacturing, Inc. (See Appendix A for details.) These assemblies, shown in Figure 2.3, have been specifically designed for optimal implementation of the Electro-Voice L-track flying systems. The GS-1B includes a double-stud, swivel-ring fitting on one end for attachment to the enclosure and a safety hook on the other end. The safety hook may be attached to 5/8-inch shackles, or may be secured directly to the grid through a 7/8-inch diameter hole in the grid bar-stock material. The LS-1B, LS-2B and LS-3B have double-stud swivel-ring fillings on both ends for linking two Xi enclosures together. The GS-1B, LS-1B and LS-2B rigging straps utilize polyester-webbing strap material. Polyester webbing was chosen for its tremendous strength and because of its dynamic flexing capabilities. The force from any sudden jolt or shift in the load is absorbed by the strap rather than transmitted directly to the loudspeaker enclosure. In addition, polyester webbing is a flexible material that is easy to handle. The user is cautioned, however, that in certain permanent-installation applications, the polyester material may not meet local fire regulations. The user is also cautioned that polyester material will deteriorate with extended exposure to ultraviolet light (direct sunlight) or to hot, dry environments, resulting in reduced strength capability. In such instances, wire-rope or chain assemblies must be substituted. The RS-1B double-stud fitting and the RS-2B single-stud fitting both attach to the Xi enclosure rigging track, and have swivel rings that are suitable for attachment to various standard rigging hardware. The user may

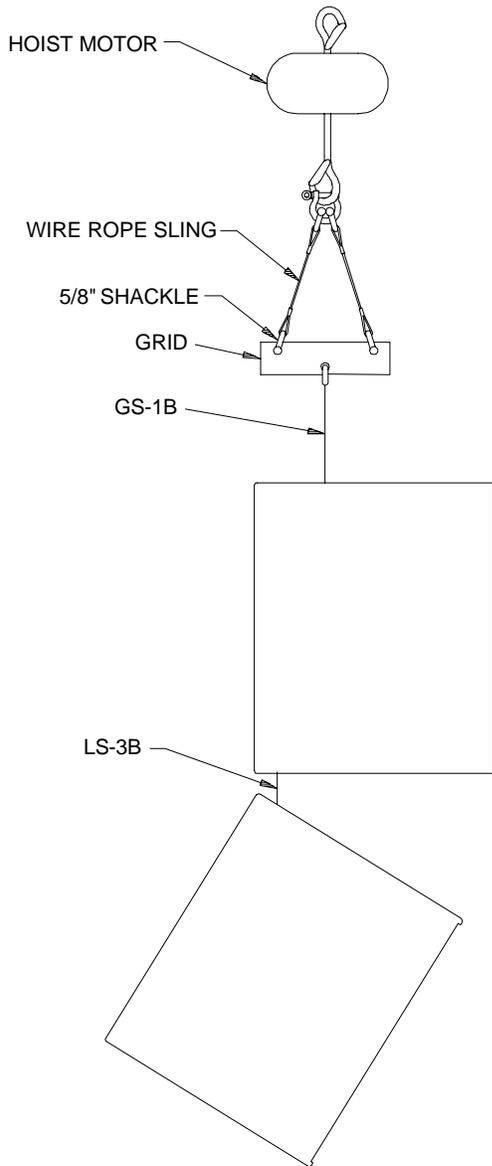
## X-Array Install™ Loudspeaker Systems Flying Manual

use the RS-1B and RS-2B to construct wire-ropes or chain rigging assemblies. In addition, the Xi enclosure rigging track will also accept the New Haven

NH32102-2 double-stud swivel-ring fillings and the New Haven NH8192-2S or Ancra 42546-10 single-stud swivel-ring fillings.

**Figure 2.1—Typical Xi Flying System**

**Figure 2.1a—Rigging Hardware on the Top and Bottom of the Enclosures**



**Figure 2.1b—Rigging Hardware on the Sides of the Enclosures**

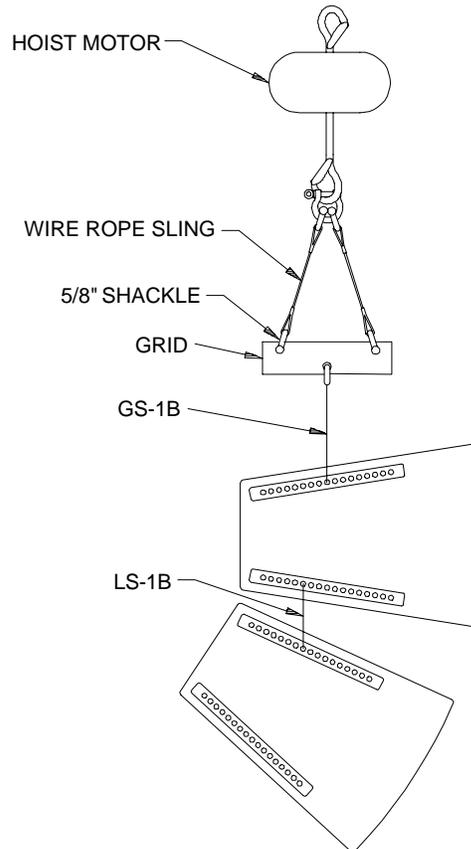
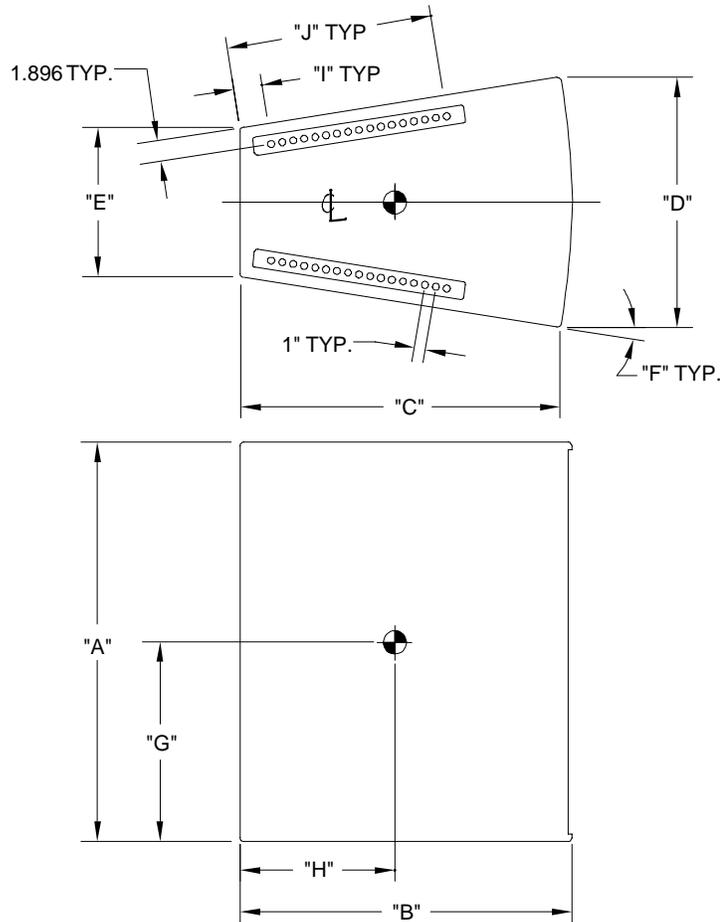


Figure 2.2—Xi Dimensions, Weight, Rigging Location and Center of Gravity

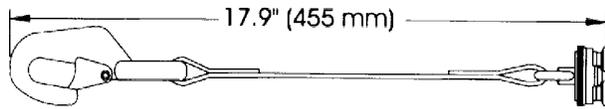
System	Enclosure							Center of Gravity			Rigging Track		Weight		
	Height	Total Depth	Side Depth	Front Width	Rear Width	Side Angle	Dim "A"	Dim "C"	From Bottom	Dim "H"	From Back	Rear Point		Dim "I"	Front Point
XI-1191	36.000	29.875	28.867	23.072	13.928	9.0	16.813	16.081	2.806	18.806	150				
XI-2153/64	48.539	29.875	28.867	23.072	13.928	9.0	24.270	15.433	2.806	18.806	250				
XI-2183/64	48.539	29.875	28.867	23.072	13.928	9.0	24.270	15.433	2.806	18.806	250				
XI-1153/64	36.000	29.875	28.867	23.072	13.928	9.0	17.969	14.815	2.806	18.806	205				
XI-1183/64	36.000	29.875	28.867	23.072	13.928	9.0	17.969	14.815	2.806	18.806	205				
XI-2123/94	—	—	—	—	—	—	—	—	—	—	—				
XI-1123/94	—	—	—	—	—	—	—	—	—	—	—				
XI-1152/64	29.875	16.281	15.255	17.733	9.750	15.0	15.406	7.878	2.544	9.544	90				
XI-1152/94	29.875	16.281	15.255	17.733	9.750	15.0	15.406	7.878	2.544	9.544	90				
XI-1122/85	23.000	14.000	13.269	14.748	7.844	15.0	12.438	7.788	2.544	8.544	69				



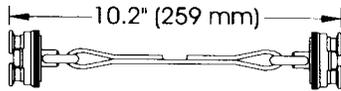
**Notes:**

- All Linear Dimensions in Inches
- All Angles in Degrees
- All Weights in Pounds
- Rigging Attachment Points Every 1.0 Inches Along Track
- Front & Rear Rigging Locations Shown for Double-Stud Fittings
- Single-Stud Fitting Locations Shifted Linearly +/-0.5 Inches

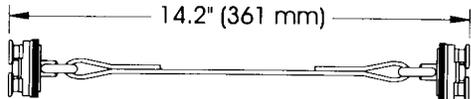
Figure 2.3—The Xi L-Track Rigging Accessories



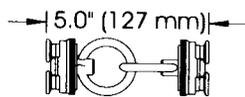
GB-1B Linking Strap (with Double-Stud Fitting)



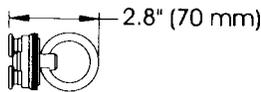
LB-1B Linking Strap (with Double-Stud Fitting)



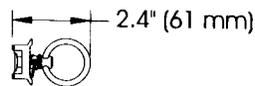
LB-2B Linking Strap (with Double-Stud Fitting)



LS-3B Linking Strap (with Double-Stud Fitting)



RB-1B Swivel-Ring Fitting (with Double-Stud Fitting)



RS-2B Swivel-Ring Fitting (with Single-Stud Fitting)

The user is cautioned that the structural strength ratings of the single-stud fittings are approximately one half that of the double-stud fittings. These lower ratings, however, are completely sufficient for suspending lighter loads overhead (for example, when flying one or two of the smaller/lighter Xi loudspeaker systems in permanent installations), making the single-stud fittings attractive lower-cost alternatives to the double-stud fittings. The reader is referred to Chapters IV and V of this manual for a detailed discussion of the structural strength ratings of the Xi loudspeakers and L-track rigging accessories, and information on how to safely suspend Xi loudspeaker systems overhead.

To attach the double-stud, swivel-ring fittings (as shown in Figure 2.4a) to the enclosure rigging track, push in the spring-loaded safety locking pin and lift the outer locking ring over the pin. Continue to lift the locking ring until the two studs on the bottom of the fitting are fully exposed. Insert the two round feet of the studs into the round cutouts in the track and slide the fitting to the desired position. Center the main body of the fitting over one of the track cutouts,

with the feet located on either side (i.e., with the stud feet positioned directly under the teeth of the track). Release the outer locking ring. The round protrusion on the bottom of the fitting should lock into the round cutout in the track with the locking ring retracting to its normal position, allowing the safety locking pin to reappear and extend over the locking ring. If the fitting does not lock into the track, nudge it along the track and wiggle as necessary until it settles into position. If the outer locking ring does not fully retract, push the ring towards the track until the safety pin reappears and extends over the locking ring. When locked, the fitting will be immovable in the track and the locking ring of the fitting may not be lifted. To remove the fitting, reverse the procedure. **ALWAYS CHECK TO MAKE SURE THAT THE FITTING IS SECURELY LOCKED INTO THE TRACK, AND THAT THE SAFETY PIN IS EXTENDED OVER THE LOCKING RING BEFORE LIFTING ANY LOUDSPEAKER ENCLOSURE OVERHEAD.**

Figure 2.4—The Double- and Single-Stud Ring Fittings

Figure 2.4a—Double-Stud Fitting

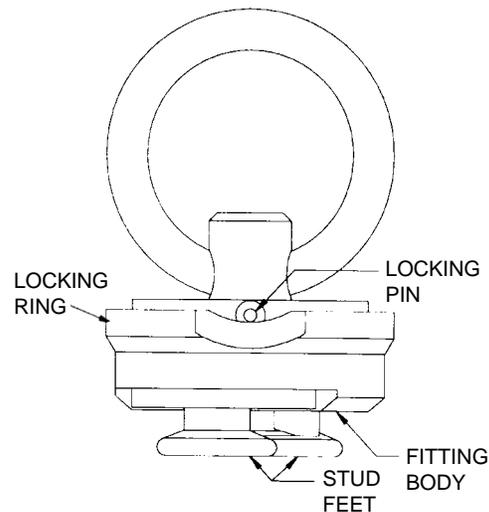
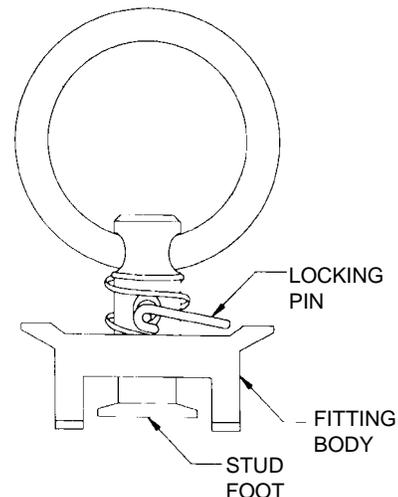


Figure 2.4b—Single-Stud Fitting



To attach the single-stud, swivel-ring fittings (as shown in Figure 2.4b) to the enclosure rigging track, remove the safety locking pin and lift the fitting body over the hole for the locking pin. Continue to lift the fitting body until the stud on the bottom of the fitting is fully exposed. Insert the round foot of the stud into a round cutout in the track and slide the fitting to the desired position. Center the main body of the fitting over one of the track teeth (i.e. with the stud foot positioned directly under one tooth of the track). Release the fitting body. The body of the fitting should lock into the round cutouts in the track with the fitting body retracting to its normal position, allowing the hole for the safety locking pin to reappear. If the fitting does not lock into the track, nudge it along the track and wiggle as necessary until it settles into position. If the fitting body does not fully retract, push the body towards the track until the hole for the safety pin reappears. Install the safety locking pin into the hole in the shaft. When locked, the fitting will be immovable in the track and the body of the fitting may not be lifted. To remove the fitting, reverse the procedure. **ALWAYS CHECK TO MAKE SURE THAT THE FITTING IS SECURELY LOCKED INTO THE TRACK, AND THAT THE SAFETY PIN IS INSTALLED BEFORE LIFTING ANY LOUDSPEAKER ENCLOSURE OVERHEAD.**

### 2.3 The Xi Flying Concept

#### 2.3.1 Acoustical Considerations

The Xi systems lend themselves to easy array construction. All of the Xi loudspeaker systems use the same L-track rigging hardware on the enclosures, and may be oriented with the rigging track either on the top and bottom of the cabinets or on the sides of the cabinets. All of the full-range Xi systems have trapezoidal enclosures, enabling high-density, point-source arrays. The horns in many of the full-range Xi systems are rotatable, allowing the cabinets to be oriented for optimal physical installation and the coverage pattern to be oriented for optimal acoustic performance. Many of the Xi systems have the same dimensions, facilitating ease of rigging and a consistent cosmetic appearance. With grilles in place, the Xi subwoofer systems are indistinguishable from the large Xi full-range systems, allowing the option of either flying the subwoofers or stacking them on the floor, or even a combination of the two, while still preserving the uniform appearance of both the ground stack and the flown array. When designing an Xi loudspeaker array, three primary acoustic goals should be kept in mind. First, the array should be designed so that the acoustic energy is directed at the audience and away from reflecting surfaces outside the listening area. This maximizes the intelligibility and clarity throughout the listening area. Second, the array should be designed to achieve even coverage throughout the audience. This ensures consistent levels and sound

quality throughout the listening area. Third, the array should be designed to achieve the required sound-pressure levels throughout the audience. This also maximizes the intelligibility and clarity throughout the listening area. The key to achieving these three goals is to select the Xi loudspeaker system with appropriate coverage patterns and acoustic-output capabilities, orient the enclosures and coverage patterns for optimal array performance, and accurately aim the systems in the array. The reader is referred to Appendix B.1 for a list of references covering the topics of acoustics and loudspeaker array design.

Because sound coming from numerous loudspeakers should arrive at any seat at the same time, the speakers in an array should be curved as if mounted on the outside of an imaginary sphere. The loudspeakers should be close-spaced to minimize lobing and maximize coupling and each speaker must be accurately aimed. The apparent source then becomes the single point at the center of the sphere. The horizontal array curve is simply achieved by hanging the cabinets closely spaced, aimed outward at diverging angles. Achieving the vertical array curve is a bit more complex to obtain.

The Xi loudspeaker systems utilize a unique two-point suspension system (shown in Figure 2.1) that can achieve all of the design criteria for a true point-source array. To tilt an Xi loudspeaker system downward, the rigging straps at the top of that cabinet are shifted along the rigging track towards the rear of the enclosure. To align the top-rear corner of an Xi cabinet with the bottom-rear corner of an Xi cabinet above it, the rigging straps at the bottom of the upper cabinet are shifted along the rigging track until the rear corners of the adjacent cabinets are in alignment. A number of examples are presented in the following section that demonstrate both the mechanical and acoustical aspects of an array design with the Xi loudspeaker systems.

#### 2.3.2 Practical Considerations

The vertical angle of the flying Xi loudspeaker system may be adjusted by choosing different positions of attachment along the rigging track on the cabinet. There are a number of attachment points allowing for a wide variety of angles. Although the center of gravity is slightly different for each of the systems, the balancing concept is the same. The further the top attachment point is towards the back of the cabinet, the greater the downward angle, as shown in Figure 2.5. As the attachment point is moved forward, the cabinet will have less downward angle and, at the furthest point forward, will have an upward tilt. This principle holds true when hanging any of the Xi systems in either rigging orientation (rigging track on the top and bottom, or on the sides).

Figure 2.5—Balancing the Xi Loudspeaker Systems

Figure 2.5a—Rigging Hardware on the Top and Bottom of the Enclosures

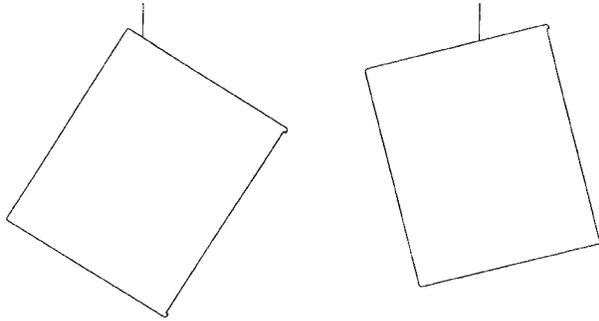
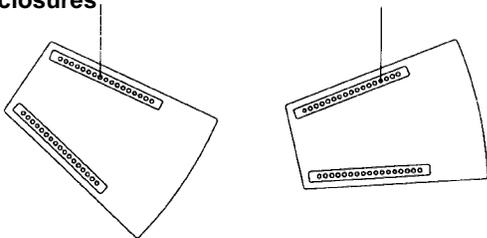


Figure 2.5b—Rigging Hardware on the Sides of the Enclosures



Vertical arrays are constructed by hanging Xi systems from one another in succession. Both the curvature of the array and the angles of the individual cabinets are controlled by the rigging attachment positions. The shape of the array curve is determined by the position on the lower track of an already hanging cabinet from which the next cabinet is hung, the further back the attachment point is on the upper box, the further back the lower cabinet is shifted and, hence, the greater the curvature of the array. The goal is to have the back, top and bottom edges to adjacent cabinets in alignment. Hanging one cabinet from another affects the angle of the first. This is best demonstrated in an example. In Figure 2.6a, one Xi enclosure is hung so that it points straight ahead and a second is added below. The addition of the second enclosure causes the top cabinet to point upward. Shifting the upper attachment point of the first cabinet back, as shown in Figure 2.6b, counteracts the additional load and results in the upper cabinet pointing straight ahead again. Note that this change has no effect on the angle of the lower cabinet. Additional Xi enclosures may be hung in succession in this fashion, creating a tall vertical line array (as long as the working-load-limit of all of the mechanical components are not exceeded and a sufficient safety factor is maintained throughout the array).

With the Xi loudspeaker systems oriented with the rigging track on the top and bottom of the cabinets, a short rigging strap is used between the cabinets to minimize the spacing between the systems. Typically, the LS-3B is used for this task. If, however, Xi enclosures having different dimensions are hung

Figure 2.6—Interaction Between Flown Cabinets

Figure 2.6a—Adding a Bottom Cabinet Affects the Top Cabinet

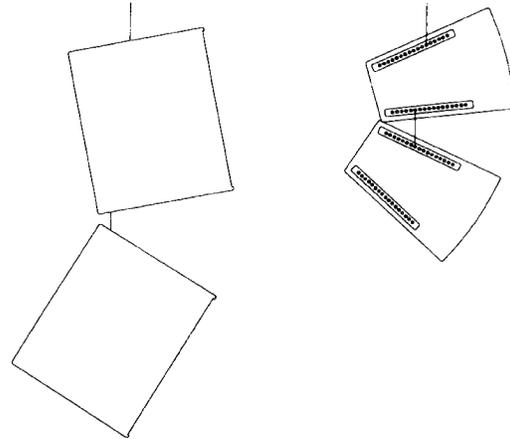
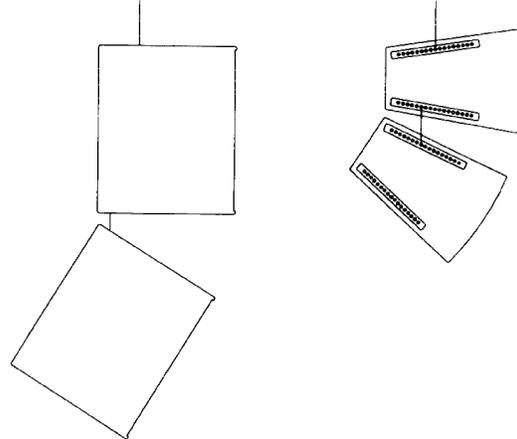


Figure 2.6b—After Readjusting the Top Cabinet



from one another (an Xi-1122 suspended beneath an Xi-1191, for example), a longer strap would be required to accommodate the different distances in width between the rigging tracks. In this instance, the LS-1B could be employed. Another option would be to use two RS-1B double-stud swivel-ring fittings linked with a threaded-chain connector or a carabiner snap hook. (The RS-2B single-stud-ring fittings could be used in lighter-weight applications.)

With the Xi loudspeaker systems oriented with the rigging track on the sides at the cabinets, a longer rigging strap is required between the cabinets to minimize the spacing between the systems. Typically, the LS-1B is used for this task. If, however, Xi enclosures having different dimensions are hung from one another (an Xi-1122 suspended beneath an Xi-1191, for example), a longer strap would be required to accommodate the different distances in width between the rigging tracks. In this instance, the LS-2B could be employed. Another option would be to use two RS-1B double-stud-ring fittings linked with a wire-rope assembly. (The RS-2B single-stud-ring fittings could be used in lighter-weight applications.)

III. ASSOCIATED RIGGING HARDWARE FOR FLYING XI LOUDSPEAKER SYSTEMS

**3.1 Grids and Associated Rigging Hardware**

The GS-1B, LS-1B, LS-2B, LS-3B, RS-1B and RS-2B rigging accessories described throughout this manual for use with the flying Xi loudspeaker systems are available from Sound Manufacturing, Inc. (See Appendix A for details.)

Electro-Voice does not manufacture grids or any of the other associated hardware required for suspending Xi loudspeaker arrays overhead. In the case of both permanent-installation and touring-sound applications, it is generally most efficient and cost effective to design a support system specific to the application, taking into account the loudspeaker array requirements. In some permanent installations, it may even be possible in some circumstances to eliminate the grid and secure the loudspeakers directly to the building structural supports. The sound-system designer is instructed to evaluate each individual circumstance and design a support system tailored to the specific application.

To aid rigging designers, the user is directed to two companies that manufacture and sell generalized and semi-custom rigging hardware and accessories for flying loudspeaker systems - ATM Fly-Ware™ and Sound Manufacturing, Inc. (See Appendix A for details on how to contact these companies.)

**Attention:** All associated non-Electro-Voice rigging hardware used for suspending any X-Array Install™ (Xi) loudspeaker systems overhead is expressly the responsibility of others.

IV. STRENGTH RATINGS, SAFETY FACTORS AND SPECIAL SAFETY CONSIDERATIONS

**4.1 Strength Ratings and Safety Factors**

Electro-Voice provides strength ratings for the Xi loudspeaker systems in terms of the working-load-limit rating based on an 8:1 minimum safety factor. The working-load-limit rating is defined as the maximum allowable force that may be applied to the mechanical component. The rated safety factor is defined as the ratio of the ultimate-break-strength rating to the working-load-limit rating. The ultimate-break-strength rating represents the force applied to a mechanical component at which the component will structurally fail. As such, the force that would result in a structural failure in the Xi loudspeaker system will be at least eight times greater than the specified working-load-limit ratings. The safety factor provides a margin of error to accommodate normal dynamic shock loading, wear and tear on the hardware components, etc. **THE USER MUST NEVER APPLY A LOAD TO AN XI LOUDSPEAKER SYSTEM THAT EXCEEDS THE WORKING-LOAD-LIMIT RATINGS.**

There are two independent strength ratings that, together, give a complete description of the overall structural performance capabilities of any Xi loudspeaker system:

- 1. The working-load-limit rating for each individual rigging point;** which is a function of the rigging track mounted on the enclosure combined with the specified quick-release rigging hardware. This rating varies as a function of the angle of pull.
- 2. The working-load-limit rating for the overall enclosure;** which is a function of the combined forces from multiple rigging points simultaneously acting on the enclosure as a whole. This rating is independent of the rigging pull angles.

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

The user must be aware of both of the above working-load-limit ratings at all times. An Xi loudspeaker system is only as strong as its weakest link. In most applications, it is usually the case that one of the working-load limits will be approached sooner than the other. For example, if only two rigging points are employed, the weakest link will always be the individual rigging points and the working-load limit for the individual rigging points will always be the dominant factor. If, however, four rigging points are used, the weakest link may be either the overall enclosure or the individual rigging points depending on the angles of pull on the rigging points.

The individual rigging points on each Xi loudspeaker system have two working-load-limit ratings, one when used with a double-stud ring fitting (as used on the GS-1B, LS-1B, LS-2B, LS-3B and RS-1B rigging accessories, or with the New Haven NH32102-2 fitting), and one when used with a single-stud fitting (as used on the RS-2B rigging accessory, or with the New Haven NH8192-2S or Ancra 42546-10 fillings). Two working-load-limit ratings are required because the double-stud and single-stud fittings have different strength ratings. In addition, those strength ratings will vary with the angle of pull relative to the surface on which the rigging track is mounted. There is only one working-load-limit rating for the overall enclosure of each Xi loudspeaker system, and that rating is independent of the angles of pull.

Specifically, the flying Xi-1191, Xi-1183, Xi-1153, Xi-2183 and Xi-2153 loudspeaker systems have the following strength ratings. When used with double-stud fillings (as used on the GS-1B LS-1B, LS-2B, LS-3B and RS-1B rigging accessories or as used with the New Haven NH32102-2 fittings), the working-load-limit rating of each individual rigging point is 500 pounds at a pull angle of 0° (i.e., perpendicular to the surface on which the track is mounted), 437 pounds at a pull angle of 45° and 375 pounds at a

pull angle of 90° (i.e., parallel to the surface on which the track is mounted). When used with single-stud fittings (as used on the RS-2B rigging accessory or as used with the New Haven NH8192-2S or Ancra 42546-10 fittings), the working-load-limit rating of each individual rigging point is 250 pounds at any pull angle. The working-load-limit rating of the overall enclosure is 1,000 pounds. Electro-Voice insists that the user must never apply a load to any Xi flying loudspeaker system that exceeds the working-load-limit rating of either the individual rigging point or the overall enclosure. The strength ratings of the flying Xi-1191, Xi-1183, Xi-1153, Xi-2183 and Xi-2153 loudspeaker systems are summarized in Figure 4.1a.

Specifically, the flying Xi-1122, Xi-1152, Xi-1123 and Xi-2123 loudspeaker systems have the following strength ratings. When used with double-stud fittings (as used on the GS-1B LS-1B LS-2B, LS-3B and RS-1B rigging accessories or as used with the New Haven NH32102-2 fittings), the working-load-limit rating of each individual rigging point is 500 pounds at any pull angle. When used with single-stud fittings (as used on the RS-2B rigging accessory or as used with the New Haven NH8192-2S or Ancra 42546-10 fittings), the working-load-limit rating of each individual rigging point is 250 pounds at any pull angle. The working-load-limit rating of the overall enclosure is 750 pounds. Electro-Voice insists that the user must never apply a load to any Xi flying loudspeaker system that exceeds the working-load-limit rating of either the individual rigging point or the overall enclosure. The strength ratings of the flying Xi-1122, Xi-1152, Xi-1123 and Xi-2123 loudspeaker systems are summarized in Figure 4.1b.

All associated mechanical components used with an Xi flying system (shackles, chains, hoists, wire-rope slings, nylon and/or polyester slings, etc.) should be load rated for overhead lifting. All load-rated hardware will typically have its load rating displayed on each piece in a visible location. Typical ratings are denoted as the static-working load (SWL), or the working-load limit (WLL). These ratings generally assume a safety factor of 5:1; however, the user should consult the hardware manufacturer to confirm the rating. Occasionally, the load rating is given as the ultimate-break strength. This requires the user to calculate the safety factor directly for a given load. The actual safety factor for a given load is defined as the ratio of the ultimate-break-strength rating of a mechanical component to the actual load applied to that component.

Electro-Voice suggests that the user maintain an overall safety factor of at least 8:1 when implementing an Xi flying system. In other words, the ultimate-break strength of each of the mechanical components in the system should be at least eight times greater than the actual force applied to those components.

This includes the Xi enclosures, the rigging-strap assemblies, the grid the hoist and all other mechanical components and hardware. The working-load limits discussed throughout this manual for the strength of the Electro-Voice Xi enclosures rigging hardware, and the GS-1B, LS-1B, LS-2B, LS-3B, RS-1B and RS-2B rigging accessories are based on an 8:1 minimum safety factor. Where local regulations require safety factors greater than 8:1, Electro-Voice insists that the user must meet the required safety factor. Where local regulations permit safety factors less than 8:1, Electro-Voice still insists that the working-load limit of the Xi enclosures/rigging hardware, and the GS-1B, LS-1B, LS-2B, LS-3B, RS-1B and RS-2B rigging accessories never be exceeded.

### 4.2 Special Safety Considerations for Xi Loudspeaker Arrays

The techniques discussed in Chapter II for constructing arrays may be expanded upon to create different arrays utilizing different combinations of Xi loudspeaker systems, as long as a sufficient safety factor is maintained. The user is reminded that the top cabinet in an array supports the weight of all the cabinets hung beneath it, and that the weight distribution between the rigging points will depend on the exact configuration. For example, the center of gravity of the Xi-1152 loudspeaker system is not perfectly centered but rather shifted slightly towards the high-frequency side of the box. As a result, when an Xi-1152 is hung sideways (i.e., with the cabinet oriented so the rigging track is on the sides), the load on the rigging strap on the high-frequency side of the Xi-1152 system would be slightly higher than the load on the horn/compression-driver side. On the other hand, the load would be distributed equally between the two rigging straps at the top of a column of Xi-1152 systems hung with the enclosures oriented with the rigging track on the top and bottom. The weight distribution of any Xi array can be calculated with the information presented in Figure 2.2. Readers unfamiliar with the process of calculating load distributions should consult the list of references in Appendix B.2 which cover the topics of rigging and engineering mechanics.

When arrays are constructed with columns of Xi systems oriented with the rigging tracks on the top and bottom of the enclosures the rigging straps between the enclosures will not hang straight down with a 0° vertical angle if the center-to-center spacing of the rigging attachment positions are different from the bottom of one cabinet to the top of the cabinet immediately beneath it. The rigging straps will deviate from a 0° vertical angle when trapezoidal cabinets are employed, or cabinets of differing size are mixed in the same column. These vertical-angle differences will result in forces (i.e., tension loads)

Figure 4.1—Working-Load-Limit Strength Rating of the Xi Loudspeaker System

Figure 4.1b—Xi-1122, Xi-1152, Xi-1123 and Xi-2123

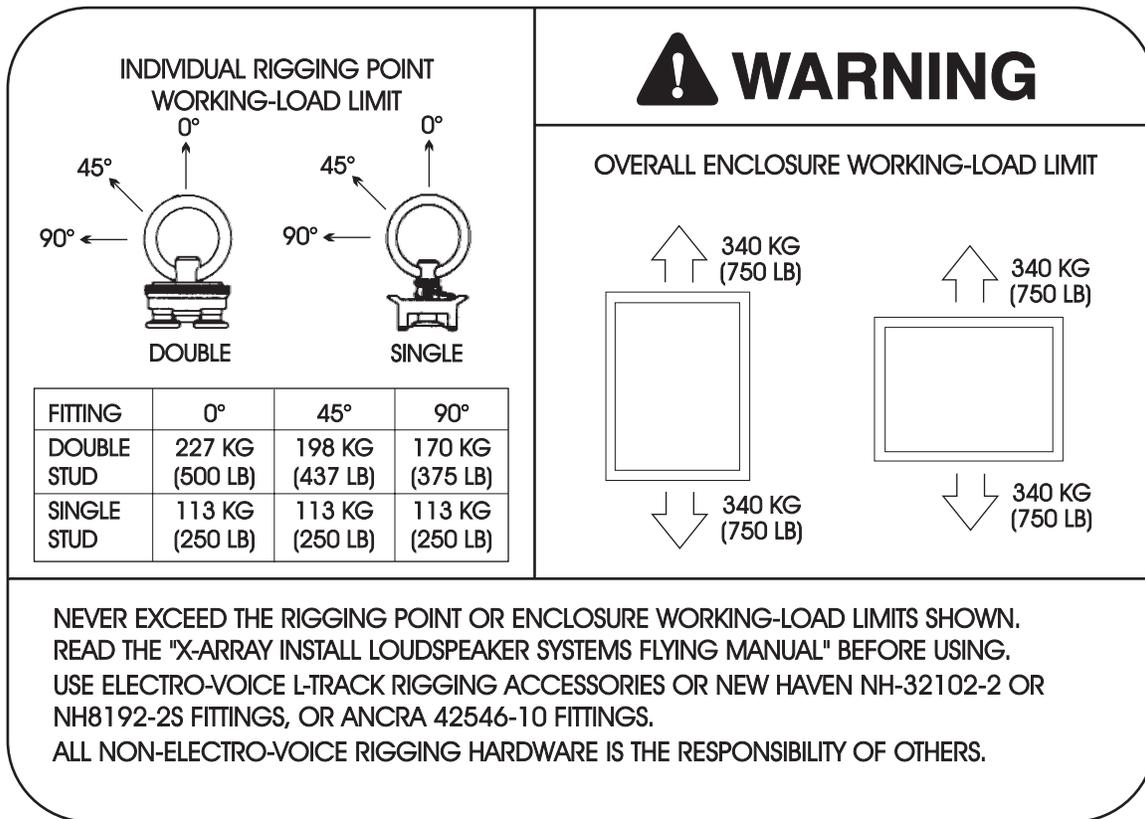
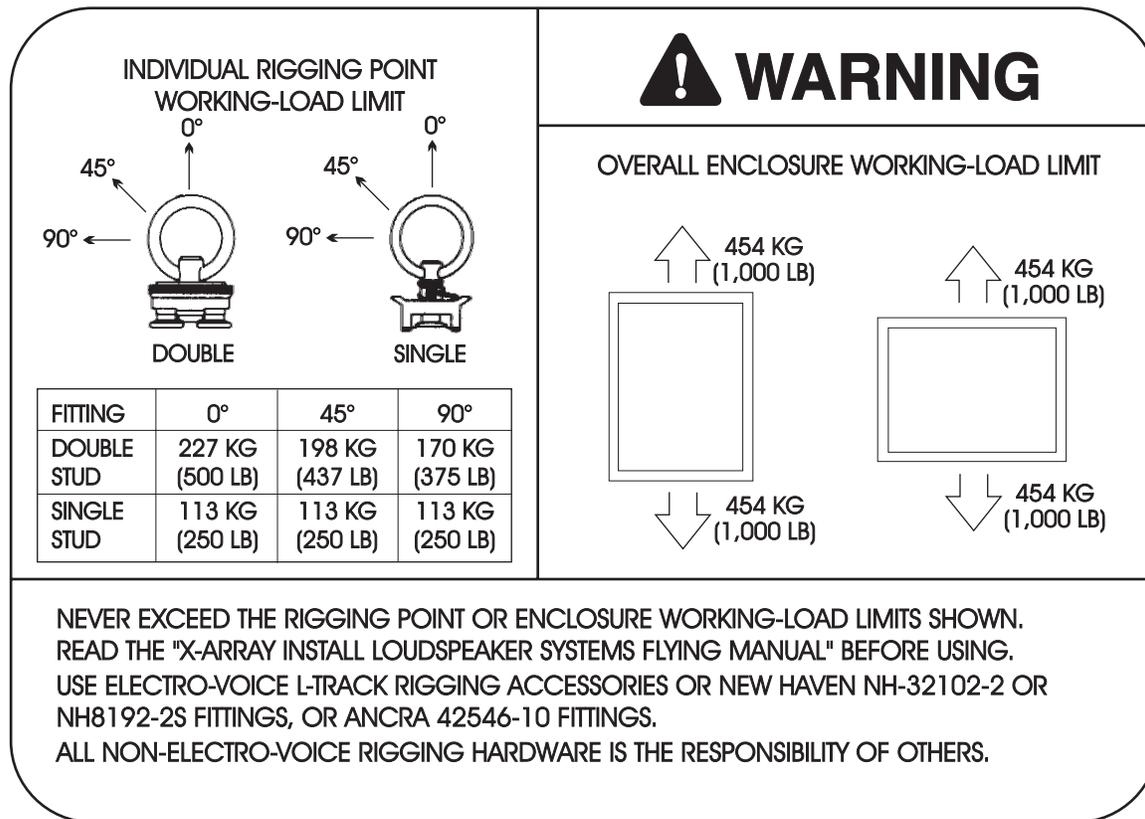


Figure 4.1a—Xi-1191, Xi-1183, Xi-1153, Xi-2183 and Xi-2153



in the rigging straps that are greater than the suspended weight. These increased forces are, in turn, transmitted to the rigging track and enclosure and must be taken into account when evaluating the load on the mechanical components and the safety factor of an array. The greater the angle difference from the 0° vertical, the greater is the increase in force above what it would be if the straps were at 0°. Readers unfamiliar with the process of calculating the increased load as a function of lifting angles should consult the list of references in Appendix B.2 which cover the topics of rigging and engineering mechanics.

The user is reminded that the top cabinet of an array supports the weight of all of the cabinets hung beneath it. This generally results in the worst case forces occurring at the top rigging-attachment point of the top cabinets (including the top rigging straps). However, if the rigging straps throughout the array are at unusual and or extreme angles, the worst-case forces in an array may occur somewhere other than the top rigging-attachment point of the top cabinets.

**Attention:** Array details and rigging configurations will affect the load on the loudspeaker systems, the rigging straps and all associated rigging hardware. The user is responsible for determining the loads on all of the mechanical components throughout the loudspeaker array, and for ensuring that the working-load limits and resulting safety factors are not exceeded. A qualified structural engineer should be consulted to evaluate the design.

### 4.3 Special Safety Considerations for Rigging Strap Assemblies

#### 4.3.1 Redundant Attachment Points

As an added safety measure, it is suggested that the user install a second set of grid straps from the top rigging points of the top cabinets in an array back to the grid (or building structural supports). These redundant safety straps can be secured to an open section of rigging track next to the primary grid straps. The safety straps should have as little slack as possible (less than one inch is preferable).

#### 4.3.2 Special Considerations for Polyester Webbing

The GS-1B, LS-1B and LS-2B utilize polyester webbing in their construction. The user is cautioned, however, that in certain permanent installation applications, the polyester material may not meet local fire regulations. The user is also cautioned that polyester material will deteriorate with extended exposure to ultraviolet light (direct sunlight) or to hot, dry environments, resulting in reduced strength capability. In such instances, wire-rope or chain assemblies must be substituted.

### 4.4 Special Safety Considerations for Grid & Building Structural Supports

When suspending loudspeaker arrays from grids or building supports the associated rigging hardware employed (i.e., rigging straps, slings, chains, wire-rope assemblies, chains, etc.) may not hang at a 0° vertical angle. These vertical-angle differences will result in forces (i.e., tension loads) in that rigging hardware that are greater than the weight suspended below. These increased forces must be taken into account when evaluating the load on the mechanical components and the safety factor of an array. The greater the angle difference from the 0° vertical, the greater is the increase in force above what it would be if the straps were at 0°. Any users unfamiliar with the process of calculating the increased load as a function of lifting angles should consult the list of references in Appendix B.2 which cover the topics of rigging and engineering mechanics.

**Attention:** Array details and rigging configurations will affect the load on the building structure, the grids, the loudspeaker systems, the rigging straps and all associated rigging hardware. The user is responsible for determining the loads on all of the mechanical components throughout the loudspeaker array, and for ensuring that the working-load limits and resulting safety factors are not exceeded. A qualified structural engineer should be consulted to evaluate the design.

## V. RIGGING INSPECTION, MAINTENANCE AND PRECAUTION

### 5.1 Xi System Components

#### 5.1.1 Xi Loudspeaker Systems

Prior to each use, inspect the loudspeaker enclosures for any cracks, deformations, missing or damaged components which could reduce enclosure strength. Inspect the track and bracket assemblies on the enclosures for any cracks, deformations, 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 Xi systems.

#### 5.1.2 Rigging Strap Assemblies

Prior to each use, inspect the webbing for cuts abrasion, tears, knots, chemical damage, burns and broken stitches which could reduce rigging-strap-assembly strength. Inspect the rigging fittings and hooks for any cracks, burrs, deformation, missing or damaged components which could reduce strap assembly strength. Replace any rigging-strap assemblies that have damaged webbing, or damaged or missing hardware. Always double check that each fitting on each of the rigging-strap assemblies is securely locked into position in the track on the

Xi enclosures and that the safety locking pin is engaged before lifting.

### **5.2 Associated Hardware**

#### **5.2.1 Grid Assembly**

Prior to each use, inspect the grid assembly and associated hardware for any cracks, deformations, broken welds, corrosion, missing or damaged components which could reduce the grid assembly strength. Replace any damaged grid assemblies. Never exceed the limitations or maximum recommended load intended for grid assembly design.

#### **5.2.2 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 which could reduce the hoist strength. Replace any damaged chain hoists. Never exceed the limitations or maximum recommended load specified by the hoist manufacturer. 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.

#### **5.2.3 Building Structural Supports**

Prior to each use, the strength and load-bearing capabilities of the building 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 structural supports for any cracks, deformation, broken welds, corrosion, missing or damaged components which could reduce the structural strength. Damaged building structural supports should be replaced or repaired and recertified by a professional engineer.

#### **5.2.4 Mechanical Components**

Prior to each use, inspect all mechanical components (chain, wire ropes, slings, shackles, hooks, fittings, etc.) for any cracks, deformation, broken welds, slipping crimps, fraying, abrasion, knots, corrosion chemical damage, loose screws, missing or damaged components which would reduce the maximum strength specified by the component manufacturer. Replace any damaged mechanical components.

APPENDICES

**Appendix A: Xi Rigging Accessories**

**GS-1B, LS-1B, LS-2B, LS-3B, RS-1B and RS-2B Xi Rigging Accessories:** These rigging accessories described throughout this manual are available from Sound Manufacturing, Inc., 3336 Primera Ave., Hollywood, CA 90068, USA, 213-850-5042.

**New Haven NH32102-2 and NH8192-2S Fittings:** The New Haven NH32102-2 swivel-ring, double-stud fitting and NH8192-2S swivel-ring single-stud fitting recommended for attachment to the Xi rigging track are available for the user to make custom rigging attachment hardware. Sound Manufacturing, Inc., 3336 Primera Ave., Hollywood, CA 90068, USA, 213-850-5042.

**Custom Rigging Strap Assemblies:** Custom wire-rope or webbing rigging strap assemblies that use the New Haven NH32102-2 and NH8192-2S fittings may be ordered. Sound Manufacturing, Inc., 3336 Primera Ave., Hollywood, CA 90068, USA, 213-850-5042.

**General Rigging Supplies:** A wide variety of standard and specialty rigging hardware components for both touring and permanent-installation applications is available. Sound Manufacturing, Inc., 3336 Primera Ave., Hollywood, CA 90068 USA, 213-850-5042 or ATM Fly-ware™, 2100 S. Wilmington Ave., Carson, CA 90810 USA, 310-834-5914

**Appendix B**

**B.1 Acoustical References**

A brief list of references covering the topics of acoustics and sound-system design is presented below:

- (1) D. Davis & C. Davis, *Sound System Engineering*, Howard Sams & Co., Indianapolis, IN (1987).
- (2) J. Eargle, *Handbook of Sound System Design*, ELAR Publishing Co., Commack, NY (1989).
- (3) G. Davis & R. Jones, *Sound Reinforcement Handbook*, Hal Leonard Publishing Corp., Milwaukee, WI (1989).
- (4) L.L. Beranek, *Acoustics*, American Institute of Physics, Inc. New York, NY (1986).
- (5) H.F. Olson, *Acoustical Engineering*, Professional Audio Journals, Inc., Philadelphia, PA (1991).
- (6) L.E. Kinsler, A.R. Frey, A.B. Coppens, & J.V. Sanders, *Fundamentals of Acoustics*, John Wiley & Sons, New York, NY (1980).
- (7) D.B. Keele, Electro-Voice, Inc., "What's So Sacred About Exponential Horns," presented at the 51st Convention of the AES (May, 1975), preprint #1038.

- (8) P.F. Fidlin & D.E. Carlson Electro-Voice, Inc., "Comparative Performance of Directional Devices Used as Concert-Sound Loudspeaker Array Elements," *Journal of the AES* (April, 1990).

**B.2 Mechanical References**

A brief list of references covering the topics of rigging and engineering mechanics is presented below:

- (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) A. Jensen & H. Chenoweth, *Applied Engineering Mechanics*, McGraw-Hill Book Co., New York, NY (1983).
- (3) J.O. Glerum, *Stage Rigging Handbook*, Southern Illinois University Press, Carbondale, IL, USA (1987).
- (4) P. Carter, *Backstage Handbook*, Broadway Press, New York, NY, USA (1988).
- (5) Wire Rope Technical Board, *Wire Rope Users Manual*, American Iron and Steel Institute, Stevensville, MD, USA (1985).
- (6) ATM Fly-Ware™, *ATM Fly-Ware™ Catalog of Rigging Hardware and Supplies*, ATM Group, Inc., Carson, CA (1996).
- (7) Broderick & Bascom Rope Company, *Rigger's Handbook*, Sedalia, MO, USA (1993).
- (8) MacWhite Wire Rope Company, *Catalog of Tables, Data and Helpful Information*, Kenosha, WI, USA (1991).
- (9) Acco Chain & Lifting Division, *Chain Sling User's Manual*, Acco Corporation, York, PA, USA (1992).
- (10) Newberry, W.G., *Handbook for Riggers*, Newberry Investments Company, Calgary, Alberta, Canada (1989).



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