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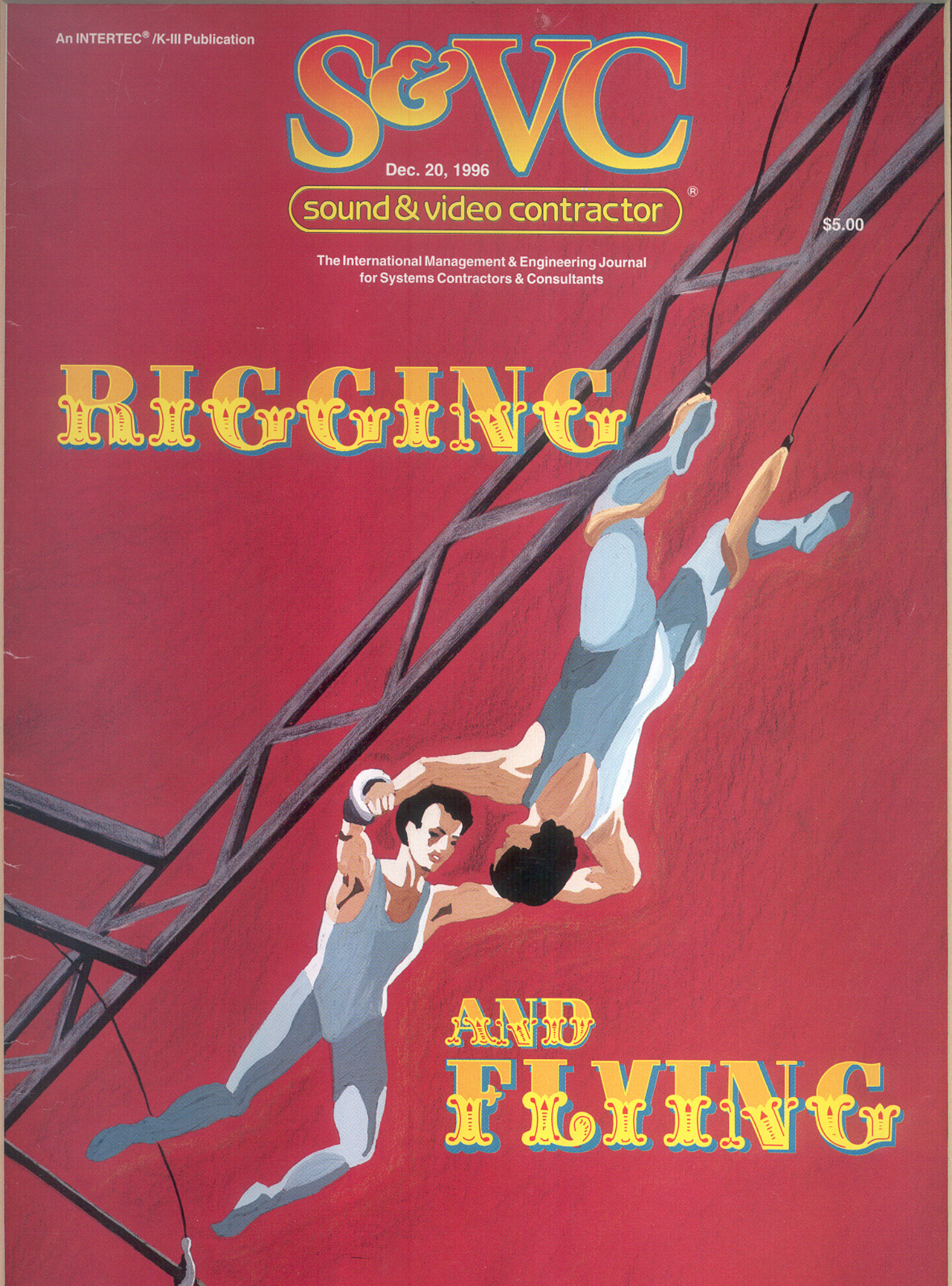
RIGGING AND FLYING



Suspending a loudspeaker safely

Even if your loudspeaker looks secure, take care to make sure the hanging hardware has been certified for that purpose.

Do you know that you are the responsible qualified professional if you specify, install or instruct someone else to install a loudspeaker in an overhead suspension application? Are you also aware that as the responsible qualified professional, you could be held liable for damages to property and injuries to individuals if a loudspeaker enclosure falls?

Your best defense is a solid offense. Please read on to learn how to suspend a loudspeaker enclosure safely, securely and with minimal product liability exposure.

Loading the loudspeaker enclosure properly

The primary consideration when suspending a loudspeaker enclosure is maximizing the strength of the installation while minimizing the loads applied to the loudspeaker enclosure suspension points and enclosure joinery. You can use several simple methods to achieve the proper loading of the loudspeaker enclosure. The following is a list of the four most common solutions to the four most common installations:

- *Redundant points:* If the possibility exists, always use redundant suspension points at the loudspeaker enclosure and at the structure attachment. (See Figure 1.) Redundant points allow one of the loudspeaker enclosure attachments or one of the structure attachments to fail while the other point remains, continuing to suspend the loudspeaker enclosure and associated hardware with the industry standard 5:1 design factor. The redundant-points design maintains the design factor; it is not to hold the loudspeaker enclosure in proper placement should one point fail. When designing with redundancy, you need not consider proper spatial alignment for each point; it is only necessary for the sum of the suspension points to provide the desired placement.
- *Distributive loading:* Many loudspeaker enclosures are equipped with three suspension points on the top or bottom. Whenever suspending this type of loudspeaker enclosure, think about loading the enclo-

By Andrew T. Martin

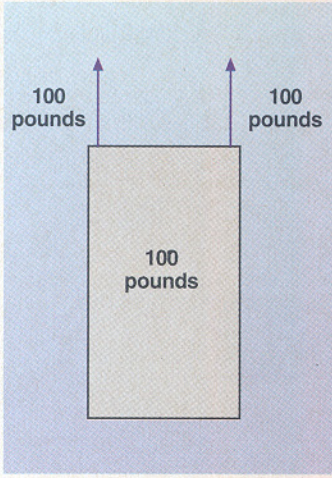


Figure 1. With redundant points, one suspension point will maintain the load at a 5:1 design factor if the other suspension point fails.

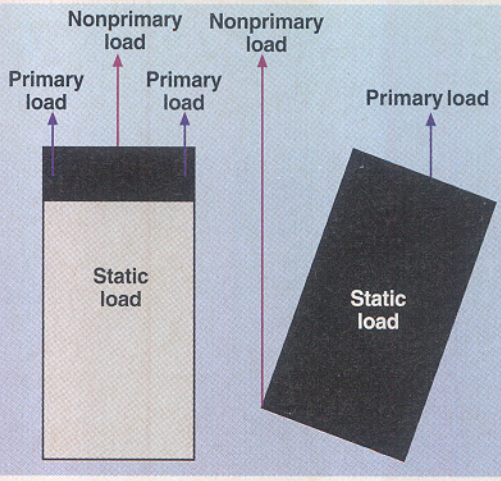


Figure 2. With distributive loading, the primary suspension point loading is distributed over two loudspeaker suspension points while the tilt is adjusted by a third nonprimary suspension point.

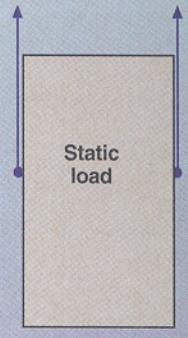


Figure 3. With vertical loading, the primary suspension load is applied vertically to the specially designed loudspeaker suspension hardware, which is installed on the side of the enclosure.

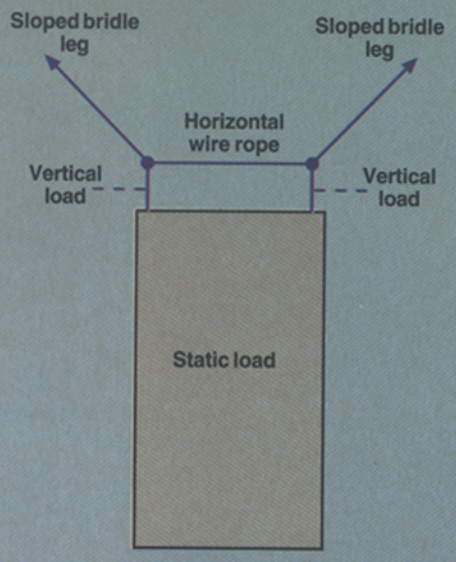
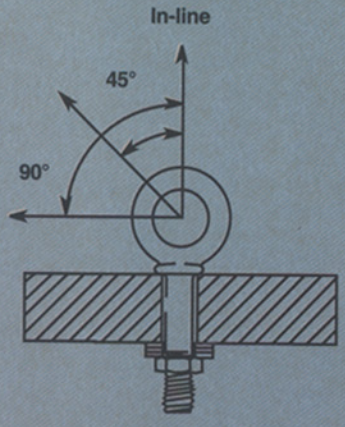


Figure 4. H-bridle suspension places a horizontal wire rope between the sloped bridle legs to load the loudspeaker suspension hardware in the vertical plane only.



Direction of pull	Adjusted working load
45°	30% of rated working load
90°	25% of rated working load

Figure 5. A Crosby shoulder eyebolt. (Courtesy the Crosby Group)

Figure 6. An offset swivel ring fitting.

sure hardware and the enclosure in such a way as to distribute an equal load over the greatest number of loudspeaker enclosure points. (See Figure 2.) Because loudspeaker enclosures are typically tilted, it is appropriate to use the forward two suspension points on the top of the enclosure as the primary suspension points. This also provides redundant suspension points. It is not appropriate to use the third point on the top of the enclosure because the tension will increase on the rear point as the enclosure is tilted, and the load will no longer be distributed equally or optimally across the loudspeaker enclosure as a whole. Because tilting the loudspeaker enclosure is usually a requirement, you must pull the bottom of the loudspeaker enclosure up until the desired tilt is achieved. The tilt attachment is not considered a primary suspension point, so you can construct it without the 5:1 design factor if you wish.

• *Vertical loading:* The strongest method of loading a loudspeaker enclosure is to apply a vertical load to a surface perpendicular to the load tension. (See Figure 3.) For most applications, this means attaching to the sides of the loudspeaker enclosure. Unfortunately, this can be extremely problematic because of hardware load-rating restrictions and cluster designs requiring tight coupling between loudspeaker enclosures. Very few hardware components are intended for a perpendicular load, and many of those have a load capacity reduction of 75% or more. Take great care to ensure manufacturer certification of the use of the hardware and the loudspeaker before suspending a loudspeaker enclosure in this fashion. Proper hardware and enclosure ratings are necessary in order for the respective manufacturers to assume product liability.

• *H-bridle suspension:* It is not unusual to have to suspend a loudspeaker where a structural suspension point is not directly above the loudspeaker enclosure location. With a situation such as this, it is common to install a bridle system consisting of two or more wire ropes attached to the structure at one end that converge at the loudspeaker on the other end. (See Figure 4.) When assembling a bridle, it is important to load the loudspeaker in the proper direction. Because the tension in a bridle leg increases as the slope of the bridle leg increases, it is common to find bridle leg tensions exceeding loudspeaker enclosure weights by three to five times the gross loudspeaker enclosure weight. Loudspeaker enclosures are not made for this type of longitudinal tension, and a load applied in this direction can quickly compromise the loudspeaker enclosure's structural integrity. To prevent the longitudinal tension from reaching the loudspeaker enclosure, insert a properly sized horizontal wire rope between the bridle legs. The horizontal wire rope absorbs the damaging lateral tension so that the loudspeaker enclosure is subjected only to vertical tension, as if it were being suspended from a point directly above.

Loading the loudspeaker hardware properly

A loudspeaker sold to be used in an overhead suspension application must be accompanied by an official certification by the loudspeaker manufacturer stating this fact. Without this certification, the product liability for the loudspeaker will be directed toward the contractor and the loudspeaker manufacturer. In short, if the contractor wants to take responsibility for the structural capacity of the loudspeaker, then a certification is not necessary; if the contractor wants minimal product liability exposure, then certification is mandatory.

Many loudspeaker enclosures are made using hardware from hardware vendors who do not provide the loudspeaker manufacturers with a certification for overhead suspension. In regard to product liability, this does not concern the contractor as long as the loudspeaker manufacturer is willing to provide the certification for overhead suspension on the loudspeaker enclosure assembly. In this case, it is the

Figure 7. Ring pan, ring/stud and stud pan fittings. (Courtesy Kinedyne)

Figure 8. Round anchor fitting. (Courtesy of ANCRA.)

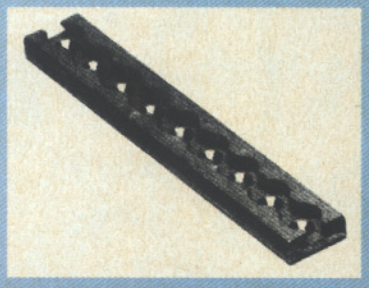


Figure 9. L-type cargo control track.

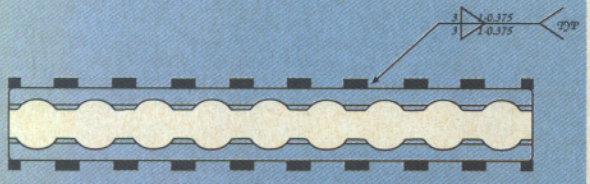


Figure 10. ATM-TRACK. (Courtesy ATM Fly-Ware)

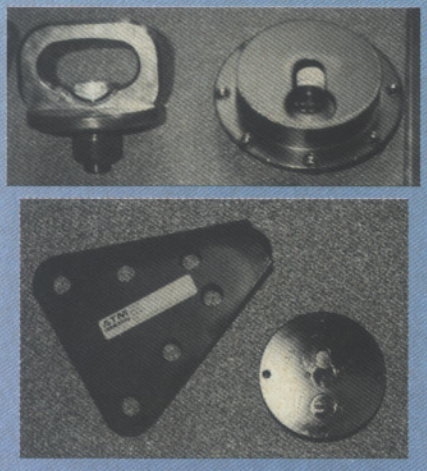


Figure 11. A pivotal fitting from MAN Systems (above) and the ATM Fly-Ware MEGS system (below).

loudspeaker enclosure manufacturer that accepts product liability for the hardware sold by the vendor. Once again, it's the contractor's responsibility to require manufacturer certification to minimize product liability exposure.

Here are some of the more popular loudspeaker enclosure hardware types and what quality points to look for:

• *Eyebolts:* Several types of eyebolts are available to the contractor, but only one type of eyebolt should be used to suspend a loudspeaker enclosure. Only a forged shoulder eyebolt with product traceability should be considered for the job of suspending a loudspeaker enclosure. A quality forged shoulder eyebolt will provide an adequate working load limit for most applications while allowing the load angle to vary as long as the load is applied in the plane of the eye. Not all forged shoulder eyebolts will allow load angles in excess of 45°; therefore, the contractor must be certain to buy an eyebolt with manufacturer certification for load angles of up to 90°. Always use eyebolts according to the manufacturer's instructions.

• *Swivel-ring fittings:* Swivel-ring fittings are used when eyebolts cannot be used because of off-axis loads applied to the suspension point. Numerous swivel-ring fitting designs are available, and most are certified for overhead suspension applications. These fittings can be useful for attachments to structural beams and can be welded on to steel surfaces. Soft surface installations will reduce the effective working load limits.

• *Pan fittings:* All varieties of pan fittings are designed for cargo control and are therefore not certified for overhead suspension by the hardware manufacturer. However, loudspeaker manufacturers that use the pan fittings will normally accept product liability for use within their products. Pan fittings can be loaded in any direction up to a maximum load angle of 45°. As with other hardware components, the load ratings are reduced for angled loads.

• *Round anchor fittings:* Round anchor fittings are also designed for cargo control with product liability similar to pan fittings.

• *Cargo control track and fittings:* As with the pan fittings and round anchor fittings, cargo control track and most associated fittings are not certified for overhead suspension.

• *ATM-TRACK and fittings:* An alternative to the aircraft cargo control track is ATM-TRACK, which is made from steel rather than aluminum. This track is identical to the aircraft cargo control track in function and inside dimension, but it is specifically designed for overhead suspension and is certified for that application. Certain ATM-TRACK fittings are certified for overhead suspension when used in conjunction with the ATM-TRACK.

• *Threaded hole:* Threaded holes are constructed for a bolt fastener to apply tension against the threads inside the enclosure, usually located on an internal brace. This type of loudspeaker enclosure hardware functions best under tension, but light torsion loads can be applied.

• *Pivotal fittings:* Loudspeaker enclosures equipped with pivotal-style rigging hardware are unique to the professional loudspeaker industry. The fittings are designed for vertical loading only and should never be loaded in any other direction. As with all rigging hardware, follow the manufacturer's instructions completely.

Loading loudspeaker suspension grids

Loudspeaker suspension grids come in all shapes, sizes and varieties. Standard suspension grids are available as off-the-shelf products from notable rigging hardware manufacturers, as are customized grids, which can be designed, certified and fabricated by various means. As a general trend, loudspeaker suspension grids tend to be flat and large enough to accommodate vertical suspension of the loudspeaker below.

Loudspeaker suspension grids should not encounter torque. The generally flat grid designs do not allow for

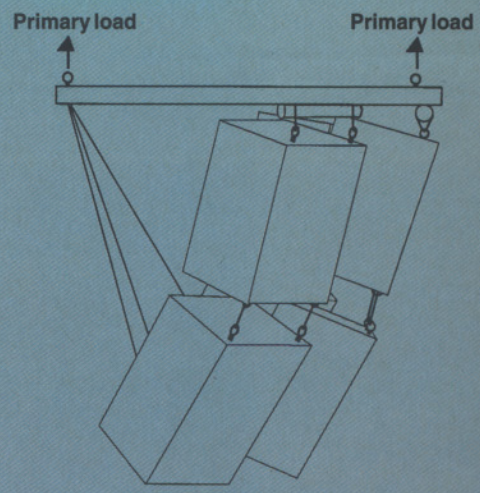


Figure 12. When loading loudspeaker suspension grids, do not torque the grid. Keep the grid flat with no slip joints, and distribute the load over the grid suspension points.

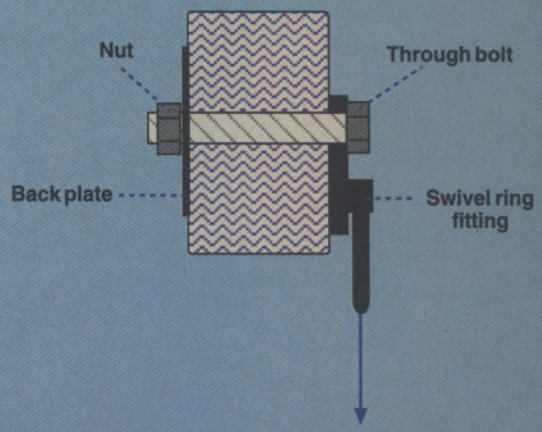


Figure 13. For wooden beam attachment, a swivel ring fitting is attached to a wooden beam using graded hardware.

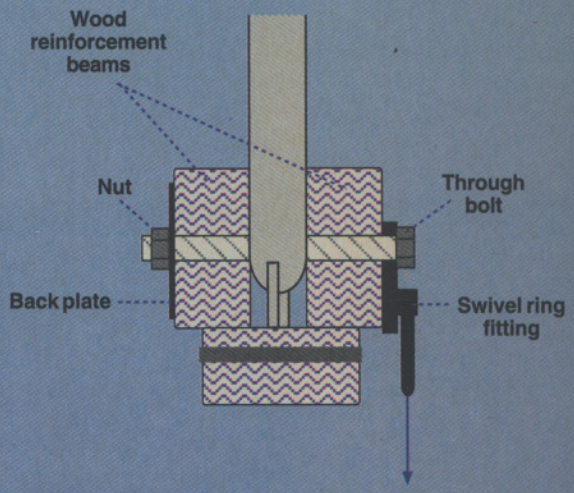


Figure 14. For joist truss attachment, a swivel ring fitting is attached to a wood and metal joist truss using graded hardware and wooden reinforcement beams.

significant stiffening of the grids. The easiest way to keep a grid from torque is to maintain a level grid with even and synchronous loading. For this reason, it is not recommended that slip joints be used in the structural framework of suspension grids.

Load distribution among the primary grid suspension points should be balanced. It is much easier to maintain a balanced load distribution with only three primary suspension points, but four primary suspension points are more common. With four primary suspension points, at the very least, two of the points should include a turnbuckle or another adjustable tension device in order to balance the load distribution in the grid.

Appropriate suspension means

The most common and practical means will accommodate almost every contingency and are as follows:

• *Wire rope:* Wire rope and wire-rope slings are the foundations of most suspension systems. Wire rope comes in a variety of types and styles to fit many specialty applications. The most common types of wire rope used in the loudspeaker rigging industry are 7×19GAC (galvanized aircraft cable) for sizes up to $^1/_2$ inch (13 mm) and 6×19IWRC (independent wire rope core) for sizes above $^1/_2$ inch. The United States requires minimum strength standards, so it is a good idea to buy only wire rope that is manufactured within the United States.

Wire-rope slings can be made on site by using U-bolt clips or compression sleeves. But it is better to order wire rope slings from a rigging distributor and request an OSHA tag for each sling, which provides added product liability safety.

Self-regulatory industry design factors for wire rope suspension systems are 5:1 for static loads and 8:1 for moving wire-rope systems.

• *Chain:* OSHA 1910.184 applicable to chain lifting slings requires no less than an annual inspection and possible certification of proof load. This standard makes chain slings impractical for most loudspeaker suspension systems. But if a chain sling must be used, only two grades are allowed for overhead suspension — Grade 5 or Grade 8. With both of these grades, the chain is available only in larger sizes and must be certified and tagged by the rigging distributor.

• *Threaded rod:* Threaded rod can be an excellent tool if used properly, but applications are limited because threaded rod is not built for bending or torsion. As long as threaded rod is loaded only in tension, it can be very strong. Threaded rod comes in many grades; grade B7 is one of the most popular high tensile strength grades, and it is readily available at steel suppliers and fastener suppliers. Low-grade threaded rods are not appropriate for overhead suspension applications.

• *Fiber slings:* Fiber slings are generally not appropriate for permanent installations because of the fire hazard presented by the nylon, polyester and Kevlar fibers used in their construction. Although the melting point of some fiber slings is above that of wood, fiber slings are generally not accepted by fire hazard regulatory agencies. Fiber slings are excellent tools for installing suspension systems and for suspending loudspeaker clusters temporarily while more acceptable means of suspension are being made.

• *Hardware:* The most common hardware types are shackles, turnbuckles, locking steel carabiners, quick links and sling links. With all of these hardware types, it is mandatory to have the manufacturer certification for overhead suspension. This must be stressed with hardware because imported hardware comes from multiple sources, and you could re-

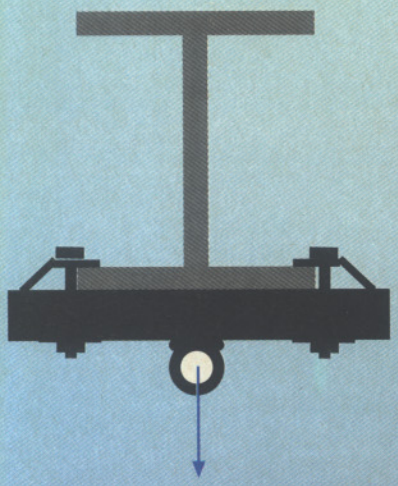


Figure 15. A typical installation of a beam clamp attached to a wide-flange I-beam.

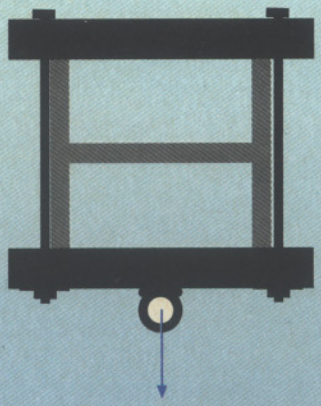


Figure 16. A typical installation of a beam clamp attached to a wide-flange H-beam.

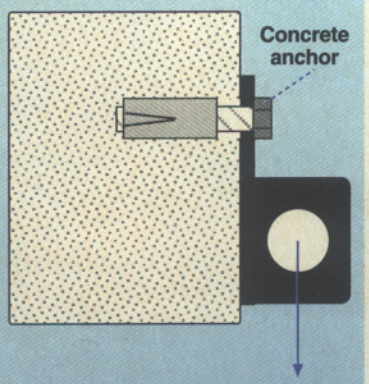


Figure 17. A typical installation of an attachment plate attached to a concrete beam.

ceive counterfeit hardware with absolutely no certification or traceability. To be safe, buy only the top brand names for overhead suspension applications. Always use hardware in accordance with the manufacturer's instructions.

Any hardware components with moving parts must be locked into position once adjusted to their final position. Screw-type hardware designs can be locked in place with thread-lock adhesive; on some of the designs a retaining wire can be wrapped around the component to prevent it from loosening.

Attachment to structures

Structural attachment can be difficult to approach because contractors face an immeasurable number of attachment circumstances. It is imperative for the contractor always to consult a professional engineer or the building architect to confirm the loading and structural-attachment-point positioning. Do not treat this issue lightly; most accidents within the loudspeaker rigging industry occur at the structure attachment and are caused

entirely by the contractor's avoidance of this step. Be aware that the damages caused by a loudspeaker enclosure or loudspeaker cluster falling will be born by the contractor if the necessary and reasonable steps to avoid the accident have not been taken.

Each type of attachment structure requires specific methods:

- *Wooden beam:* Loudspeakers may be attached to structures built with large wooden beams by installing swivel ring fittings with through bolts that travel from one side of the beam to the other. Lag bolts should not be used to attach hardware to wooden beams.
- *Wood and metal joist truss:* Installing reinforcing cords to the truss' lower cord and installing swivel-ring fittings with through bolts that travel from one side of the reinforcing cord to the other is the way to attach your units to a wood and metal joist truss. Do not use lag bolts to attach hardware to wooden beams.
- *Steel I-beam:* The attachment can be made by installing beam clamps, which are positioned along the I-beam flange and clamped down at the desired location. Various beam clamp designs are available for vertical loading only, and additional designs are available for off-axis loading.
- *Steel H-beam:* Position beam wraps along the H-beam, clamping them down where you need them. The various beam clamp designs are manufactured for vertical loading only or manufactured for off-axis loading.
- *Concrete:* Concrete requires steel attachment plates with redundant concrete fasteners designed for the appropriate tension or shear load. If possible, the fasteners should be placed in shear rather than tension.

Looking for more answers

Most responsible loudspeaker manufacturers have technical service people who are happy to help contractors install their products appropriately and safely. Rigging contractors are an excellent way to get information as well. With small jobs, the rigging contractor will probably offer advice free of charge. On large jobs, a rigging contractor can perform the work faster and eliminate safety concerns.

The rigging hardware manufacturer can help, too. Rigging hardware manufacturers have a wealth of information on all kinds of challenging installations. Responsible rigging hardware manufacturers will be happy to help the contractor, even if the contractor is not buying product from them. Whatever you do, be sure to ask all the questions you need before you suspend that first loudspeaker. S&VC

Martin is president of ATM Fly-Ware, Carson, CA.