Suspension System

Warning!
The information in this section has been assembled from recognized engineering data and is intended for informational purposes only. None of the information in this section should be used without first obtaining competent advice with respect to its applicability to a given circumstance. None of the information presented herein is intended as a representation or warranty on the part of JBL. Anyone making use of this information assumes all liability arising from such use.

All information presented herein is based upon materials and practices common to North America and may not directly apply to other countries because of differing material dimensions, specifications, and/or local regulations. Users in other countries should consult with appropriate engineering and regulatory authorities for specific guidelines.

Are You New to Rigging?

If you are new to rigging, then you should do the following:

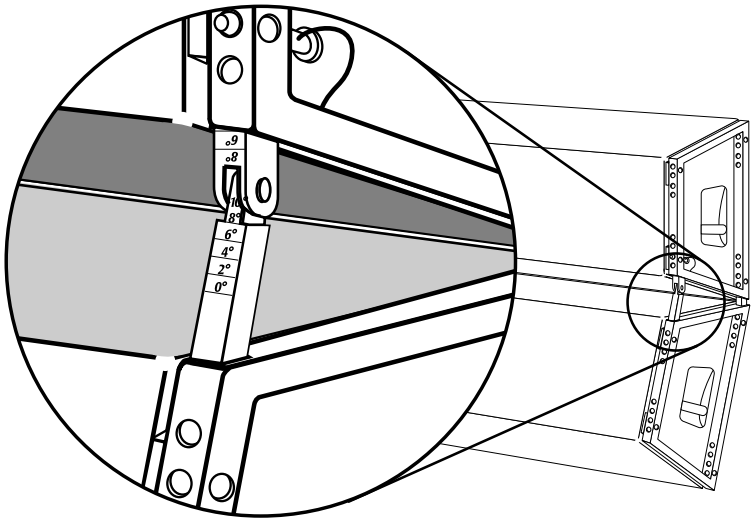
- Get, read, and study JBL Technical Note Volume 1, Number 14: Basic Principles for Suspending Loudspeaker Systems. Know the Rules for Safe Rigging.
- Think strongly about attending a safe rigging seminar, such as that presented by professionals like Rigging Seminars(tm) or by Chain Motor Hoist manufacturers like Columbus McKinnon Corp. (manufacturers of the C/M Lodestar).
- Meet and establish a relationship with a licensed mechanical or structural engineer. Get in the habit of asking them questions instead of guessing about their answers. Learn from what they tell you.
- Meet and discuss this aspect of your business with your Insurance Agent.
- Research and understand the codes, practices, and requirements in the venues where you intend to operate your sound system.

Warning!
The safety issues that accompany suspending any sound system in the air (especially above the heads of personnel) must be learned, followed and adhered to. Ignore this at your (and your company's) peril. Work with rigging and suspension techniques and equipment correctly and you have nothing to fear. Do it incorrectly and you may encounter serious legal issues related to property damage or personal injury.

VERTEC Suspension System

The VERTEC suspension system consists of:

- One of two array frames (large array frame VT4889-AF and short array frame VT4889-SF). These are not supplied with the loudspeaker and must be purchased separately. You need one array frame per vertical array. You may elect to use two as discussed later in this chapter.
- Two heat-treated metal alloy suspension brackets, or “Rigging Frames”. These are supplied with every VERTEC loudspeaker system.
- Hinge Bars of two types - short (for front-of-box use) and long (for back-of-box use). The hinge bars are part of the rigging frames, attached to each VT4889 enclosure. This set of 4 bars, 2 of each type, is also available separately as Part VT4889-RIG.
- Quick-release pins with restraining lanyards.



Box splay angles are adjusted with the pair of rear hinge bars.

Each VT4889 enclosure includes its own integral suspension hardware. This hardware is captive to its own box and travels with it. The suspension hardware package is an extension of JBL's time-tested S.A.F.E. rigging hardware system, relying on quick-release pins and custom tubular metal frames to couple adjacent VT4889's together into arrays that are rigid for maximum support strength, yet flexible in design and application.

- Premium-grade heat-treated chromemoly steel alloy, cadmium-plated hinge pins and stainless steel restraining lanyards provide a degree of resistance to weather exposure.
- Suitable suspension equipment such as shackles, SpanSets (synthetic polyester fiber slings) or bridle cables, and chain motors are supplied by you, the system user, as required.

Note: While fiber slings are lightweight, easy to handle and softer on equipment, their fire ratings are relatively poor compared to steel wire rope. ***Fire codes vary - consult local authorities before using fiber slings.***

S.A.F.E.™ Suspension Hardware

S.A.F.E. (Secure Array Flying Ergonomics) suspension hardware technologies were first introduced by JBL in 1992. Hallmarks of this suspension hardware include the ability to rig a cluster quickly and securely, and the use of field-replacable external frames. An array can be quickly assembled to provide desired coverage using a minimum number of fittings, each purpose-engineered for the VerTec VT4889 enclosure.

- This hardware system features bolt-on end-mounted rigging frames that can be removed and replaced in the field if necessary. Quick release pins, secured with restraining lanyards, couple to the rigging frames.
- Examples of each individual piece of the suspension system have been tested to confirm their Ultimate Strength.
- All quick release pins must be fully inserted and checked for positive locking prior to applying a load.
- An enclosure is 'ready to fly' as soon as it comes out of the truck and into the venue.

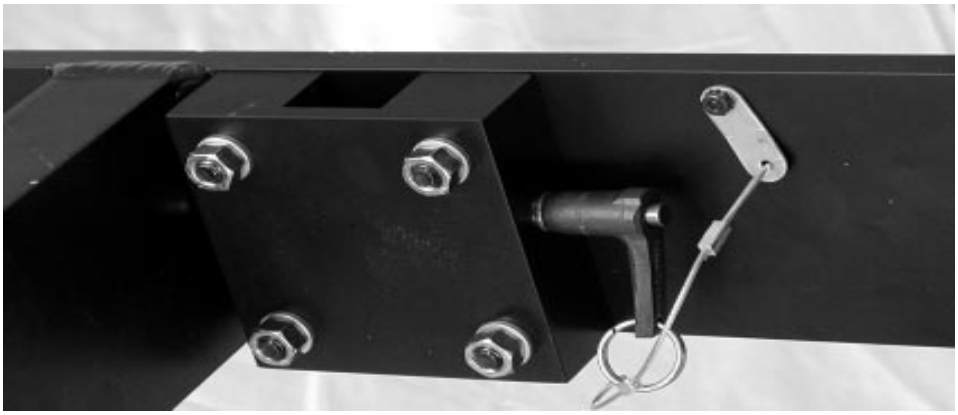
Warning!
Correct use of this hardware is required for secure array construction. Careful calculations should always be performed to ensure that all components are used within their rated workload before the array is suspended. Never exceed the maximum recommended load ratings.

NOTE: JBL Technical Note Volume 1, Number 14 (Suspending Loudspeaker Systems) explains basic principles of suspending loudspeaker systems and provides further references.

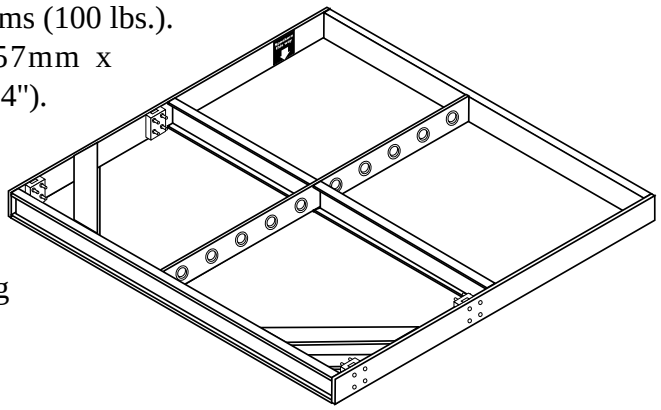
VT4889-AF (Array Frame)

The VT4889-AF array suspension frame is crafted of 6061 T-6 aluminum. It includes 11 (eleven) attachment holes for fitting 6.5 ton 3/4" shackles. Each of these holes is fitted with a bronze bushing for longer life. These holes are set on 102mm (4") centers. Each hole has an I.D. (Inner Diameter) of 25.4mm (1").

The frame includes four receiver blocks, designed to attach Hinge Bars from the VT4889 enclosures. These blocks are made of 7075 Grade aluminum. They are coupled with Grade 8 bolts, and the attached steel quick release pins are secured with stainless steel restraining lanyards.



The VT4889-AF weighs 45 kilograms (100 lbs.). It measures approximately 1257mm x 1129mm x 102mm (49.5" x 44.45" x 4").



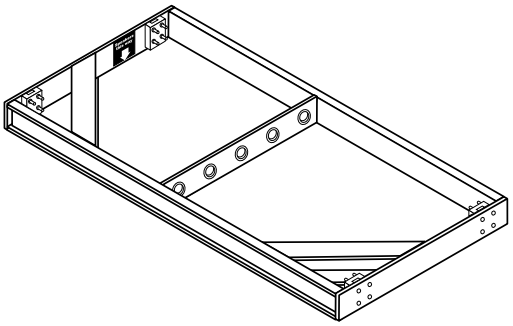
The maximum number of VT4889 enclosures to be suspended with this frame is 18 (eighteen). WLL (Working Load Limit) is 1,298 kg (2,862 lbs.)

VT4889-SF (Short Frame)

Like the larger VT4889-AF, the Short Frame is crafted of 6061 T-6 heat-treated aluminum. It includes 6 (six) attachment holes. Each hole is fitted with a bronze bushing for longer life. These holes are set on approximately 102mm (4") centers. Each hole has an I.D. (Inner Diameter) of 25.4mm (1"). The frame includes four receiver blocks, designed to attach Hinge Bars from the VT4889 enclosures. These blocks are made of 7075 aluminum. They are coupled with Grade 8 bolts, and the attached steel quick release pins are secured with stainless steel restraining lanyards.

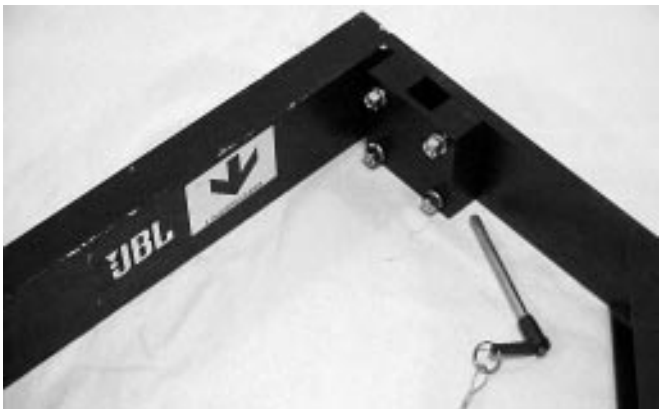
The VT4889-SF weighs 23.6 kilograms (52 lbs.). It measures approximately 1257mm x 660mm x 102mm (49.5" x 26" x 4").

The maximum number of VT4889 enclosures to be suspended with this frame is 18 (eighteen). WLL (Working Load Limit) is 1,298 kg (2,862 lbs.)



Array Frame Configurations

Each array frame is fitted with a graphic label showing an arrow, and the word “Loudspeakers”. The purpose of this label is to inform you, and your stagehands, which way is “up”. When using an array frame to suspend loudspeakers, the speakers hang below the frame, thus the frame should be set so that the arrow points down towards the speakers.



When using a frame to ground-support a stack of VT4889 enclosures, the frame is designed to be turned over so the arrow points up (towards the speakers it is supporting). What is the difference between one side up, or the other? The front and rear receiver blocks on the VT4889-AF and VT4889-SF are designed to receive the hinge bars from an enclosure in a specific manner. The array frame must be properly oriented to the enclosures and to the hinge bars in order to attach the enclosures to the array frame.

For detailed information on putting VERTEC arrays together, see Chapter 7, “Array Setup”.

A typical hanging array of VT4889 enclosures can be suspended from either one VT4889-AF array frame, or one VT4889-SF short frame.

The VT4889-AF's primary uses are:
- Suspension of a VerTec array up to 18 (eighteen) enclosures.
- Ground stacking up to 6 (six) VT4889 enclosures.

The VT4889-SF's primary uses are:
- Suspension of smaller arrays, typically 4-6 boxes if using only a top array frame.
- As an 'anchor' array at the bottom of very large arrays, if a separate chain motor is required at the bottom of the array for manipulating arrays tilted at radical angles.
- Suspension of larger arrays, if also using a bottom 'anchor' array frame with separate chain motor attached.
- Ground stacking up to 4 (four) VT4889 enclosures.

Working With Array Frames

A typical array requires only one array frame. Use either a VT4889-AF (Array Frame) or a VT4889-SF (Short Frame). Details of these two frames are provided earlier in this chapter. Either product supports up to 18 (eighteen) VT4889 enclosures with a 7:1 design factor.

The Working Load Limit (WLL) of any part of the array suspension system is the Ultimate Strength divided by the Design Factor. The 7:1 design factor represents a more conservative approach to suspension system design than 5:1 or 6:1 ratings.

Caution...
Before suspending any array always inspect all components of the array (enclosure, rigging frames, pins, Array Frames, etc.) for cracks, deformations, corrosion, missing or damaged parts that could reduce strength and safety of the array. For any items not supplied with the VERTEC system, always use only load-rated hardware. Building structural supports and chain-motor hoists require inspection prior to each use by knowledgeable professionals.

Array Frame Angle

The A.F.A. (Array Frame Angle) usually matches the Box 1 Aiming Angle shown in the Line Array Calculator software.

For more information on this software application see Chapter 9, "Line Array Calculator Software".

You can adjust the A.F.A. by one of two methods.

1. Use a single hoist and adjust the angle of the array frame by choosing one of the available holes on the VT4889-AF or VT4889-SF array frames
2. Use two hoists and operate them independently to achieve the desired array angle.

For more information, see Setting the Array Frame Angle in Chapter 7, "Array Setup".

When using a single chain motor hoist, the specific hole on the array frame's center support rail determines the natural angle of hang, based on the array's center of gravity. A secondary, separate bridle made of deck chain or other appropriate material can be used to modify the attitude of the array.

When using two chain motor hoists, the front and back motors can be operated independently to adjust the array frame's attitude. Under these conditions, the distance between the two pickup points on the VT4889-AF array frame is typically less than one meter (3.3 feet). The pickup points may be moved forward or backwards on the array frame's center spine to modify the angle that the array frame hangs at when it is loaded.

The specific pickup points chosen vary based upon array size (the number of boxes affects the overall array weight), and enclosure splay angles (which also affects the center of gravity).

Rigging Frames and Hinge Bars

The Rigging Frame is the metal structure attached to each end of a VT4889 enclosure. Stored within each of the rigging frames are long (rear) and short (front) hinge bars that are secured into the rigging frames with spring-loaded locking pins. The locking pins are attached to the rigging frames with aircraft cable lanyards.

The rigging frames are made of heat-treated 4130 premium steel alloy. They attach to the VT4889 enclosure with machine screws set into four pads on each end of the enclosure. The surfaces of these pads have been carefully milled to a tolerance of ± 0.010 inch. This ensures that the rigging frames on each box couple smoothly to the rigging frames on other VT4889 enclosures.

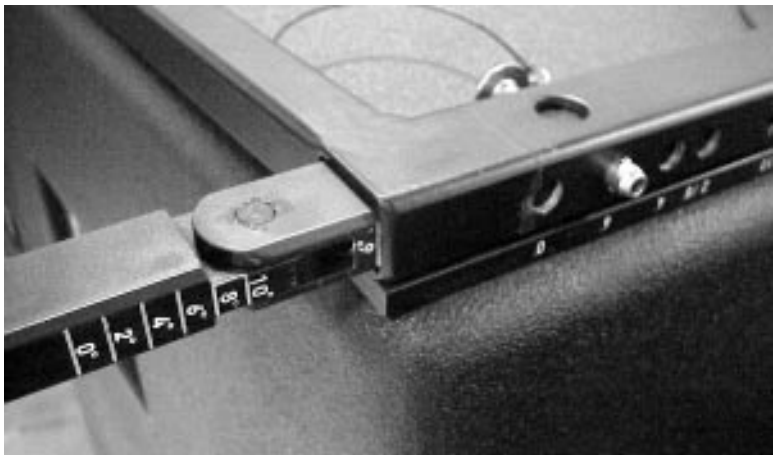
VT4889-RIG comprises a set of two long (rear) and two short (front) hinge bars...the same set of bars supplied inside the rigging frames on a VT4889 enclosure.

The hinge bars slide in and out of the rigging frames Quick-release pins lock the hinge bars into the rigging frames for storage as well as for operation. The hinge-bar design allows changing the angular relationship of any enclosure in the array to its neighbors in one-degree increments from 0-degrees to 10-degrees. The hinge bars store inside of the rigging frames, so there is no need to carry loose hardware pieces in assorted sizes as with some other modular systems.

The front hinge bar is the smaller one in the set. It is captive in the rigging frame, with a small thumb, or ‘slider’ knob threaded in place after the front hinge bar is fitted into the rigging frame channels. The slider knob’s threads are coated with a thread-locking compound prior to assembly.

Front hinge bar, showing quick release pin clipped in place.

The rear hinge bars, of which there are two with each VT4889 enclosure, are longer. Each one is marked by degrees, from 0 to 10 in 2-degree increments. This labeling enables you to set the box splay angles. Although the rear hinge bars are marked in 2-degree increments, the design allows adjustment in 1-degree increments.



End corner view of a VT4889 enclosure showing the long (rear) hinge bar out of its storage channel, and pinned to the rigging frame. Note this bar is set in the six degree position.

To set a particular angle using the hinge bars slide the hinge bar out of the rigging frame until the desired angle marked on the bar aligns with the edge of the rigging frame. Lock the hinge bar to the rigging frame by inserting the quick-release pin into the hole located opposite the desired angle marking. Do this for both arms of the hinge bar.

The hinge bars are marked in two-degree increments. However they may be set at one degree increments by choosing settings that bracket the desired angle. For example, to set a five degree angle, pin one arm at six degrees and the other arm at four degrees. Ensure that you match this on the other side of the enclosure.

For more information on connecting VT4889's using the Hinge Bars, see Chapter 7, "Array Setup".

Despite their compact size, the hinge bars are extremely strong. The bars are made of chromemoly, a premium-grade steel alloy that has molybdenum and chromium as its primary additives. Each bar includes chromemoly hinges and cryogenically tempered chromemoly hinge pins.

Note: Each rigging frame and each AF and SF frame is equipped with dated and serialized tags with source codes, allowing materials and vendor to be traced, and containing important safety and WLL (Working Load Limit) information. The Working Load Limit is the Ultimate Strength divided by the Design Factor.

Testing of Rigging Hardware

Rigging Frames and Array Frames supplied with the VERTEC system are specified based on guidelines set forth by the AWS (American Welding Society), ASTM (American Society for Testing and Materials), OSHA (Occupational Safety and Health Administration), and ANSI (American National Standards Institute).

All suspension hardware is load rated, and has been tested by NTS (National Technical Systems). The results of this testing show that the following parts will meet or exceed the specified 7:1 Design Factor at these WLL's (Working Load Limits), considering the worst-case scenario in array use of two suspension points only:

Item	JBL Product / Part No.	WLL (Working Load Limit)
Rigging Frame, VT4889	888-00110-00	1,431 lbs. (649 kg)
Hinge Bars, VT4889	VT4889-RIG	1,431 lbs. (649 kg)
Array Frames	VT4889-AF, VT4889-SF	2,862 lbs. (1,298 kg)

For more information on testing and load limits, consult the document, "Suspension Hardware Testing & Working Load Limits-VT4889 System", available to system owners.

JBL suggests using a 7:1 design factor in suspension systems. Each piece of the overall suspension system has an ultimate strength that is at least 7 times the weight of the equipment being suspended. Up to 18 VT4889 enclosures can be suspended in a single array while conforming the 7:1 Design Factor.

Note that this 7:1 factor is based on "worst-case" scenarios, i.e. an assumed two-point suspension, where only two out of four hinge bars are actually supporting the enclosures below them. This may occur in arrays that have extreme box angles and/or radical attitude adjustment on the array frame. Under these conditions, the load of the suspended array beneath a set of hinge bars can sometimes be shifted all the way forward...or back. When this occurs, most if not all, of the load beneath the set of 4 connected hinge bars is actually being carried by only 2 of that set of 4 hinge bars.

The VERTEC system's recommended 7:1 Suspension System Design Factor should always be followed to prevent mishaps. When properly set up and used, VT4889 arrays can be assembled and set to hang at radical angles.

A Few Words About Chain Motors

A chain motor or chain hoist is an electric motor that lifts a load into position. Most are modified, or supplied as “inverted” motors so as to climb up the chain in the process of hoisting the load. Chain motor hoists are the key to flying lights, sound, and other apparatus used for staging an event.

Chain hoists are made in a variety of lifting capacities, duty cycle, mounting arrangements, and electrical power configurations. Smaller hoists use single-phase power, but larger capacity hoists often use three-phase power.

The lifting capacity of a chain hoist refers to the maximum safe lifting capability of the motor, as well as the maximum static load allowed when the motor has stopped. The manufacturer has already de-rated the hoist as a safety consideration in the unit’s design factor; you can reliably specify a hoist simply based on the load that it must lift. For example, a “1-Ton” motor is said by the manufacturer to be able to use for lifting one ton (2,000 lbs. or 907 Kg). The duty cycle refers to the on/off cycle expected during use. Since the hoists are used intermittently during setup and teardown, lower duty-cycle devices are permissible.

Columbus McKinnon (CM Lodestar) is the dominant manufacturer of chain hoists used in entertainment applications worldwide.

http://www.cmworks.com/products/Hoists/section02.pdf

Once again, safe rigging happens by design and training, not by accident. Training is very useful.

http://www.riggingseminars.com

Summary

JBL's VERTEC system offers the most flexible hardware attachment and suspension system available on any commercially-available line array. It has been engineered to provide fast setup, long life "on the road" and resistance to environmental hazards while maintaining a 7:1 Design Factor, even on large arrays of up to 18 (eighteen) enclosures.

Warning!
Never exceed the WLL (Working Load Limit) noted on Rigging Frames and Array Frames. Overhead suspension of loudspeaker systems should be undertaken only by trained and qualified personnel. JBL Professional is not responsible for the use, misuse or misapplication of these products.