

LIFTING BAGS

A TECHNICAL MANUAL FOR LIFTING BAGS

- HOW THEY WORK
- DIFFERENT TYPES
- LIFTING TECHNIQUES
- CRIBBING SUMMARY
- DO'S AND DON'TS

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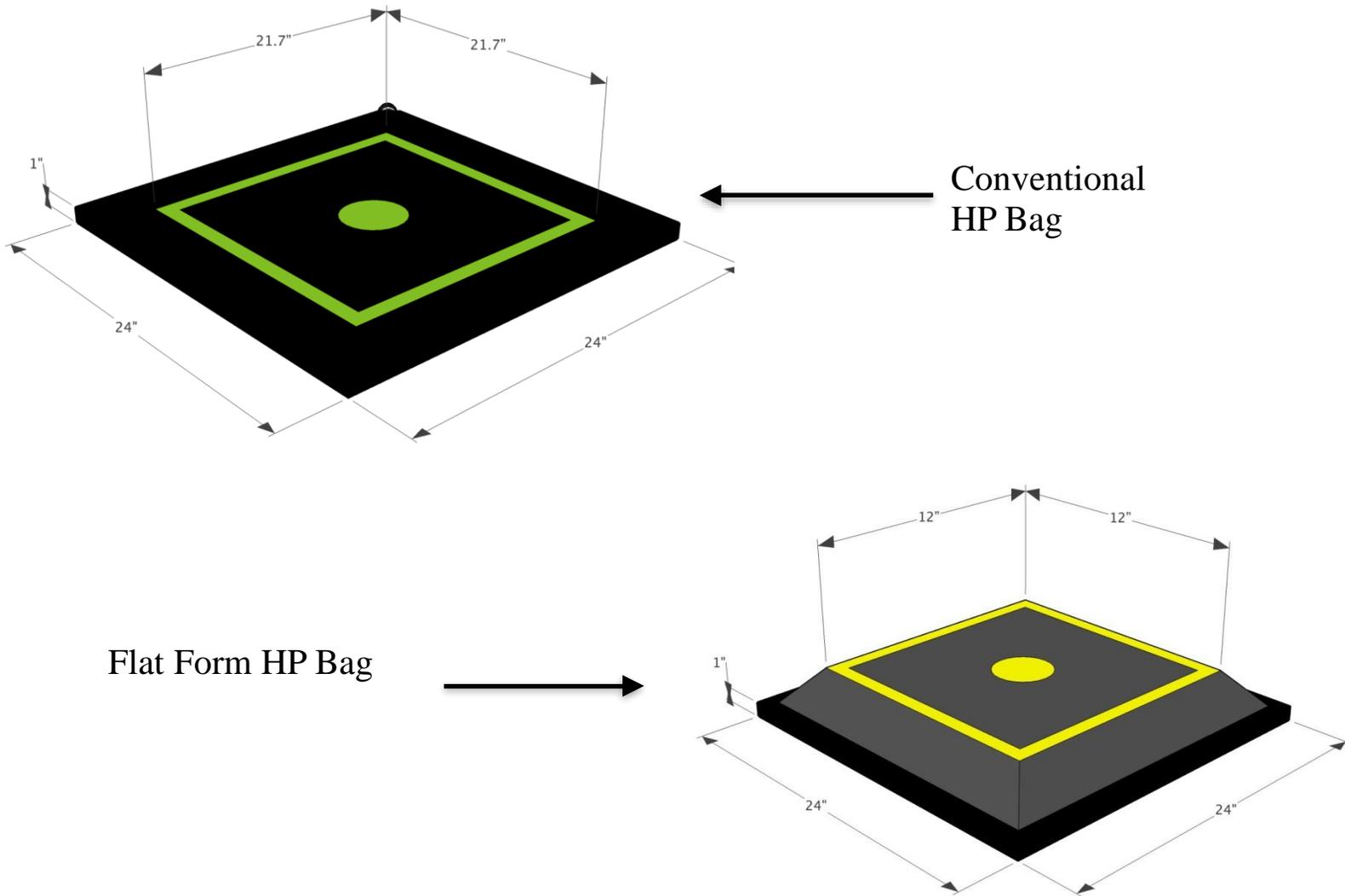
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HOW IT WORKS

1. CALCULATING LIFTING CAPACITY

A Lift bag obtains it's lifting capacity by multiplying the following two components.

1. The functional area of the lift bag (The area in contact with the object being lifted)
2. The internal air pressure.



Example

Say the functional area of the airbag is 24 square inches (SQ.IN) and the operating pressure is 116 pounds per square inch (PSI)

The resulting lifting capacity would be:

24" x 24" HP bag has a 21.7" x 21.7" lifting surface at 1"

$$21.7" \times 21.7" = 470.87 \text{ SQ.IN}$$

$$470.87 \times 116\text{psi} = 54,623\text{lbs (27 Tons)}$$

Flat Bag resulting lift capacity would be:

24"x 24" HP Flat Lifting bag has 21.7"x 21.7" lifting surface at 1 inch.

At Max height the bag has 12"x12"=144sq" of lift zone 144"sq" x

$$116\text{PSI} = 16,704\text{lbs (8 Tons)}$$

Conclusions

1. The bigger the bag, the more the weight it will lift.
2. The greater the contact area increases, the higher the lifting capacity.
3. The higher the internal pressure, the higher the lifting capacity.
4. As surface contact diminishes so does lifting capacity.

2. Hoop Stress

Hoop stress is the stress in the material caused by the internal pressure and is directly related to the size of the pressure vessel (In this case, your liftbag)

Even with a constant internal pressure, the stress in the material increases with the size (diameter) of the liftbag.

This greatly limits the size of the lift bags. Especially high pressure bags. The biggest high pressure lift bag you'll find are in the 65 to 70 ton range. If they get any bigger, the material has to be so thick, it is no longer useful as an lift bag. For the same reason, on the far larger high lift, lift bags, the operating pressure is greatly reduced to accommodate this problem.

3. Power Curve (Conventional Lift Bags)

Application: HIGH PRESSURE LIFT BAGS

When fully deflated the total size of the lift bag can be utilized for maximum functional area. When the bag is inflated and gains weight, the functional area diminishes since more and more of the lift bag is used for height and not for the functional area.

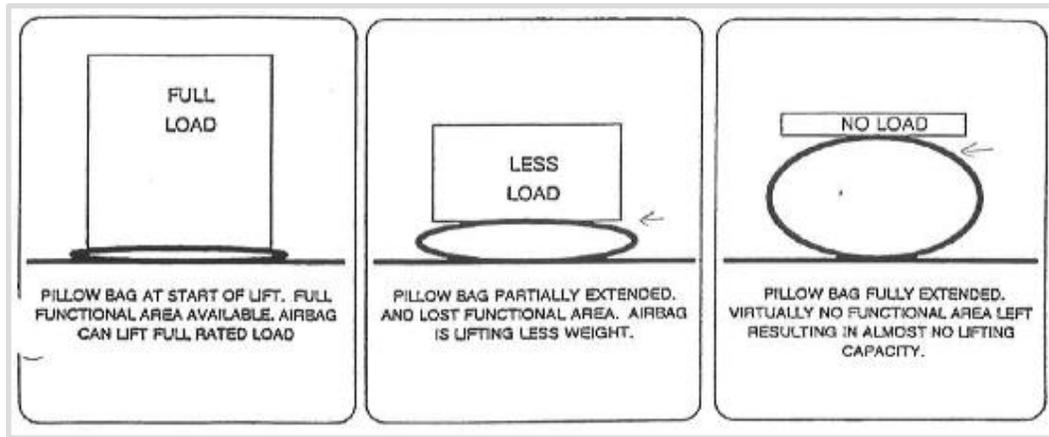
Knowing that the lift bag capacity is directly related to the functional area and assuming the internal pressure to be a constant pressure, the following applies.

1. The conventional HP Lift Bags have a diminishing power curve (Less contact > Less Capacity)

1. At maximum height the bag will theoretically lift no weight (point lost at the top)

See figure 1 on next page

Figure 1:



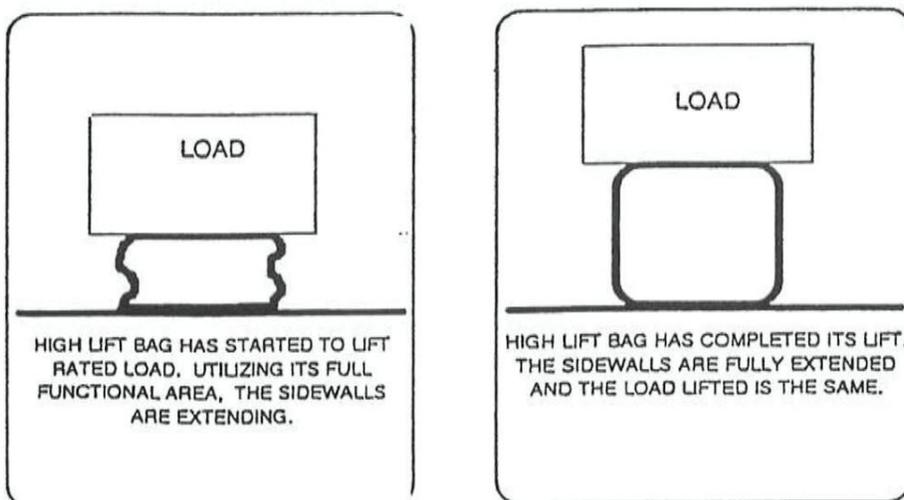
Application: High lift bag or "Cushion"

The lifting height will depend on the required area to lift the load. It is as a third dimension was added to the pillow shaped lift bag. There is a sidewall between the top and bottom plates of the lift bag. With this type of bag, the lifting platform or functional area remains mostly constant throughout the lift as the sidewalls extend.

Knowing that the lifting capacity is directly related to the functional area and assuming the internal pressure to be constant, the following applies.

1. The lifting platform or functional area remains constant therefore the lifting capacity remains virtually constant throughout the lifting range of the sidewall.

Figure 2: Shows lifting progression using pillow bags.



Types of Lift Bags in General

1. High Pressure Lift Bags

Basically consist both a top plate and bottom plate, inflates into “Pillow” shape. All high pressure lift bags use common operating pressure 118 to 145 psi. 8 Bar = 116 to 120 psi 10 Bar = 145psi

Advantages:

- Relatively thin insertion space required, as little as 1 inch thick.
- Thick rubber with aramid reinforcement “Kevlar” has good puncture resistance.
- Tremendous lifting capacity at start of lift.
- Relatively stable lift up to half it’s maximum lifting height.

Disadvantages:

- Diminishing power curve (Pillow bags lift 0 lbs at max height)
- Limited lifting height
- Relatively stiff and heavy handle
- Very difficult or impossible to repair

1A. Flat form Lift Bag

The Flat Form Lifting bag is constructed the same as the conventional high pressure lifting bag except it has a specially constructed inner system. Another difference is that the Flat Form Lifting Bag has a square flat zone top and bottom.

The flat zone does not decrease when air pressure is increased. Therefore the Flat Form Lifting bag maintains a pre-calculated lifting capacity.

The Flat Form Lifting bag will never be reduced to a zero lifting capacity. Also because of the flat zone of the Flat Form Lifting Bag. These bags will maintain a level lifting foot print. That means a stable lift. Operating pressure of 116 psi (8 bar) or 145 psi (10 bar).

ADVANTAGES:

- Very thin insertion, as little as 1 inch
- Thick rubber with aramid reinforcement “Kevlar” has good puncture resistance
- Tremendous lifting capacity, remains consistent through the lift
- Very stable which allows for stacking up to 3 bags

Disadvantages:

- Limited lifting height
- Relatively stiff and heavy to handle
- Very difficult or impossible to repair

3. High Lift Air Cushions

Consists of top and bottom plate with “side wall” in between. Sidewall extends as bag is inflated. Available in cubical or cylindrical shape. Common operating pressure is 15psi. These bags may be configured to follow pressure.

Advantages:

- Constant lifting force as total top plate area is used when sidewalls extend.
- Tremendous lifting weight and height
- Low pressure allows use against sheet metal and on soft ground.

Disadvantages:

- Requires more insertion space. Typical 2 inches
- Less powerful than high pressure lift bags
- Specialized air source

Common shape of lift bags

Square HP Bag Shape

- Used mostly for high pressure lifting bags.
- This shape offers bed power versus lifting height ratio.
- **Relatively stable at low lifting heights with heavy loads.**
- Unstable with lighter loads and or greater lifting heights. Bag takes shape of a ball and becomes very unstable in all directions.

Rectangular HP Bag Shape

- Used for both high and low pressure lift bags
- Not as good power versus height ratio as square bag
- This shape has a big advantage in that when it inflates. It shapes like a long and is therefore stable in one direction at any height.

Cylindrical Sidewall Shape

- Used for some high lift bags.
- Should not be considered stable at any height, especially during lifting process.
- Some stability will be obtained at full lifting height when the sidewalls are fully extended, provided the bag is not higher than its maximum diameter.

Rectangular Sidewall Shape

- Used for high lift bags
- Should not be considered stable at any height, especially during the lifting process.
- Considerable stability can be obtained when the sidewalls are fully extended. Again, the full height of the bag should not exceed the base width of the bag.

INTERNAL TIE DOWNS

High lift bags with internal tie down

Some sidewall bags have internal ties between top and bottom plate. The main reason for these ties is to eliminate the hoop stress on the top and bottom plate of the bags. (See "Hoop Stress" Page 2) Allowing the manufacturer to use less costly seams.

This design adds some stability to the bag only when full height is reached and the internal ties are under tension and only when lifting a light load. In general vertical strands do not provide lateral stability. (As any structural bridge or roof support design) So caution should still be taken against lateral shifting of the load

High Lift Bags Without Internal Tie Downs

The manufacturer has produced a more complex seam that can overcome the hoop stresses at the top and bottom plates. Lack of internal strands allows the bag uninterrupted contact area with the load. However, when raising lighter loads caution should be taken not to exceed the height of sidewall in order to maintain shape.

Multiple Pillow Shape:

A new concept whereby multiple low pressure lift bags have been vulcanized together. When multiple "cells" are inflated, considerable lifting height is obtained.

Note: This style bag has a far greater lifting height than its lifting platform and is therefore less stable at any height. Also, this design is more subject to side loads exerted by angled loads on the top cell. Great caution should be taken at higher lifts.

Basic Lifting Rules:

- While lifting an object, no point of that object should come down.
- No lateral movement of the object can be allowed.
- Any height gained must be secured and maintained.
- Conventional or HP Lift bags alone should not be considered stable
- Avoid being under the lift.

Stability:

Airbags are basically unstable. By lifting a load and assuming the lift bag is not stable, the burden of stability rests on proper cribbing.

Flat lift air bag is far more stable than a conventional HP type lifting bag. As they cannot be rounded or point loaded

Cribbing is essential when using lift bags. Stability using cribbing will be explained for the different shapes of bags in a different chapter.

Stacking Conventional Lifting Bags

- High lift and/or low pressure lift bags should never be stacked.
- High pressure conventional lift bags should should never be stacked.

NOTE: In some cases they can be stacked to a max of two bags only when:

**The object is positively secured against lateral movement*

** The bags are not inflated more than two thirds their max weight*

**The object will not undergo a significant angle change, causing the lift bags to lift against an angled surface*

- Flat lift high pressure bags can be stacked 3 high when required

Side Loading:

Sometime high pressure lift bags are stacked to gain lifting height. Great caution should be taken the the above rules are adhered to. Stacking lift bags should not be standard operating procedure and should be used as a last resort to gain lifting height.

4. Lift Bags & Cribbing:

To obtain stability and safety during a lifting procedure, cribbing is essential in general it is good practice to:

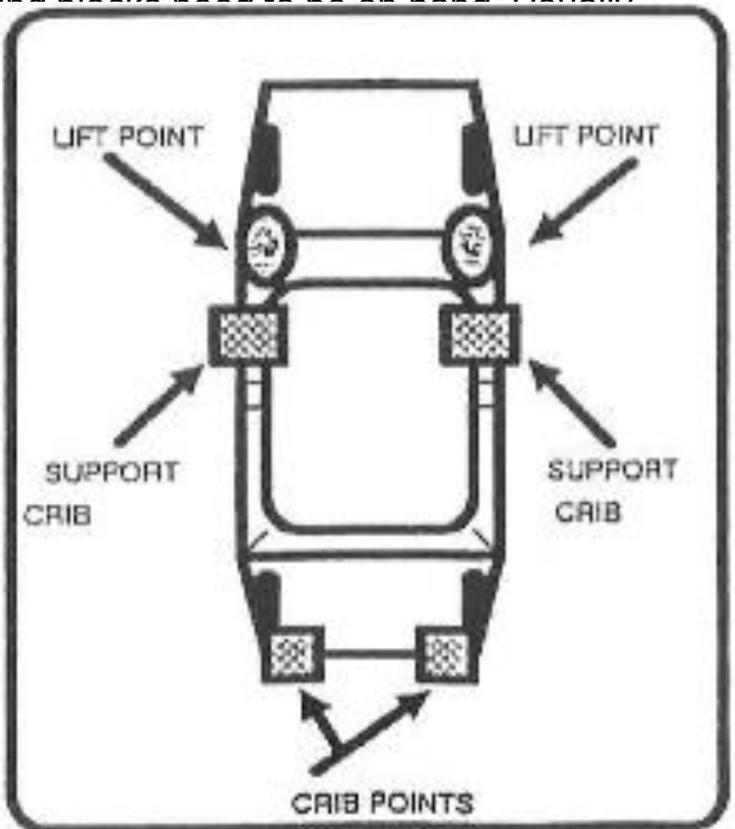
- Crib as you go -OR-
- Lift an inch then crib an inch

To do effective cribbing, a variety of cribbing blocks need to be on hand. Usually consisting of 4x4, 2x4 and 2x6 lumber, at least

Basic single point vehicles lift:

(Small vehicle. car, van, suv)

- Crib two points on downside
- Place lift bag at lift point. Use gravity.
- Place support crib next to lift



Note: When using high lift bags the side supports crib should be at least 8 inches from

During the lift, the support crib will need to be raised. This is a good scenario to use a high lift bag, since it overcomes the distance between the vehicle and the ground without the need to brace the bag on top of a cribbed platform.

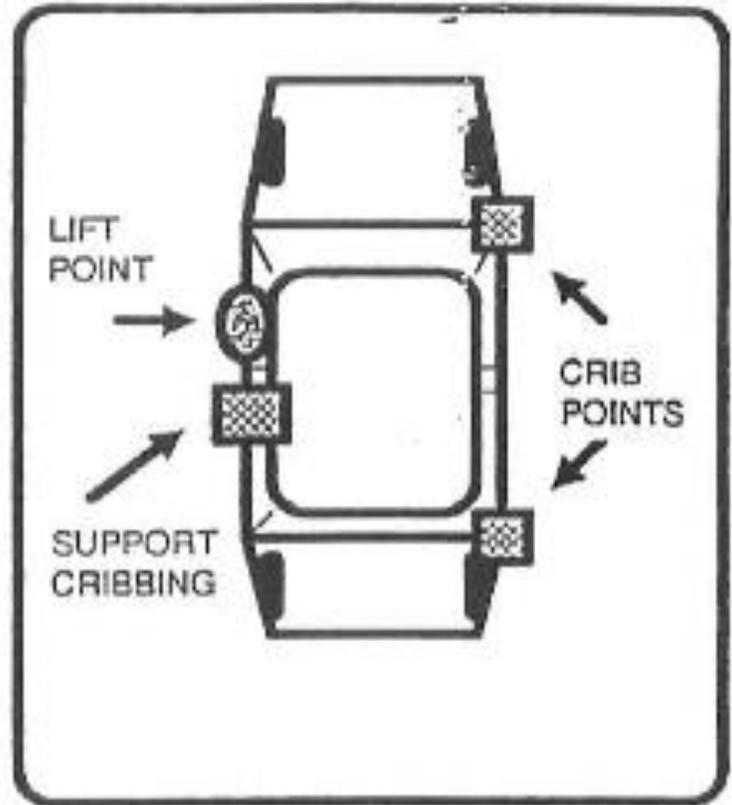
Note: A high lift bag will need to be inserted at least two thirds its functional area. Be aware that high lift bags are flexible and can easily fold around an object causing unwanted side loads. Proper placement is very important.

Dual Point Front or Rear Vehicle Lift

Due to the length of the vehicle, this type of lift is more subject to lateral shifting. The bags should be as close as possible to the crib points. However, they must be clearly on one side of the center of gravity so as not to lift the vehicle backwards.

Try to put the crib points at the widest point of the vehicle for max side load support.

By placing the support or the safety of the crib on the downside if the lift bag, less cribbing height needs to be obtained. Again helping the overall stability of the lift.



Multi-Point Lifting

Lifting busses and vehicles with rigid bodies. Be aware, trucks can bend and flex easily. That will require more lifting points. Each lifting point will require a safety support crib. Often the lift is started with a pillow type high pressure bag at the roof rail or cross support.

Usually there is little insertion room so the pillow bag will work well.

Once the vehicle is lifted a few inches, a high light bag can be used to continue the lift. The advantage is that the lift can usually be done against sheet metal since high lift bags operate on low pressure.

Allow the vehicle to move up. The down side should be supported but not cribbed in such a way to prohibit the movement of the vehicle.

Be careful not to lift the vehicle off its crib points onto its wheels. All lateral stability will be lost.

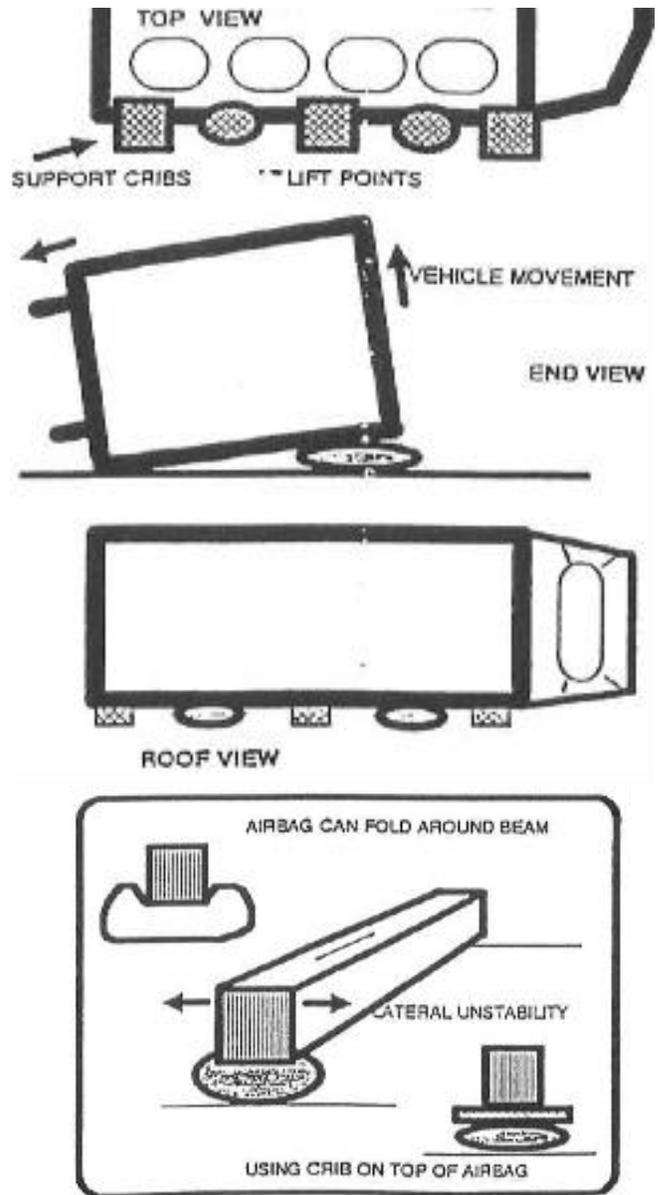
Deflating the tires will allow extra lifting height. Nice that the lift points are 1/4 of the total distance of the vehicle from each end. So the weight is evenly distributed onto the lift bags.

Beam Lift

Lifting beams in a building collapse scenario offers a unique challenge to the lift bags and the operator. Lateral instability is a particular problem.

Usually the beam is much more narrower than the lift bag, causing the bag to fold around the beam.

The functional lifting area is only the contact area of the bottom of the beam on the bag. This is often not enough so the use of cribbing on TOP of the bag is necessary to distribute the load and gain functional area.



NOTE:

The beam will be anchored on one end causing it to be stable in the length direction. The beam is lighter when lifted closer to the end.

Tank and Pipe Lift

1. Place the pillow bags on both sides of the object. Note: Bags may NOT be stacked for this scenario.

1. Inflate them simultaneously to create an even lift.

If more lifting height is required, you can:

1. Place larger pillow bags next to the existing bags. Do NOT use high lift bags. Note: Be sure to keep the bags a sufficient distance from the center to maintain good platform width.

1. Both bags may be placed on a single platform crib at least the same width as the lifting platform distance. Note: Due to the angled forces, individual cribs beneath the lift bag could push out and should therefore be avoided.

Since the bags will be working at severe angles, great caution should be taken to avoid slipping. Unfortunately, practice shows, that special surface designs do very little against slipping since the bags are of softer material than the usual steel or concrete surface about to be lifted.

.Be sure that the bags are clean for best grip.

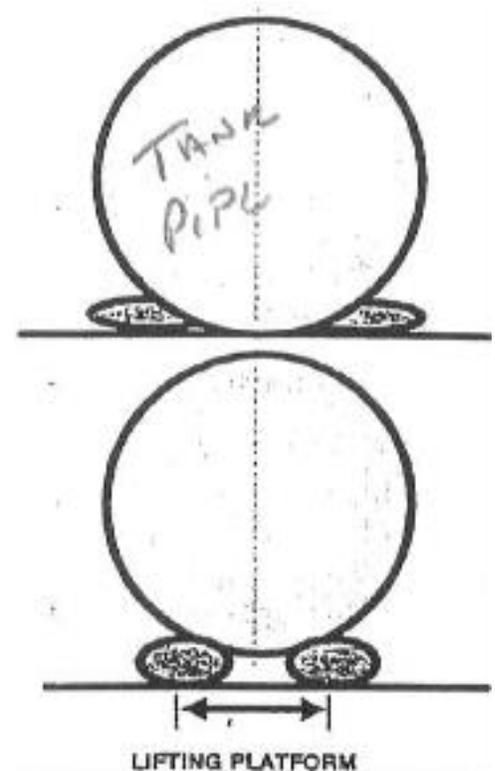
. Do not use cribbing on top of bag.

.In general, it is better to NOT cover the bag

(Consult manufacturers recommendations)

. When possible, bags should be tied to prevent any travel distance should they slip.

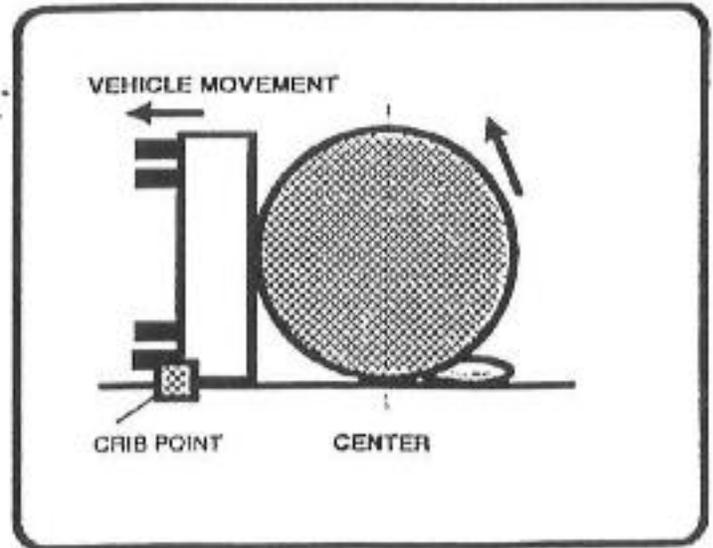
Note: Allow slack so the bag can move up and down unrestricted.



Tanker Truck Lift

Even though tanker trucks are round, they are considerably easier to lift than the previous scenario. The advantage is that only one side of the round surface is lifted whereas the other side is anchored to the truck frame.

1. Use high pressure pillow bag to start the lift. Look for reinforcement ribs to place the lift bags. Place as in "Bus Scenario"
2. Crib as you go. Refer to "Bus scenario" for positioning.
3. High lift bags may be placed under the center of the tank if more height is required (Consider Weight)
4. Allow vehicle to rotate when lift occurs. Note: Do not lift onto its wheels



5. How to crib a lifting bag

2. Multi member lay-up of 2x4 to 8x8 lumber in two or three member per layer configuration.
3. Capacity is determined by perpendicular to grain load on sum of all bearing surfaces.
4. Stability is dependent on height to width of crib and should not exceed 3 to 1.
 - Need to overlap corners a minimum of 4" to guard against splitting of corners of individual pieces that can negatively impact overall stability.
4. Cribs used by contractors (or in short-term emergencies) often rely only on the friction between bearing for later strength, not sufficient for aftershocks.
5. Individual pieces may be notches like Lincoln Logs, to provide lateral resistance in addition to the friction between pieces. Metal slips may also be used to improve lateral strength, as well as diagonal braces between pairs of cribs.

For Lifting Height

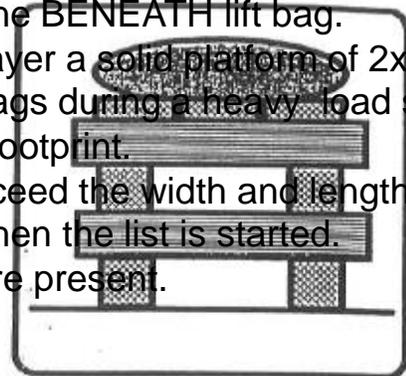
To gain lifting height, cribbing should ONLY be done BENEATH lift bag.

Use a box style crib for height and make the top layer a solid platform of 2x4s for high lift bags or lighter loads. Use 4x4s for high pressure bags during a heavy load scenario.

The box crib should be higher than the size of its footprint.

When using high lift bags, the top plate should exceed the width and length of the lift bag to hold the sidewalls that may fold over the edge when the lift is started.

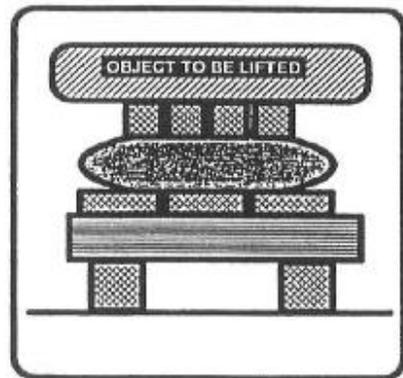
Do not use this type of crib when severe angles are present.



For Load Distribution

Lift bags may be cribbed on top of the bag in order to distribute a load over the full functional area of the bag.

This crib should be limited to one layer



Use 4x4s for heavy loads when using high pressure lift bags and 2x4s or 2x6s (better) for lighter duty operations and when using high lift bags.

When cribbing on top of high lift bags the crib should be at least 20% longer the width of the bag.

CRIBBING – CAPACITY AND LAYOUT

CAPACITY BASED ON CROSSGRAIN BEARING
 (VARIES FROM 200 PSI TO 1000 PSI DEPENDING ON WOOD SPECIES
 500 PSI IS USED HERE - EXAMPLE 500 x 3.5 x 3.5 x 4 = 24,000)

FOR 2 MEMBER x 2 MEMBER LAYOUT

4 x 4 CRIB CAPACITY = 24,000 LBS (12 TONS)

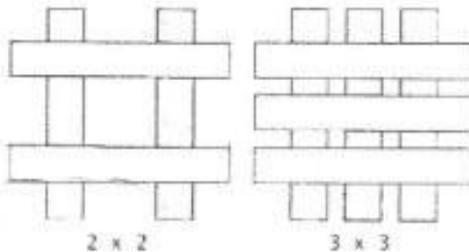
6 x 6 CRIB CAPACITY = 60,000 LBS (30 TONS)

FOR 3 MEMBER x 3 MEMBER CRIB, CAPACITY IS 94 AS MUCH
 500 x 3.5" x 3.5" x 9 = 55,000, 500 x 5.5" x 5.5" x 9 = 136,000



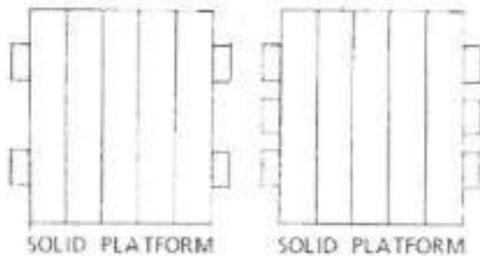
- BOTTOM LAYER SHOULD BE SOLID TO SPREAD THE LOAD ESPECIALLY ON SOIL OR ASPHALT PAVING
- LIMIT HEIGHT TO 3 TIMES WIDTH (SHORTEST WIDTH FOR NON-SQUARE CRIBS)
- OVERLAP CORNERS BY 4 INCHES TO ASSURE SLOW CRUSH TYPE FAILURE

SHOR 4r 9 98



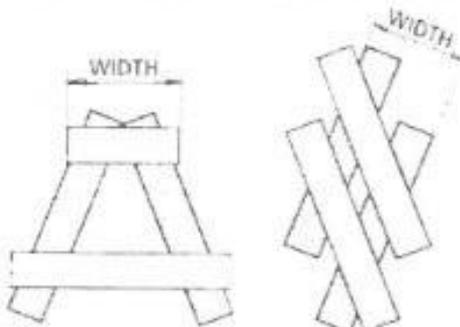
2 x 2

3 x 3



SOLID PLATFORM

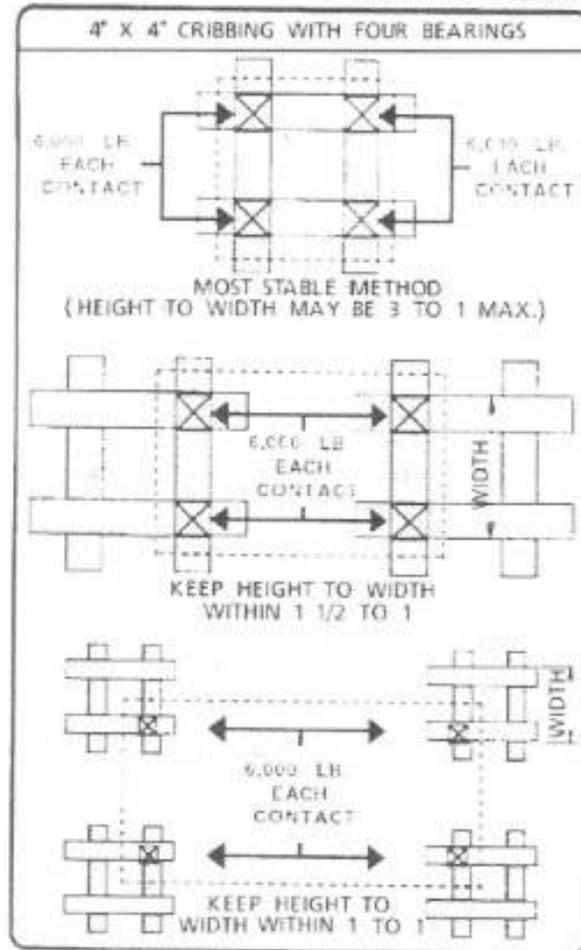
SOLID PLATFORM



TRIANGLE

PARALLELOGRAM

BOTH ARE NOT VERY STABLE, KEEP HEIGHT TO WIDTH WITHIN 1 TO 1



DO

- Always use safety crib follow object being lifted
- Stabilize vehicle on down side against lateral and downward movement
- Use full functional area of the lift bag whenever possible

DO NOT

- Stack high lift bags and/or low pressure bags
- Stack high pressure bags (Unless Flat Lift Bags)
- Lift vehicles to severe angles
- Turn vehicles over

(That is for recovery bags, not rescue bags)

- Lift against sharp edges

To Summarize

As you can see there are a few things to keep in mind when lifting a load. Lifting with lift bags is a combination of anticipating angles, physics, and common sense. None of it is difficult but all of it is dangerous. Experience is your best tool to do an effective and safe lift.

Spend some time with cribbing and lift bags at on of your future training classes.