A TECHNICAL MANUAL
ABOUT HIGH LIFT AND
HIGH PRESSURE AIRBAGS

-HOW THEY WORK-

-DIFFERENT TYPES-

-DO’S AND DON’TS-

-LIFTING TECHNIQUES-
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HOW IT WORKS

1. LIFTING CAPACITY

An airbag obtains its lifting capacity by multiplying the following two components:

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

Example:

Say the functional area of the airbag is 20 square inches (sq.in.) and the operating pressure is 100 pounds per square inch (psi).

The resulting lifting capacity would be: 20 sq.in. x 100 psi = 2000 pounds (lbs.)

Double the size of the airbag then the capacity is: 40 sq.in. x 100 psi = 4000 lbs.

Conclusions:

1. The bigger the bag the more weight it will lift.
2. More contact area increases the lifting capacity.
3. Higher internal pressure increases the 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 airbag).

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

This greatly limits the size of airbags, especially high pressure bags. The biggest high pressure airbags 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 airbag. For the same reason, on the far larger high lift airbags the operating pressure is greatly reduced to accommodate this problem.

3. POWER CURVE

Pillow Shape:

Application: High Pressure Airbags (Figure 1 on next page)

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

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

1. Pillow shaped airbags have a diminishing power curve (less area > less capacity).
2. At maximum height the bag will theoretically lift no weight (point load at top).

The lifting height will depend on the required area to lift the load.
CUBICAL OR CYLINDRICAL SHAPE:

APPLICATION: **HIGH LIFT AIRBAGS** (SEE FIGURE 2 BELOW)

IT IS AS IF A THIRD DIMENSION WAS ADDED TO THE PILLOW SHAPE AIRBAG. THERE IS A SIDEWALL BETWEEN THE TOP AND BOTTOM PLATES OF THE 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.

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**FIGURE 1:** SHOWS LIFTING PROGRESSION USING PILLOW BAGS.

- **FULL LOAD**
  - Pillow bag at start of lift. Full functional area available. Airbag can lift full rated load.
- **LESS LOAD**
  - Pillow bag partially extended. Airbag is lifting less weight.
- **NO LOAD**
  - Pillow bag fully extended. Virtually no functional area left resulting in almost no lifting capacity.

**FIGURE 2:** SHOWS LIFTING PROGRESSION USING HIGH LIFT BAG.

- **LOAD**
  - High lift bag has started to lift rated load. Utilizing its full functional area, the sidewalls are extending.
- **LOAD**
  - High lift bag has completed its lift. The sidewalls are fully extended and the load lifted is the same.
1. HIGH PRESSURE PILLOW AIRBAGS

Basically consists of top plate and bottom plate, inflates into "pillow" shape. All high pressure airbags are pillow shaped bags. Common operating pressure is 118 to 145 PSI.

Advantages:
- Relatively thin insertion space required, as little as 1 inch.
- Thick rubber has good puncture resistance.
- Tremendous lifting capacity at start of lift.
- Relatively stable lift up to half its maximum lifting height.

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

2. LOW PRESSURE PILLOW AIRBAGS

Same configuration as high pressure pillow bags except thinner rubber and substantially lower operating pressure (15 PSI)

Advantages:
- Very thin insertion, as little as 1/2 inch.
- Low pressure allows use against sheet metal and on soft ground.
- Flexible and lightweight.
- Easily repairable.

Disadvantages:
- Low pressure reduces lifting capacity.
- Diminishing power curve due to pillow shape.
- Less puncture resistant.

3. HIGH LIFT AIRBAGS

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 of 15 PSI.

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

Disadvantages:
- Requires more insertion space typically 2 inches.
- Less powerful than high pressure airbags.
AIRBAG DESIGNS AND THEIR FUNCTION

SQUARE PILLOW SHAPE:
- Used mostly for high pressure airbags and some low pressure bags.
- This shape offers best 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 PILLOW SHAPE:
- Used for both high pressure and low pressure bags.
- Not as good a power versus height ratio as square bag.
- This shape has a big advantage in that when it inflates, it shapes like a log 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 the 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 1) 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 (see 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 manufacturers have 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 the sidewall in order to maintain its stability.

MULTIPLE PILLOW SHAPE:
A new concept whereby multiple low pressure airbags 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.
LIFTING WITH AIRBAGS

BASIC LIFTING RULES:

1. While lifting an object, no point of that object should come down.
2. No lateral movement of the object is allowed.
3. Any height gained must be secured and maintained.
4. Airbags should not be considered stable.

STABILITY:

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

Cribbing is essential when using airbags. On the previous page stability was explained for the different shapes and types of bags. The stability obtained from an airbag is helpful but should in general not be relied on.

The next chapter will cover proper cribbing in more detail.

STACKING AIRBAGS:

1. High lift and/or low pressure airbags should never be stacked.
2. High pressure airbags should not be stacked. In some cases they can be stacked to a maximum of two bags only when:
   - The object is positively secured against lateral movement.
   - The bags are not inflated more than two thirds their maximum height.
   - The object will not undergo a significant angle change, causing the airbags to lift against an angled surface.

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

The following diagram shows the stacked lift progression. It clearly shows how the angled object exerts side forces on the bags causing them to roll out. This is obviously very dangerous. A specific airbag surface will not prevent the bags from rolling.
AIRBAGS AND CRIBBING

To obtain stability and safety during a lifting procedure, cribbing is essential. In general, 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 18" long, plus wedges and stair steps.

The following are some simple lifting scenarios and basic cribbing requirements.

BASIC SINGLE POINT VEHICLE Lift (example: small vehicle, car, van)
1. CRIB two points on downside. This CRIB needs to be laterally stable.
2. Place airbag at lift point, usually under driver area, look for center of gravity.
3. Place support crib next to airbag.
   Note: When using high lift bags the sidewalls will "balloon" out at the start of the lift. The support crib should be at least 8 inches from the airbag platform.

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 lace the bag on top 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 to 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 maximum side load support.
By placing the support or safety crib on the downside of the airbag, less cribbing height needs to be obtained, again helping the overall stability of the lift.
OVERTORN BUS OR TRUCK LIFT.

DUE TO THE LENGTH OF THE VEHICLE, MULTIPLE LIFTING POINTS ARE ADVISED. BUSES ARE VERY RIGID BUT TRUCKS CAN BEND AND FLEX EASILY, POSSIBLY REQUIRING EVEN MORE LIFTING POINTS.

EACH LIFTING POINT WILL REQUIRE A SAFETY OR 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 LIFT BAG CAN BE USED TO CONTINUE THE LIFT. THE ADVANTAGE IS THAT THE LIFT CAN USUALLY BE DONE AGAINST THE 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 MOVEMENT OF THE VEHICLE.

BE CAREFUL NOT TO LIFT THE VEHICLE OFF ITS CRIB POINTS ONTO ITS WHEELS. ALL LATERAL STABILITY WILL BE LOST.

LIFTING THE TIRES WILL ALLOW EXTRA LIFTING HEIGHT. NOTICE 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 AIRBAGS.

BEAM LIFT

LIFTING BEAMS IN A BUILDING COLLAPSE SCENERIO OFFERS A UNIQUE CHALLENGE TO THE AIRBAGS, AND THE OPERATOR. LATERAL UNSTABILITY IS A PARTICULAR PROBLEM.

USUALLY THE BEAM IS MUCH NARROWER THAN THE AIRBAG, CAUSING THE BAG TO FOLD AROUND THE BEAM.

THE FUNCTIONAL LIFTING AREA IS ONLY THE CONTACT AREA OF THE BEAM ON THE AIRBAG. 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.

THIS SCENERIO LENDS ITSELF WELL FOR THE USE OF RECTANGULAR SHAPED AIRBAGS. WHEN USED SIDEWAYS WITH THE BEAM A RECTANGULAR BAG OFFERS GOOD LATERAL STABILITY.

A LATERALLY 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.
ROUND OBJECT LIFT

ROUND OBJECTS CAN ONLY BE LIFTED FROM THE GROUND BY USING PILLOW TYPE BAGS.

1. PLACE THE PILLOW BAGS ON BOTH SIDES OF THE OBJECT. NOTE: BAGS MAY NOT BE STACKED FOR THIS SCENARIO.
2. 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 SUFFICIENT DISTANCE FROM THE CENTER TO MAINTAIN GOOD PLATFORM WIDTH.
2. 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 AIRBAG 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 A 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 THE BAG.
- IN GENERAL IT IS BETTER TO NOT COVER THE BAG. (CONSULT MANUFACTURER RECOMMENDATIONS)
- WHEN POSSIBLE BAGS SHOULD BE TIED TO PREVENT ANY TRAVEL DISTANCE SHOULD THEY SLIP. NOTE: ALWAYS 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 A HIGH PRESSURE PILLOW BAG TO START THE LIFT. LOOK FOR REINFORCEMENT RIBS TO PLACE THE AIRBAGS. 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.
HOW TO CRIB AN AIRBAG

FOR LIFTING HEIGHT

Gain lifting height, cribbing should only be done beneath the airbag.

Use a box style crib for height and make the top layer a solid platform of 2x4's for high lift bags or lighter loads. Use 4x4's for high pressure bags during a heavy load scenario.

The box crib should not be higher than the size of its footprint.

When using high lift bags, the top plate should exceed the width and length of the airbag 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

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

Such crib should be limited to one layer.

Use 4x4's for heavy loads when using high pressure airbags and 2x4's or 2x6's (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 than the width of the bag.
DO'S AND DON'TS

DO

✓ ALWAYS USE A SAFETY CRIB.
✓ STABILIZE VEHICLE ON DOWN SIDE AGAINST LATERAL AND DOWNWARD MOVEMENT.
✓ USE FULL FUNCTIONAL AREA OF THE AIRBAG WHENEVER POSSIBLE.

DO NOT

✓ STACK HIGH LIFT BAGS AND OR LOW PRESSURE BAGS.
✓ STACK HIGH PRESSURE BAGS MORE THAN TWO AND ONLY IN ACCORDANCE WITH SAFETY RULES.
✓ CHANGE OR ALTER MANUFACTURERS EQUIPMENT IN ANY WAY.
✓ LIFT VEHICLES TO SEVERE ANGLES.
✓ TURN VEHICLES OVER (THATS FOR RECOVERY BAGS, NOT RESCUE BAGS).
✓ LIFT AGAINST SHARP OBJECTS.

TO SUMMARIZE

AS YOU CAN SEE THERE ARE A FEW THINGS TO KEEP IN MIND WHEN LIFTING A LOAD. LIFTING WITH AIRBAGS IS A COMBINATION OF ANTICIPATING ANGLES 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 AIRBAGS AT ONE OF YOUR FUTURE TRAINING CLASSES.

SHOULD YOU HAVE ANY QUESTIONS OR IF YOU WOULD LIKE TO SEE CERTAIN SCENERIOS EXPLAINED, PLEASE CALL WIN VANBASTEN AT 215/657-7825.
SINGLE POINT LOADING

PUSH DOWN 50 LBS. EFFORT

WEIGHT OF LIFTED LOAD

1000 LBS.

50 LBS. EFFORT X 10:1 (M.A.) = 500 LBS.

WEIGHT OF LIFTED LOAD = 500 LBS.

SINGLE POINT LOAD = 1000 LBS.