Pneumatic Lifting Devices – Air Bags

Introduction

There are several different tools carried on Truck companies and Rescue Squads used for lifting. One such piece of equipment is the air bag.

Air lifting bags are capable of lifting heavy loads with relative ease and efficiency. Some of the largest bags are capable of lifting over 90 U.S. tons. Proper training and education are paramount to a successful lifting bag operation. Operators must fully understand the principles behind bag design and operation as well as the necessary safety precautions.

Just a few of the applications that air lifting bags can used for include:

- Lifting and up-righting overturned vehicles
- Person(s) pinned under a heavy object (e.g. tractor trailer, train, vehicle, etc.)
- Rescue/recovery after collapses
- Forcing solid objects apart
- Providing a seal for leaking pipes drums or other cylindrical containers

Some of the advantages of air bags include:

- Long life
- Fairly lightweight
- Low insertion heights
- Quick and easy to set up
- Relatively low operating pressures
- Ability to lift on a slope
- Provide a smooth, quiet lift
- Provide an anti-slip surface
- Flexible
- Corrosion resistant
- Fairly simple to use

Air lifting bags are categorized into three different types based on their working pressures:

1. High Pressure
2. Medium Pressure
3. Low Pressure

Each type has unique features and capabilities. However, all three share a similar equipment cache for operating. Each type of bag and the associated equipment will be discussed in this module.

Equipment

Air Source and Pressure Regulator

Several different types of air sources were covered in the “Pneumatic Tools and Equipment” module. While most of those air sources are capable of providing air for an airbag operation, some are preferred over others.

Air from industrial and vehicle-mounted compressors often use oil to lubricate internal essor components. In addition, these air sources contain moisture from ambient hile filters and dryers are often incorporated into the compressor design, they do arantee the absence of contaminants. Some of the synthetic oils used in modern air compressors have been shown to damage and degrade interior components of air bag systems, specifically O-rings. Conversely, breathing air sources (e.g. SCBA cylinders) are filled with air that meets stringent OSHA and NFPA respiratory standards. The essors that supply breathing air are equipped with advanced moisture separators urification chambers that eliminate the contaminant and moisture issues of ial compressors. For this reason, breathing air is the preferred source for air bag evolutions.

As with pneumatic tools, air must often be taken from a high pressure source like an SCBA cylinder and brought down to a proper operating pressure for air bags. The pressure regulators described in the “Pneumatic Tools and Equipment” module are used to perform this task.

The working pressures for air bag lifting systems range from 7 psi up to 145 psi.

**Note: Another common unit of pressure used with airbags is "bar”.

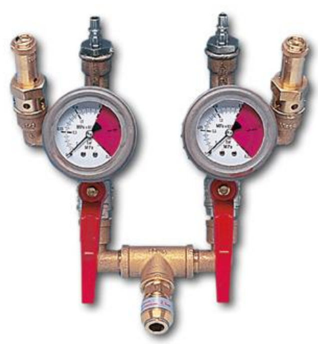
1 bar = 100 kPa = 14.5 psi.

Do not confuse the unit of bar with Standard Atmospheric Pressure (atm), which is 14.7 psi or 1.01325 bar.

Controller

The controller is the device which allows air to flow in and out of the bag. It contains the gauges that allow the monitoring of the air pressure inside the bag. It also contains two internal relief valves to prevent over pressurization of the bags. Most high pressure air bag systems have a maximum working pressure of 8 bar/116 psi or 10 bar/145 psi. Whenever the pressure inside the bag exceeds this mark, it will be indicated on the gauges on the controller and the internal relief valve will vent (allow the extra pressure to escape). It will continue to vent until the correct pressure is reached. This is called relief valve reset and it should occur at the maximum working pressure as indicated on the controller by a red marking.

Controllers are outfitted with either “deadman” controls or quarter turn valves. Deadman controls return to a neutral position when they are released preventing accidental over pressurization. Quarter turn valves act like an on off switch but they must be manually set to the desired position (much like a gated wye). Attention must be paid not to keep the quarter turn valve in the open position after the desired lift has been achieved.



Connections

Controllers provide a coupling, typically with a female end, to connect to the air supply. At this point in the connection, the air pressure should have already been reduced by the air regulator to the working pressure of the lifting system. If this is not true and air is applied to the controller at high pressure from the air source, severe damage can occur to the controller. Some couplings may be quarter turn, which require that you turn and push the collar back before you can attach to the other part of the fitting. Others may be quick-connect which will always readily go together. The type of couplings will vary by manufacturer.

The set of couplings located on the front of the controller are most likely proprietary by manufacturer in order to avoid mixing components from one brand name to another. These connections are used to connect the air hoses going from the controller to the air bags. Some manufacturers make these couplings in such a way that you cannot connect the hoses directly from the air supply to the bags without using a controller, thus interposing a relief valve which prevents over pressurization of the bags. These connections may also be used to add a second relief valve, usually with a shut-off, between the bag and the controller.

In-Line Relief Valves

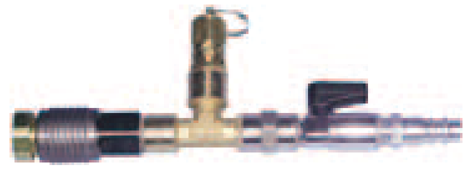
Placement

In-line relief valves work in the same fashion as the internal relief valves. They are considered in-line because they are located between the controller and the airbag rather than an internal component. In-line relief valves can be placed at the controller or at the airbag itself. Frequently these devices are placed at the controller to limit persons working near the load. Relief valves are usually only placed at the airbag when there is a limited number of air hoses and only one controller. By placing the relief valve at the bag, the hoses and controller can be removed and used at a different location on a different bag. Prior to disconnecting the hoses the quarter turn valve is closed to prevent air from being lost from the bag. Some manufacturers incorporate the relief valve into the air hose so the placement of the relief valve is predetermined.

Relief valve placed at the airbag

Relief valves placed at the controller

Operation



Relief valves are preset to a specific pressure, normally the maximum working pressure of the system. Whenever the pressure inside the system exceeds this benchmark, the relief valves vent allowing the excess pressure to escape through vent holes on the valve body preventing over pressurization of the bag. When the relief valve vents, a hissing noise will be heard until the proper pressure is reached.

Hoses

Lengths

Hoses are usually around 16, 32, and 50 feet in length, ¼" to 1 ½" in diameter (depending on type/pressure of bag), and color coded for easier identification of the bags when using more than one bag.

Couplings

Couplings are different from one lifting system to the other. The couplings for the high pressure system are different from the couplings for the low and medium pressure systems. In addition, the hoses from the low and medium pressure systems are different from the hoses used by the high pressure system. The low and medium pressure systems use a higher air volume therefore, their diameter is greater.

Hose couplings are often manufacturer specific. This prevents a specific manufacturer's air bag from being used with inappropriate or non-rated equipment.

Air Bags

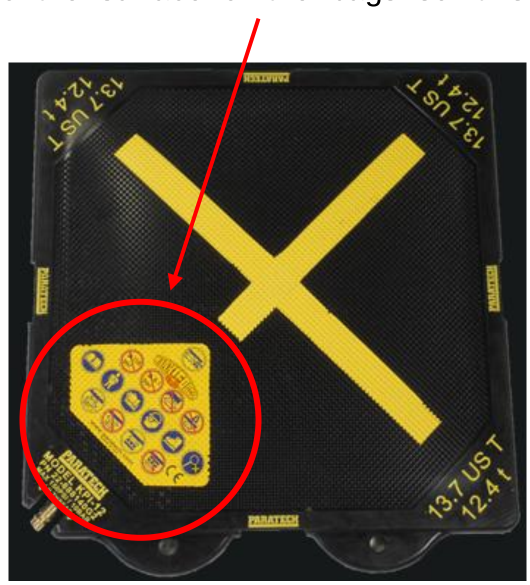
High Pressure Bags

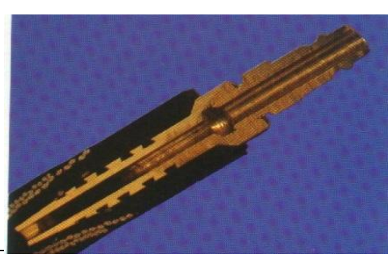
Capacities and Sizes

The bag is the component in direct contact with the load and is the component performing the actual lift. Air bags range in capacities from 1 to more than 90 tons and have lifting heights from 3” to a couple of feet. Bags are constructed in different shapes and sizes. Some of the smallest bags measure 5.1” x 5.5” while some of the largest bags measure 37” x 37”. High pressure airbags are anti-static, self-extinguishing, oil and ozone-resistant, have a good resistance to chemicals, cold resistant to 40°F and heat resistant to 239°F on a short term basis. High pressure airbags have a bursting pressure between 32.5 bar and 74.3 bar (471 - 1,077 psi) giving them a safety factor of 4 to 9.3 times the maximum operating pressure.

Construction

The bags are made of Neoprene, a family of synthetic rubbers, and are molded in a way to provide grip and slip resistance. They are reinforced with layer(s) of either steel wire (similar to steel-belted radial tire construction) or in the case of newer bags, Aramid fibers. By using Aramid fibers, such as Kevlar™, the bag becomes stronger, lighter, and more flexible than a bag made with steel wire. All capacities, operating pressures and lifting heights are permanently vulcanized to the surface of the bags so it is available for reference as needed.

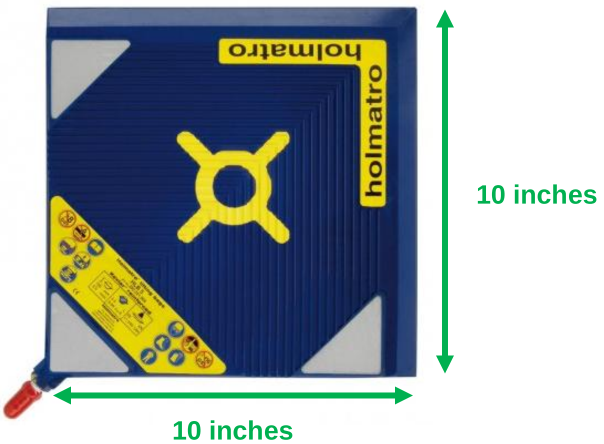




The nipple has a small orifice in order to allow the bag to deflate slowly.

Operation

Air bag capacities are determined by their surface area and operating pressure. To determine the maximum lifting capacity, the bag's surface area is multiplied by its operating pressure. Operating pressure for high pressure air bags is either 8 bar/116 psi or 10 bar/145 psi.



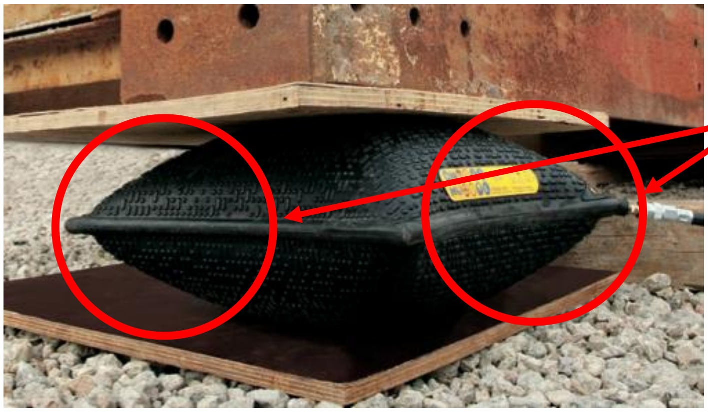
Surface Area (A) = Length (L) x Width (W)

A = 10 inches x 10 inches
A = 100 in^2 (square inches)

Operating Pressure = 8 bar = 116 lbs/in^2 (psi)

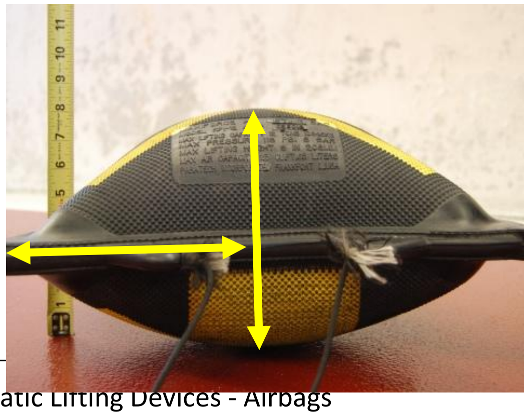
Capacity = Surface Area x Operating Pressure
Capacity = 100 in^2 x 116 lbs/in^2
Capacity = 11,600 lbs = 5.8 U.S. tons

High pressure air bags are **rated at one inch of lift**. The air bag is only capable of lifting its rated capacity if the entire surface of the bag is in contact with the object being lifted. Once air is introduced to the bag, it starts taking the shape of a pillow thus, reducing the surface contact with the object being lifted, and decreasing its capacity. Once the bag reaches its maximum height, the rated capacity is reduced by roughly 50%. Surface contact is paramount when calculating lifting capacities and when operating with air bags.



The bag has lost surface contact with the ground and the object. As a result, the lifting capacity at this height is reduced

As a rule of thumb, the maximum height of a high pressure air bag is equal to half of the length of the shortest side of the bag.



Medium pressure bags

The walls or sides of the medium pressure bags are made of hermetic, Kevlar™ impregnated or nylon reinforced Neoprene. The top and bottom external surfaces are made of reinforced fabric with a gripping surface in order to reduce slippage. Some manufacturers claim that, due to the manufacturing process, the seams are the strongest part of the bag.

Inside low and medium pressure air bags, running from the top to the bottom surfaces, are vertical reinforcing straps. These straps help the bags keep lateral movement to a minimum and at the same time prevent the surfaces of the bags from bulging out.

Medium pressure bags are offered in a number of sizes and styles. Some have cylindrical shape. Others are multi-cell, which is similar to three bags stacked on top of each other.

Some applications for medium pressure air bags include lifting or stabilizing overturned vehicles, especially on situations dealing with thin metal walls like on tractor-trailers. They provide a large footprint for the area being lifted and minimize the possibility of punch through or collapse of the surface being lifted or pushed. They are also used to fill voids in trench rescue operations.

Medium pressure bags provide their rated capacity during the entire lift. As long as surface contact is maintained with the bag, it will lift the rated capacity. Medium pressure bags that are cylindrical in shape will reach their maximum stability at full inflation. Lifting capacities range from 3 to 13 tons. Air consumption varies from 10 to over 100 cubic feet. As with the high-pressure system, to operate the medium pressure bags you need an air source, an air pressure regulator, a controller with relief valves, and hoses.

Because of the pressure difference between systems, these components are not interchangeable with the high pressure systems. Medium pressure systems are designed to operate at 1 bar/14.5 psi. They have a much higher air consumption rate than high pressure bags. For that reason, the air hoses have a larger diameter.

Low pressure bags

This type of bag is constructed of reinforced Neoprene, very similar to medium pressure bags. The top and bottom surfaces are made of multi-layer rubber to provide abrasion resistance. Inside the bag there are reinforcement straps running from the top to the bottom plate. They keep the bag from bulging and prevent some lateral movement. Sizes and capacities compare to those of the medium pressure system. Some applications for low pressure air bags include lifting or stabilizing overturned vehicles, especially on situations dealing with thin metal walls like on tractor-trailers. They provide a large footprint for the area being lifted and minimize the possibility of punch through or collapse of the surface being lifted or pushed. They are also used to fill voids in trench rescue operations.

As with medium pressure bags they provide the rated capacity during the entire lift. As long as maximum surface contact is maintained with the bag, it will lift the rated capacity. Low pressure bags, like medium pressure bags, reach their maximum stability at full inflation.

Operating pressure for low pressure bags is around 0.5 bar or 7-8 psi. The same components as medium pressure bags are needed to operate these bags (air source, pressure regulator, controller, relief valves, and hoses). Some manufacturers build their low and medium pressure systems with interchangeable components.

Setup and Operation

Establish safe zones

When lifting heavy objects there is always the risk of the load shifting or falling. In order to prepare for this event, identify the area that might be affected if the load was to fall or shift and keep personnel and equipment clear from that area as much as operationally possible. When operating around air bags and lifting loads, always pay attention to the load and maintain a stance that will allow for a rapid egress from the danger area should the load shift or fall. Maintain all equipment not being utilized in a centralized area, in the safe zone in order to minimize trip hazards and for rapid localization. Whenever possible, work on a flat surface to avoid slippage and shifting of the air bags and or the load.

Cribbing

Whenever a load is lifted from the ground by any means it must be supported by some type of cribbing material. (See the “Stabilization” module of this manual for more information on cribbing.)   When using cribbing in combination with air bags it is used in two different ways: supporting the load and supporting the air bags.

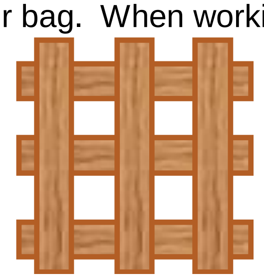
<u>Supporting the load</u>

“Lift an inch, crib an inch.” This is a critical part of the overall lifting process. As you lift the load, you must simultaneously crib as you go. This is done in order to prevent the load from traveling unsupported. In the event of a failure somewhere in the lifting system, the load still needs to be supported to prevent dropping the load and causing damage to equipment, the load, and harm to personnel.

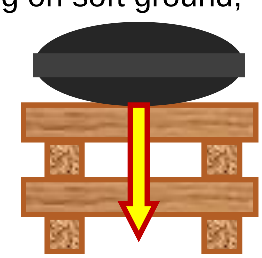
<u>Supporting the Bags</u>

As stated previously, high pressure air bags are rated for their maximum lifting capacity at 1 inch of lift. As the air bag inflates beyond 1 inch, it begins to lose surface contact with the ground and the load. To help alleviate this problem, the air bags must be as close to the load as possible. This can be accomplished by cribbing up to the load prior to inserting the airbag.

Additional factors must be considered when constructing a box crib to support a lift rather than simply support the load. The top of the box crib needs to be a solid layer of cribbing to maintain full surface contact with the air bag. When working on soft ground, the bottom layer should be solid as well to help distribute the load. When constructing the box crib, a minimum of 3 by 3 crib layout should be used. When a standard 2 by 2 layout is used, the center of the box crib is empty and is therefore not supporting the airbag as it inflates. This can lead to decreased box crib capacity and



3 by 3 Box Crib



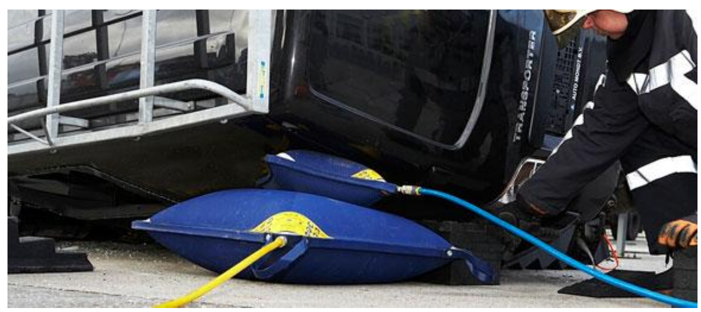
2 by 2 Box Crib

stability.

Lifting

Another point to consider when lifting a load, especially if it is resting on a victim, is that when lifting, every action has an equal and opposite reaction. In the event of a patient being pinned under a load, you must crib the opposite side that you are lifting in order to provide a hinge point for the load and prevent sway, which could cause further harm to the victim.

In order to keep the load under control and keep it from shifting, bags should be inflated slowly. This is called “feathering”. Air that is rapidly introduced to the bag will jolt the load and create a chain reaction that will be very difficult to control and can cause the load to shift or fall. If more than one bag is used for the lift, inflate one bag at a time: lift one bag one inch then the next bag one inch. Once both bags are inflated one inch, continue to inflate each bag a little, going back and forth between each bag. This will allow for maximum surface contact and therefore maximum stability and strength in the bag. Place the bags as close to the load as possible in order to maximize the lifting height. When the bags are slid under the load they should be just barely touching the load. There should not be a large space between the bag and the load. Locate a solid surface under the load and use this area as the lifting point, cribbing on both sides of the bags as you lift. Again, the rule is to lift an inch, then crib an inch.



The nipples on the bags can be stacked on top of each other or they can be staggered for easier manageability of the hoses. In-line relief valves can be placed either at the controller or at the bag. By placing the relief valve at the controller, the person operating the controller has the ability to shut off the air flow to the bag, remove the controller from the system while maintaining bag inflation, and deploy another set of bags in a different location if needed. This is the preferred method because the person operating the shutoff valve will be away from the load. Position the controller in an area with a full view of the lift but in the safe zone if possible.

When lifting the load one person is responsible for operating the controls on the controller. A second person will be responsible for directing the rescuer at the controller as to which bag to inflate or deflate. The rescuer at the controller will only take commands from this person and those commands should simply be “Up”, “Down”, and “Stop”. Follow each command with the color of the air hose connected to the bag being inflated/deflated (e.g. “Up on red” or “Down on yellow”). Air hoses are typically stored in a rolled fashion and tend to develop a “memory” in that shape. For that reason, and to prevent kinks and air flow restriction, they should be completely uncoiled and extended before inflation. Using different color hoses for different bags will aid in identification during the lifting operation.

Applications

Stacking Air Bags

High-pressure air bags can be stacked to a maximum of two bags. By stacking bags, we increase our overall lifting height. Recall that the maximum bag height is approximately half the length of its shortest side. When two bags are stacked, their useable heights are added together to provide the total lift height. The larger bag is always placed on the bottom and the smaller bag on the top. The bag with the smaller capacity will dictate the total lifting capacity (e.g. a 19-ton bag stacked on a 26-ton bag would only yield a maximum capacity of 19 tons). Use caution when stacking bags, the more inflated the bags, the more susceptible they are to kicking out. If the load is at an angle, it is recommended that only one airbag be used.

Using bags in tandem

When two bags are sharing a load at two different points, they are said to be working in tandem. Two bags working in tandem can have their capacities added together in order to determine the total lifting effort, however the bags MUST be lifting the same part of the load. Also, the portion of the load on each bag cannot exceed bag capacity.

For example, a 7-ton air bag and 3-ton bag can theoretically be placed in tandem to lift a 10-ton load. However, the 7-ton bag must only see 7 of the 10 tons and the 3-ton bag must only see 3 of the 10 tons. If each bag is responsible for lifting an equal share of the 10 tons (5 tons each), the lift will not be possible. One solution would be to use two 7-ton bags in tandem (each capable of lifting half of the 10-ton load).

Recall that air bags are rated at 1 inch of lift. The maximum tandem lifting capacity will be achieved only at that height. This method is useful when presented with a load that exceeds the capacity of the largest bag on hand.

Maintenance

- Inspect the bags after every use.
- Inflate the bags to half of their working pressure and apply a mixture of soap and water. (It is NOT recommended to inflate an air bag that is not under load to its maximum operating pressure.) Look for leaks or air bubbles.
- Check the surface of the bags for cuts, abrasions or any signs of structural damage. Check that the nipple is firmly attached to the bag and it does not swivel.
- Leave the bags inflated for several minutes monitoring for any leaks, this can be seen in the inflation of the bag or on the pressure gauge on the controller.
- Inflate and deflate the bags repeatedly in order to exercise the bags and keep them from developing a memory in one position and to provide stretch and movement to the different layers.
- Place the bags under an appropriate load and inflate them to their maximum operating pressure, allowing the relief valves to vent and reset. Note the pressure when the relief valve vented and the pressure when it reset. Compare those pressures with the manufacturer's recommendations.

This procedure should be done once a month. In addition, air bags should be hydrostatically tested every five years by a qualified service technician.

Air bags are made of rubber. Rubber is a living material, which is subject to changes. For that reason manufacturers have a stringent battery of tests and standards that must be followed when manufacturing air bags. Some of these tests include bursting tests, abrasion tests, piercing, penetration, and wear resistance, among others. After meeting the requirements of all of these tests some manufacturers may submit their bags to a pressure test of 1.5x their working pressures for a number of minutes. Air bags have a working life of approximately ten years based upon use, storage, and maintenance.