PNEUMATIC HANDLING
OF DRY BULK TANKERS AND CONTAINERS

SOLIMAR

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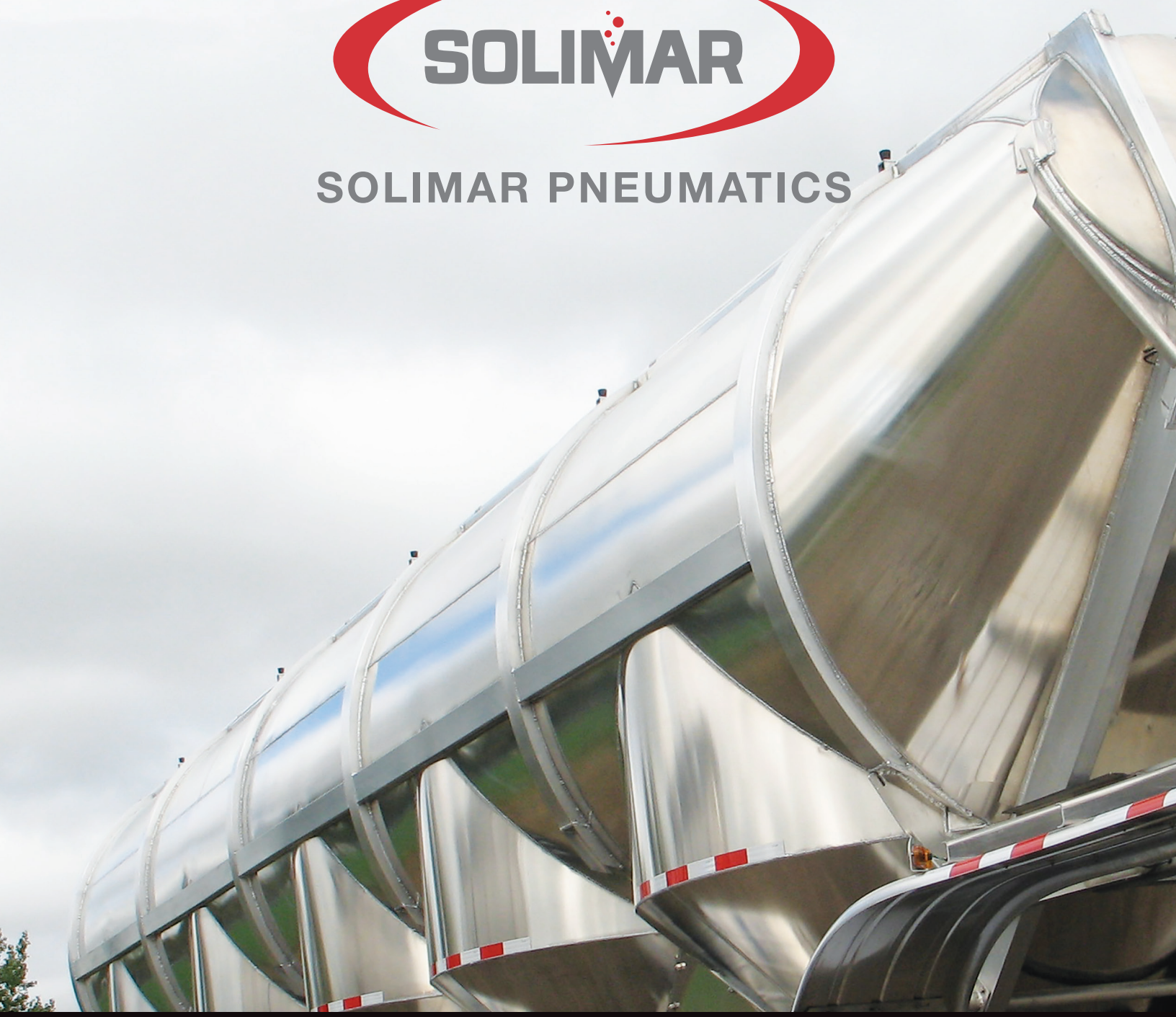

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ROAD TANKER DESIGN FOR SILO FILLING

Like the automobile and the airplane, the dry bulk trailer (powder tanker) has gone through an evolution from something small and crude to something bigger and more sophisticated. Always pushing the limits of physical size, gross weight limits and lower tare weight, using lighter and stronger materials. The customer also wants more versatility and better clean-out.

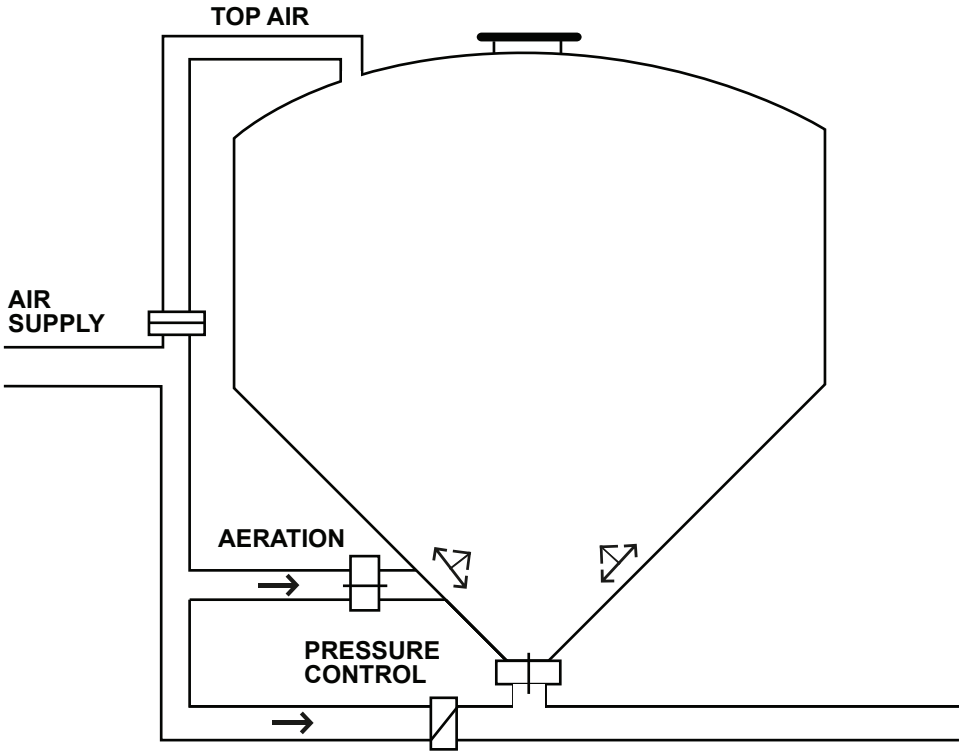
A. THE ORIGIN

The transport of cement in bulk by road tanker and rail using compressed air unloading became common in Europe after World War II. In Sweden and other countries, this shift from bag to bulk transportation was caused by a severe shortage of bags and sacks. Bulk handling was seen to have great advantages over the current bag system. The first advantage was the elimination of back-breaking work of loading and unloading cement bags by hand. Pallets were not yet invented and forklifts were still a novelty. The second advantage was that the cement could be transported in pipelines and elevated into the silo without any mechanical devices, spillage and no disposal problem of empty bags. Three different types of vessels soon developed.

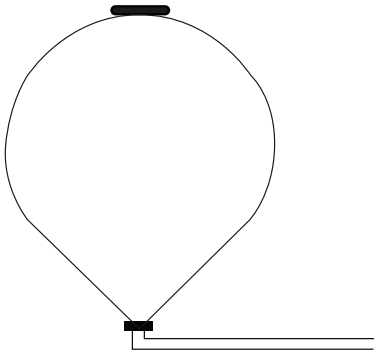
B. THREE TANK DESIGN CONCEPTS

The Vertical Tank

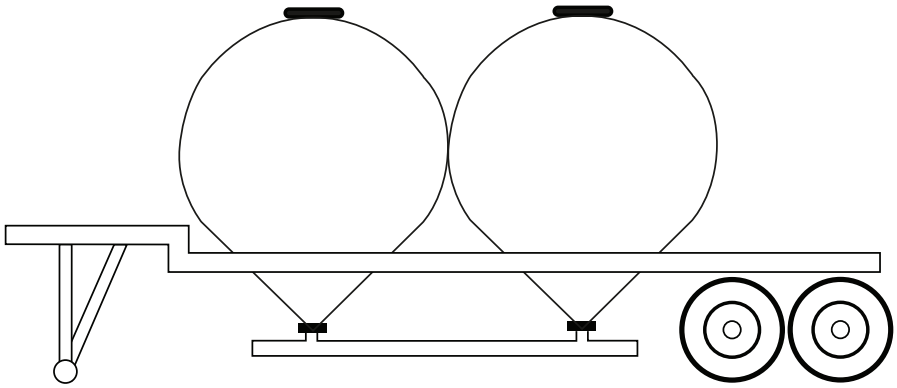
The first was a vertical cylinder vessel with a 45-degree bottom cone where the cement fed to the bottom by gravity. To prevent bridging of the product in the bottom portion, one or more air nozzles were installed near the outlet.



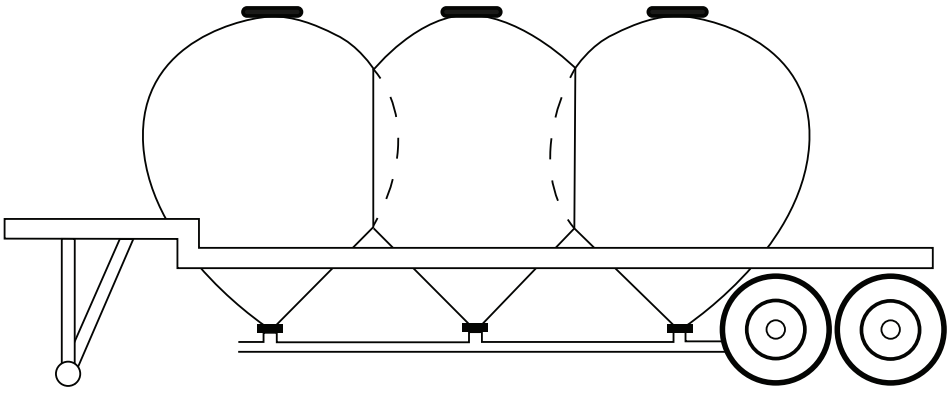
To minimize the weight of the vessel, Swedish company, Interconsult, developed the spherical vessel. Since the sphere is the perfect pressure vessel with only half the stress level compared with a cylinder, you can either use twice the operating pressure with the same weight or keep the same operating pressure and reduce the weight. You cannot cut the weight in half, however, because there is a minimum practical limit to the shell thickness you can use to carry the load.



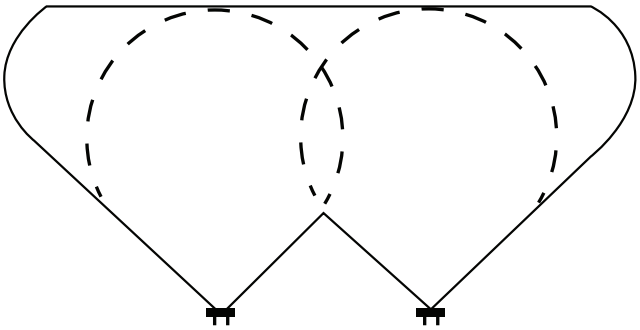
Next, two or more vessels were mounted on a trailer frame.



To get more volume the tanks were built so close that you had interference and they had one wall in common.

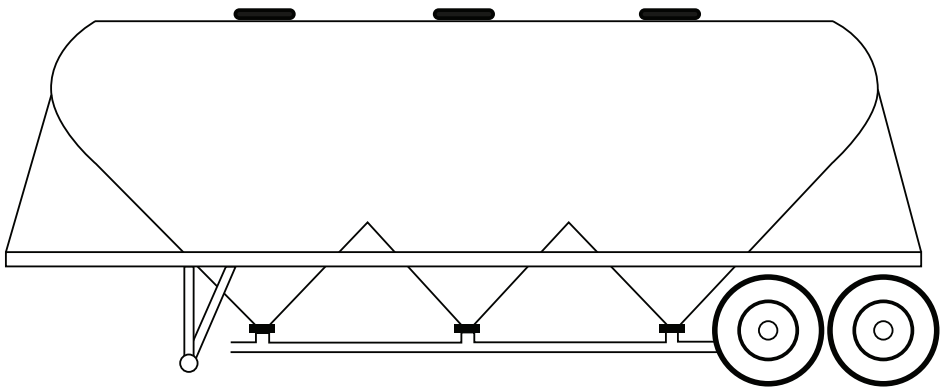


Later two individual spherical vessels were combined and the 45-degree cones were extended toward both ends to gain more volume.



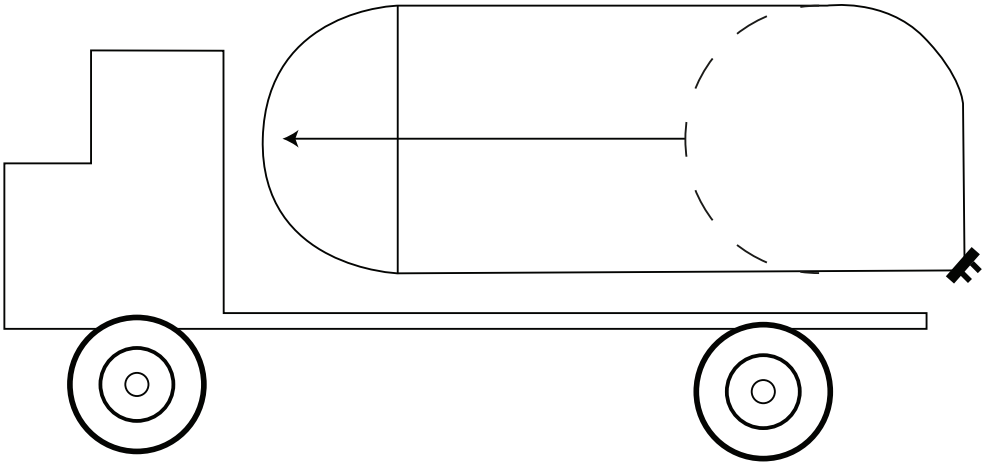
Finally, the separate frame was eliminated and the load carrying structure was made an integral part of the tanks.

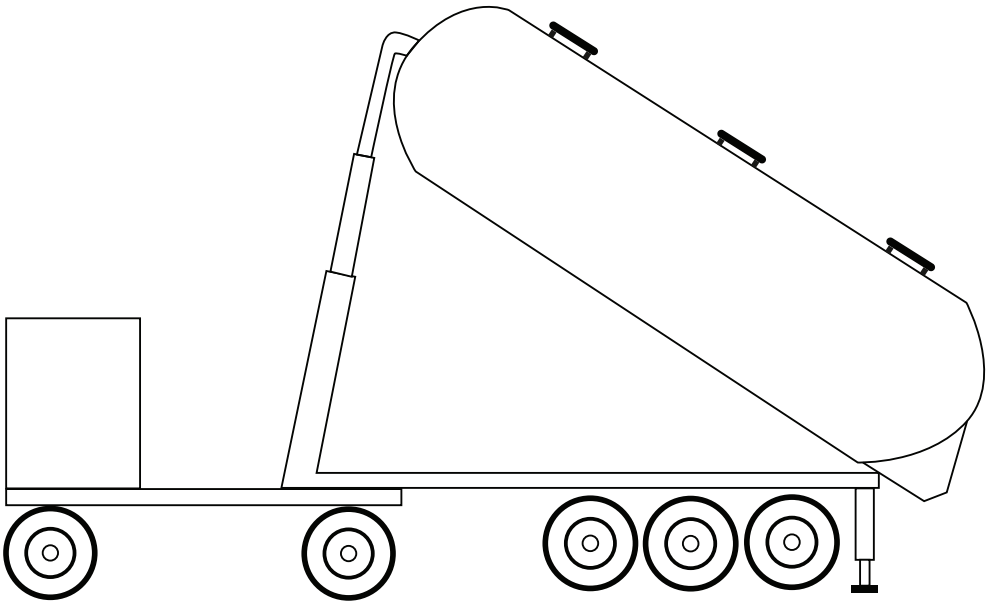
Eventually, this type of trailer was to have a cylindrical upper portion with 2 to 5 hoppers in the lower section, as well as, a conical or wedge shape portion in each end. This is what we have for cement trailers in Europe and for all types of trailers in Canada, the United States, Australia and the Pacific Rim.



The Tipper

The second type of vessel consists of a horizontal, tippable cylinder with the outlet at the pivoting end. In Europe, this type of vessel has developed into today's food, chemical and plastics tipping trailer because of its "clean" interior and larger volumes. It is also easy to clean and inspect. The Evolution of the Tipper is interesting. It started with a spherical tank that was cut on a 45-degree angle and a cylinder was added in between the two holes.



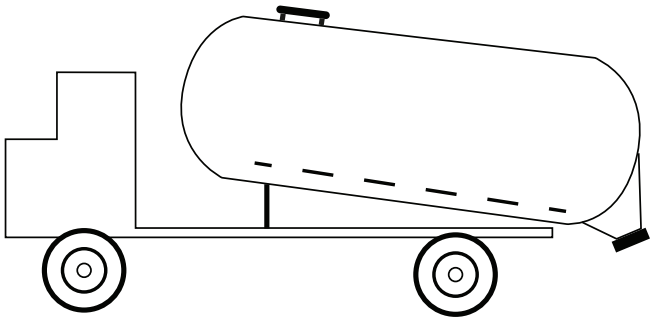


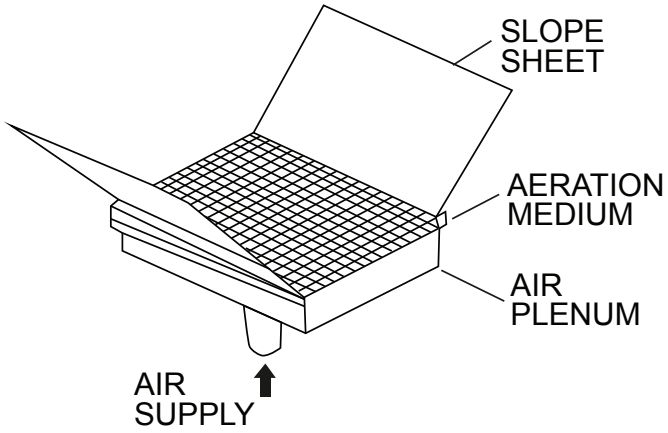
The draw back of the tipper is the extra hydraulic equipment necessary for its operation. It adds both weight and initial cost. In the U.S. you cannot use the tipper because of the risk of accidentally tipping over sideways and prevalent overhead power lines.

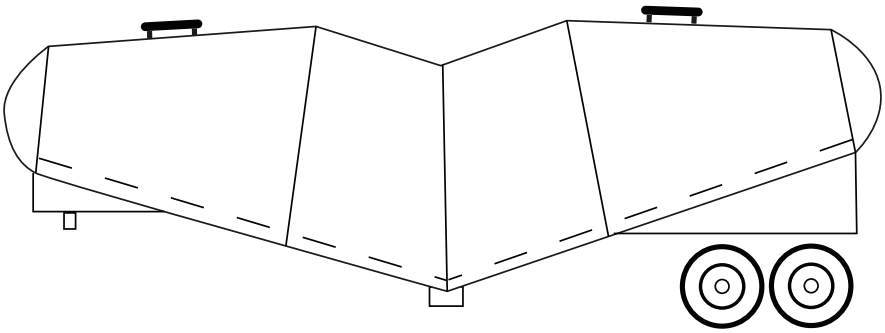
The Pressurized Airslide

Another type of vessel used for transporting and unloading bulk materials is the pressurized airslide. In the airslide, the product is moved lengthwise to the outlet. This is made possible by aeration along the whole length of the bottom of the trailer. Originally, this type of trailer had the outlet at the rear end. As the trailers become longer, the outlet was moved to the center of the trailer.

The advantages of the airslide trailer are that it is simple and inexpensive to build, but its major drawback is the erratic and poor clean-out. Often a ton or more of product is left in the trailer. For better clean-out, the bottom is sloped up to 20 degrees. The airslide tank has now practically disappeared form the American and European markets but it is still common in the Pacific Rim region.







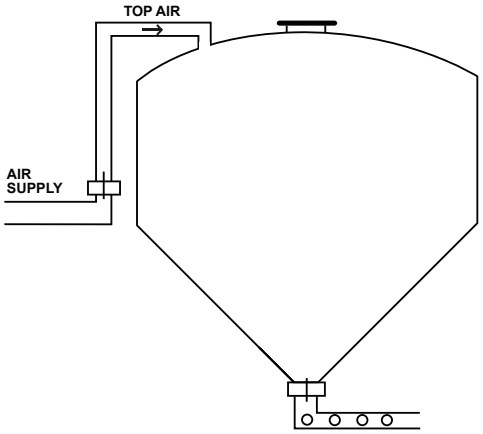
C. BASIC PNEUMATIC TANK FUNCTION

1. **The first task is to get the product out of the trailer.**

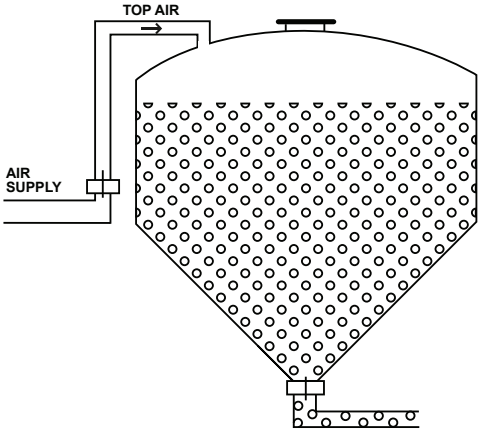
2. **The second task is to get the product through the unloading pipe efficiently.**

3. **The final task is to meet all of the legal requirements for weight and size limitations, as well as, pressure vessel codes and, at the same time, minimize weight to allow maximum payload.**

The simplest form of a pneumatically unloaded tank is a standing cylinder with a conical bottom that is pressurized through a top airline. This is often called a blow tank.

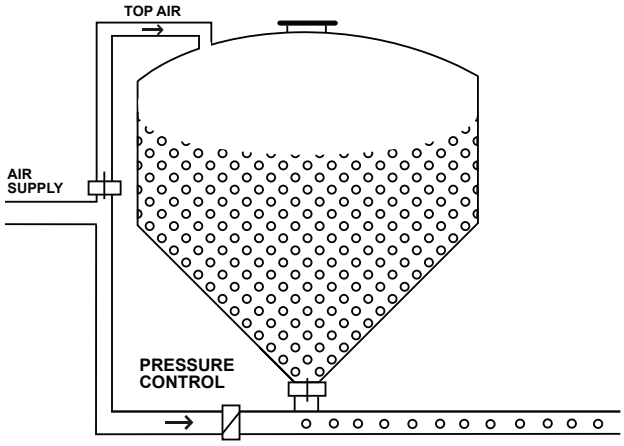


To unload, start the blower to pressurize the tank. When normal operating pressure is reached, the product valve is opened at the bottom of the tank and product starts flowing out into the product line. Before you know it, the tank is empty. This system works well with a free flowing product such as, plastic pellets, and a complete clean-out is expected.



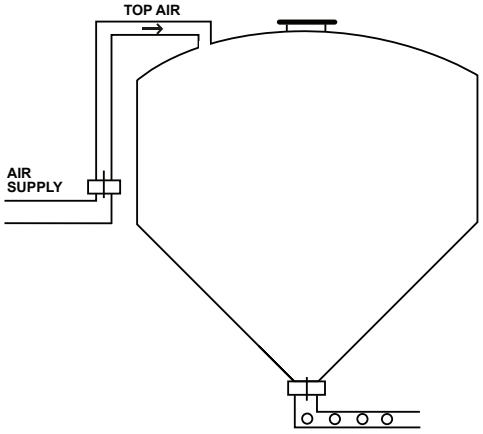
PLASTIC PELLETS (SHORT LINE)

If the product line is long enough, the operating pressure may get too high. Trailers are generally restricted to 1 or 2 bar operating pressure. A higher pressure would make the tanker too heavy and reduce payload. To solve this problem, we add a pressure control line. We take air from the air supply line and divert it to the product line and add a pressure control valve. Now we can dilute the product/air mixture in the product line to reduce the backpressure of the product mix flowing through the line. It is this backpressure that ultimately determines the tank pressure.



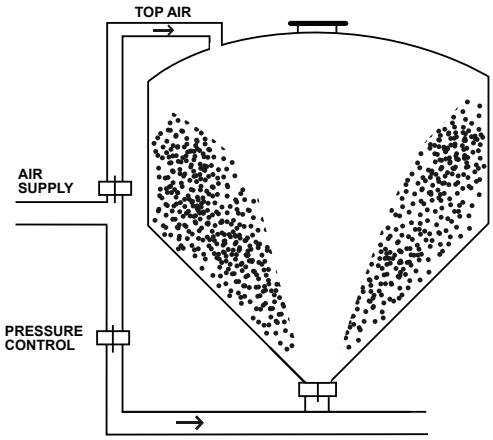
PLASTIC PELLETS (LONG LINE) AIR ASSIST OR PRESSURE CONTROL NECESSARY TO AVOID OVER PRESSURIZATION

If the pressure is rising in the trailer, we open the pressure control valve more to dilute the mixture. If the pressure is falling, we close the pressure control valve somewhat to make the mixture richer thus keep the pressure from falling further.



PNEUMATIC CONVEYING OF PLASTIC PELLETS – COMPLETE CLEAN OUT

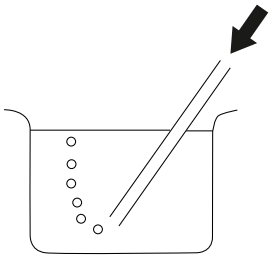
Most of the time however, we do not work with free flowing products but with powders like cement and flour. These powders are not naturally free flowing and worse yet; they get very compacted when the trailer goes over the road. If we would try unloading the trailer with only top air, we would just blow a hole through the product down to the outlet.



POWDER WILL RATE HOLE
VERY POOR CLEAN OUT

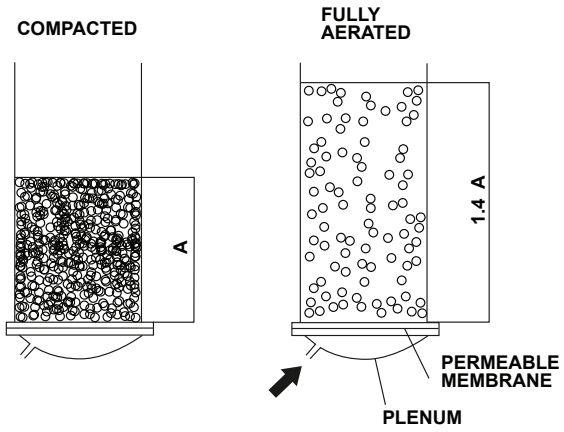
D. AERATION AND OUTLETS

To make this compacted product flowable, we again have to loosen the product with aeration. Aeration is a method in which air is introduced in the bottom of a container through a permeable medium, such as textile fabric, sintered metal, stainless steel wire mesh, porous stone or porous plastic.



When air is introduced into the product, it will always seek its way to the top just like blowing air into water with a straw.

When air is forced through a compacted product it will gradually expand the product, in the case of cement by about 40%. Finally, air will burst out on top and the product is now fully aerated. This happens when the passing air has sufficient velocity to lift and separate the individual particles so that they more or less lose physical contact with each other and the product starts behaving like a liquid or fluid, thus the word “Fluidization”.

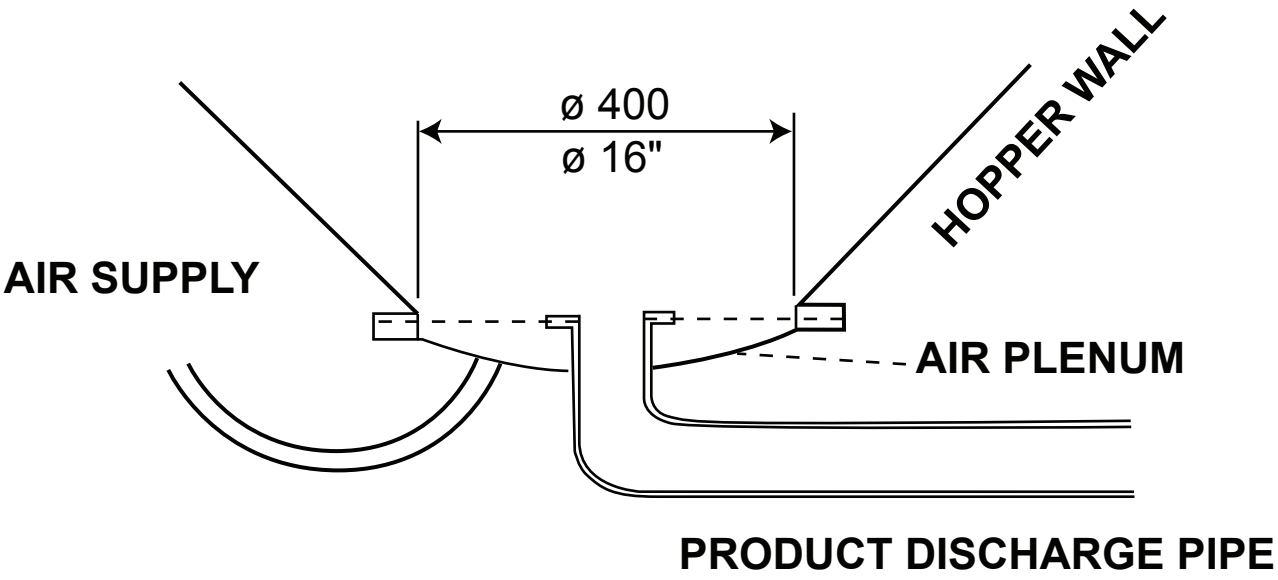


Historically, the aeration medium in tankers has been fabric. It is hard to beat fabric for low cost and as a dispersion medium of the air in to the product. Today, with flour, starch and resins, cleanliness and contamination are becoming a concern when using fabric. If the trailers are washed down inside, it will take several hours to dry the fabric. Condensation inside the trailer may cause problems like hardening of the product and mildew in the fabric.

The advantage of fabric is that it is not rigid but flexible so it is somewhat self-cleaning. The substitutes for fabric are sintered metals and woven stainless wire cloth. They work well when new but with condensation, rigidity and repeated use they become clogged with product and may have to be cleaned with acid.

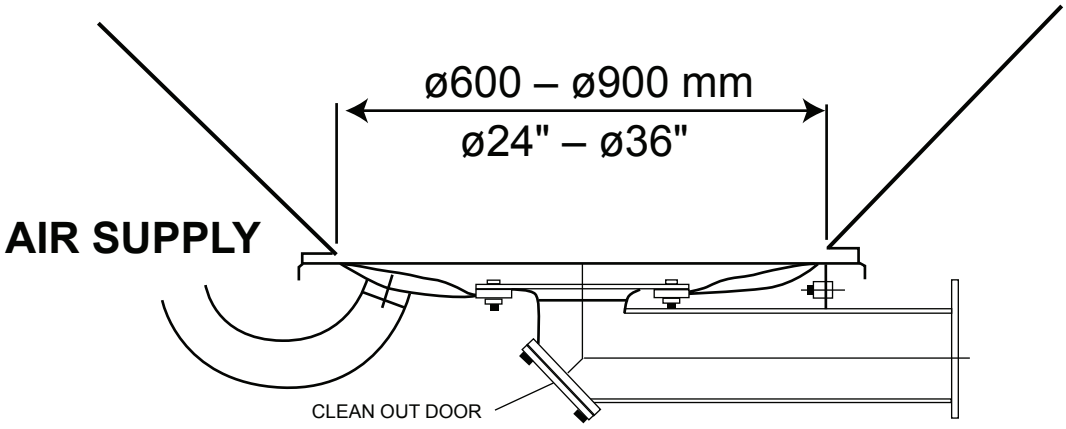
Original Fabric Aerator

The first aerator bottom that I remember had a flat fabric clamped between flanges. The bottom outlet pipe was located in the center of the fabric.



Current Fabric Aerator

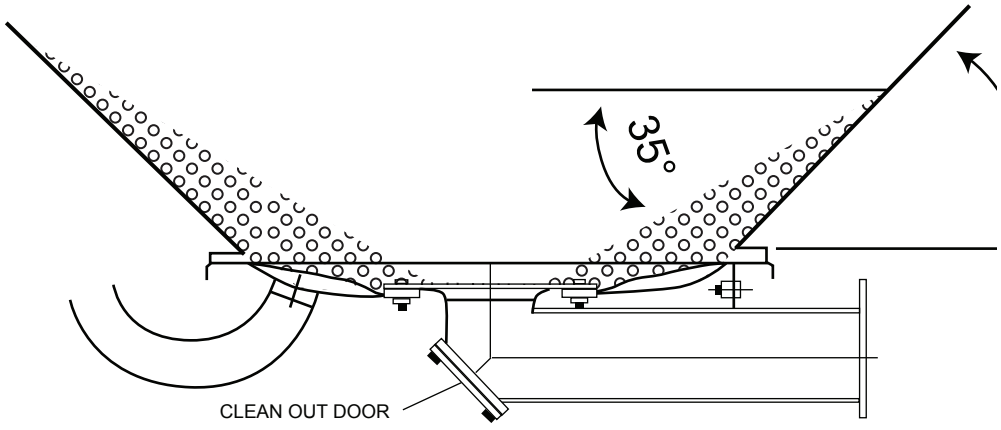
Currently the fabric aerators has grown in diameter and the fabric is sloping toward the outlet for better clean-out.



BOTTOM OUTLET

Pebbles and Pellets
Poor Clean-Out

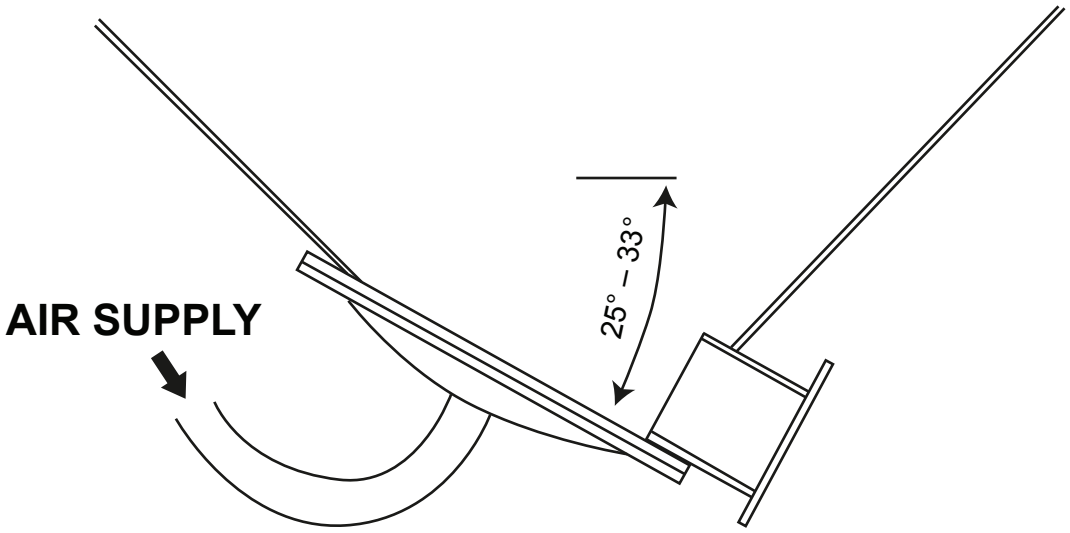
Products with large particle size like plastic pellets or pebble lime are too course to be aerated. They have an angle or repose of about 35 degrees. This causes a very poor clean-out on an essentially flat bottom.



Sloping Aerator

To minimize over all height or maximize volume or ground-clearance, a sloping aerator was developed.

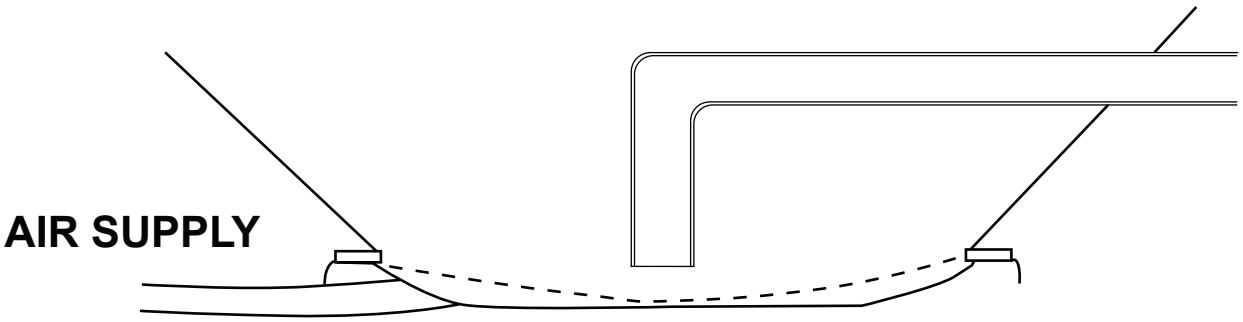
If the slope is 25-33 degrees, it is quite versatile and will handle many products from powders to pebbles.



Riser Outlet
Aerateable Products Only

Maximum Ground Clearance

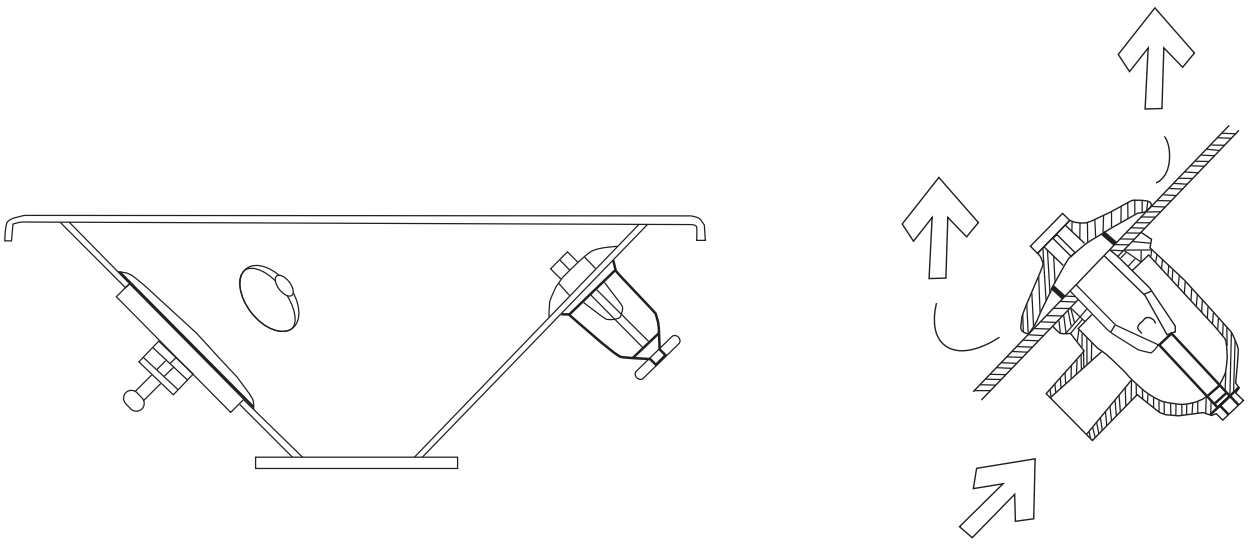
When the tank is located over the drive shaft, an axle or the fifth wheel a bottom outlet becomes impractical and a riser outlet can be used. Aerated products like cement or flour is forced up and out by the pressure in the tank.



Point Aeration

The latest aeration device on the market is a rubber disc that lets air into the tank, but acts as a check valve to prevent air and product to back up into the air supply line. It does not disperse the air into the product as evenly as fabric does. It acts more as a circular nozzle that blows air into the product.

Disc aerators generally require a 45 degree slope for an acceptable clean out. Toward the end of the unloading, as soon as the discs are uncovered by the product, they will start to vibrate. These vibrations have the additional benefit of shaking down the dust layer that normally covers the slope sheets and upper portions of the trailer. With fabric, the dust layer would remain on the slope sheets until the return trip when the empty tanker bounces over the road.

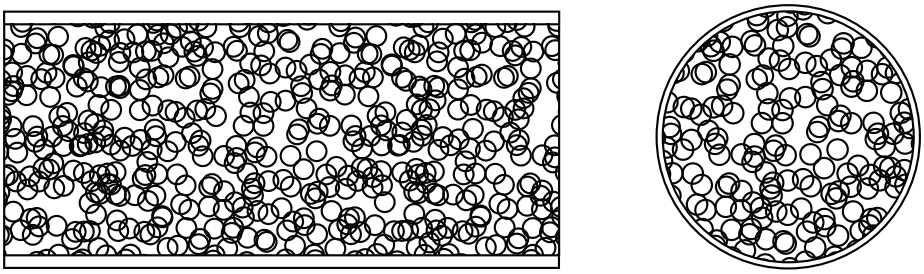


E. PNEUMATIC CONVEYING PHASE

Dense Phase Conveying

In our first case, when we talked about short unloading lines without extra air, we are essentially talking about an extrusion process where the top air is pushing out the product and through the line. Conveying is primarily a function of the tank pressure.

DENSE PHASE CONVEYING

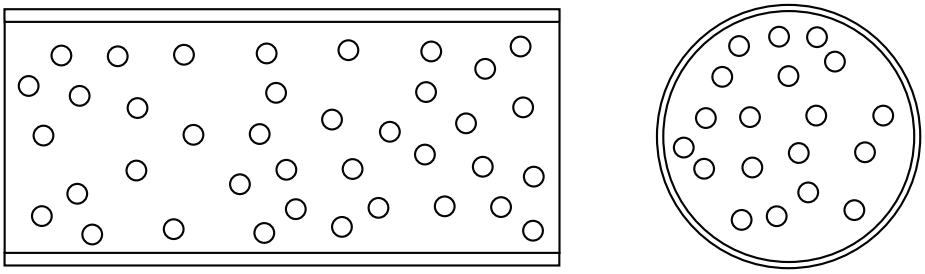


This type of conveying is called dense phase conveying. It is used over short distances and when high transfer rates are desired. Because of the low velocity it causes minimum particle break-up and degradation. This type of conveying is often used for cereals and other food products.

Dilute Phase Conveying

The other type of conveying is called dilute phase, because the product in the line is heavily diluted with air to make it easier to convey over longer distances. To convey a product in dilute phase requires a much higher air velocity than it does in dense phase.

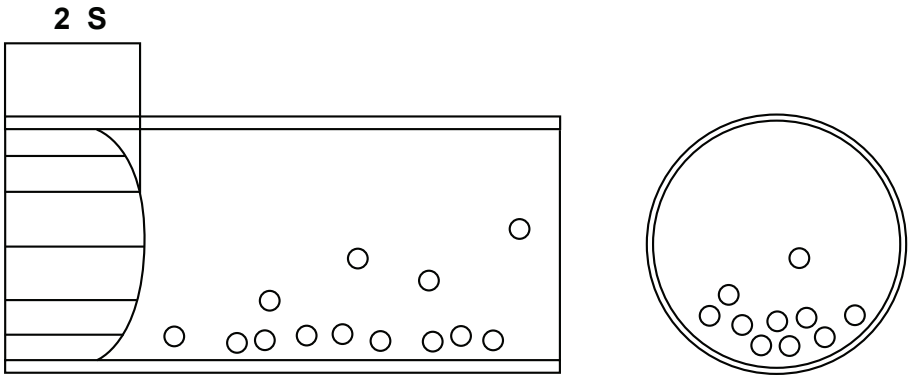
DILUTE PHASE CONVEYING



Particle Pick-Up Velocity

If we have a conveying line with a certain product in the bottom and we gradually increase the line velocity, we will eventually reach a point when the particles will be picked up and carried in the air stream. Just like sand or snow is picked up by the wind to cause a sand or snow storm. This is called particle pick-up velocity. This velocity has to be exceeded to convey a product in dilute phase. The advantage with dilute phase is that the operating pressure can be easily controlled with minimal risk for plugged lines and product can be conveyed over great distances.

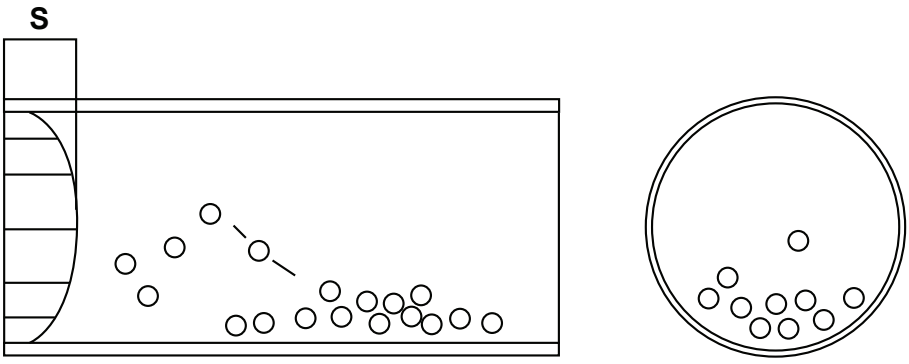
PARTICE PICK-UP VELOCITY



Saltation Velocity

Conversely, if the velocity in the dilute phase is decreased, at some points the particles will fall out of the airstream and collect on the bottom of the pipe. This is called saltation velocity. This is how sand dunes and snowdrifts are formed.

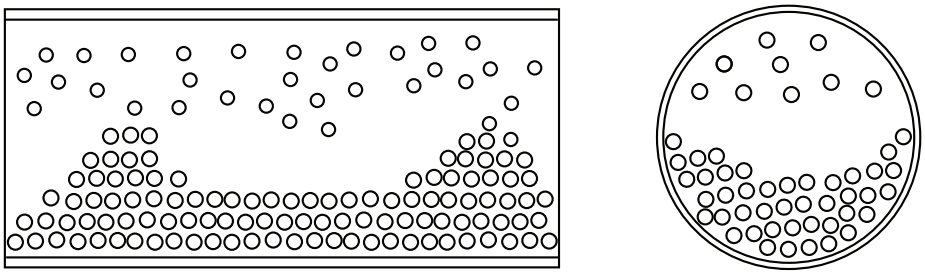
SALTATION VELOCITY



Two-Phase, Mixed, Medium or Intermediate Phase Conveying

If the velocity is decreased further, the product will collect further and partially fill the pipe in heaps of nodes similar to sand in shallow water. The heaps may also drift along in the pipe like wandering sand dunes or snowdrifts.

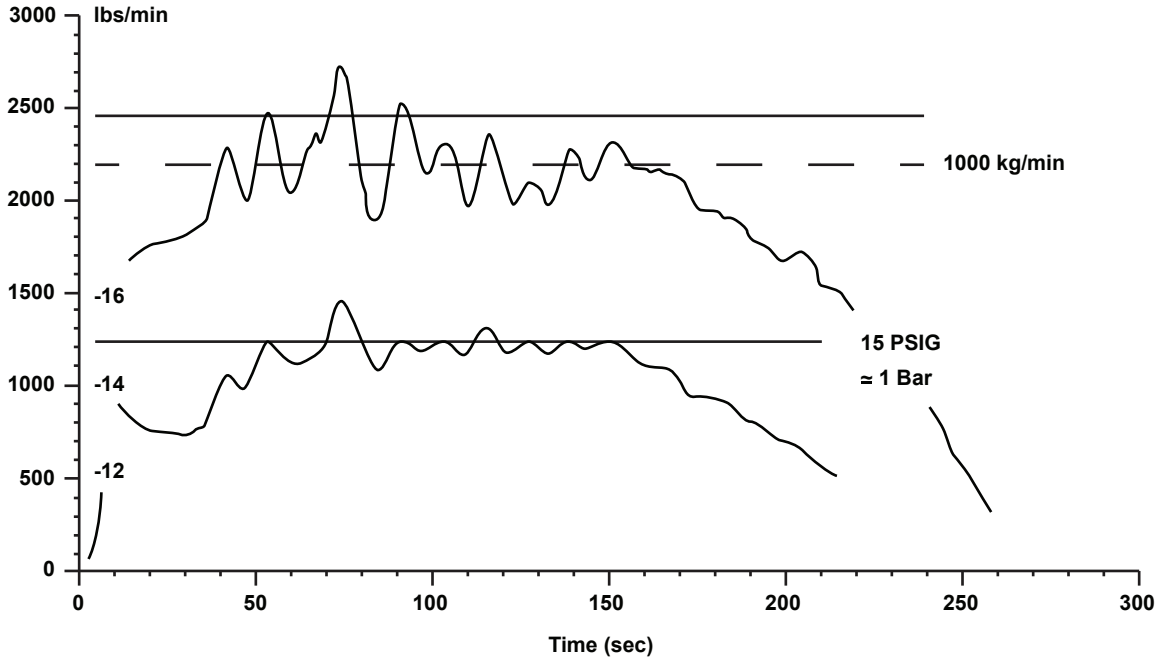
INTERMEDIATE PHASE CONVEYING



Because the upper "open" portion of the pipe is decreased, the velocity increases. This will cause the air to pick-up more product off the top of the nodes. In this way, the flow is self-regulating and plugging is unlikely to occur. This phase could also be called an unstable phase since the condition inside the pipe keeps changing. This has been proven with our own test facility, where the unloading pressure and unloading rates are electronically recorded.

CEMENT UNLOADING

4" LINE 105 ft. (32m)
425 SCFM (725m 3/h)



F. FACTORS THAT EFFECT UNLOADING RATES

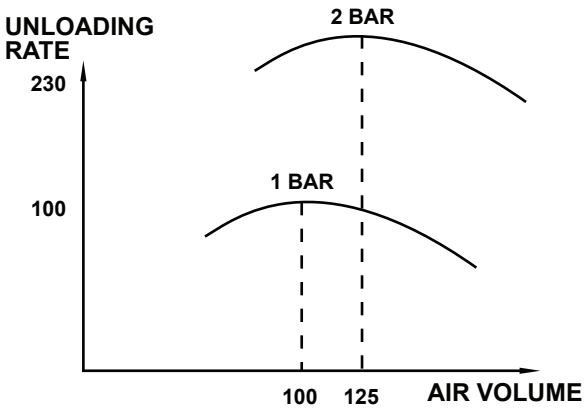
Now that we have covered how to get the product out of the tank, we will cover how to get it through the line efficiently. We will look into the five most important factors that affect the unloading of a trailer.

1. Tank Pressure
2. Line Size
3. Length of Unloading Line
4. Unloading Line with Incline
5. Air Volume and Line Velocity
6. Clean-Out Cycle

Tank Pressure

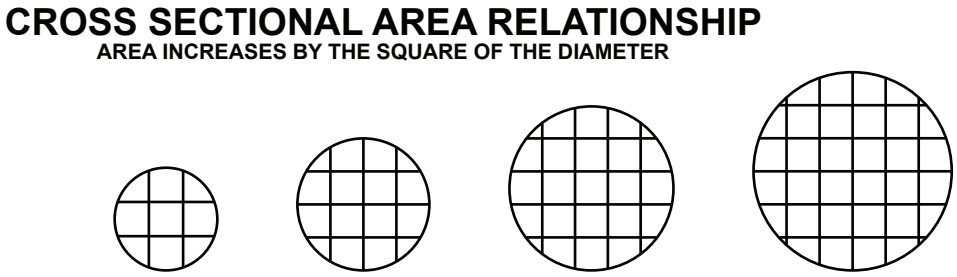
In Europe the tankers normally operate at 2 bar tank pressure, while in the U.S.A. the tank pressure is usually 1 bar. Originally, the reason for the lower pressure in the U.S.A. was that if the operating pressure was kept below 1 bar the vessel did not have to be built to the pressure vessel code and could be much lighter. Of course a higher operating pressure results in a faster unloading.

Generally speaking, if the operating pressure is doubled you can expect at least double the unloading rate and the optimum air volume, which we will cover later, will increase by about 25 percent.



Line Size

When you double the line size you quadruple the unloading rate because the cross sectional area of product line increases by the square of the pipe diameter. The unloading rate is directly proportional to the cross-sectional area of the pipe.

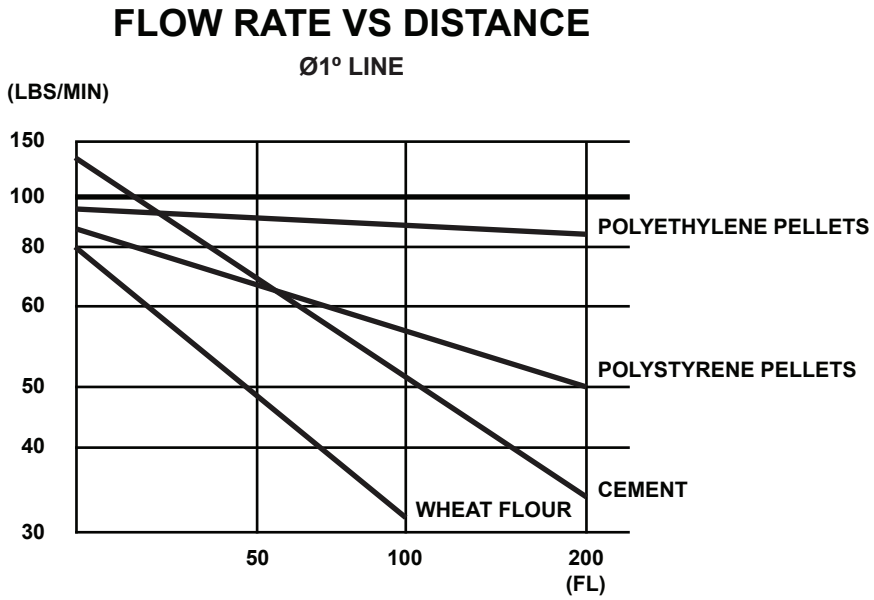


Line Size In Inches	3	4	5	6
Line Size Squared	9	16	25	36

A 4" line compared to a 3" line has 16/9 = 1-7/9 = 177% bigger area
A 5" line compared to a 4" line has 25/16 = 1-9/16 = 156% bigger area
A 6" line compared to a 4" line has 36/16 = 2-4/16 = 225% bigger area

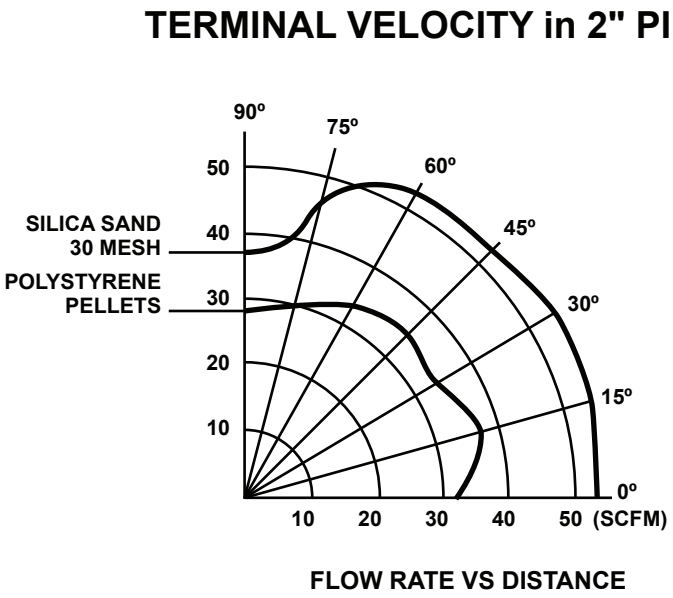
Length of Unloading Line

If you double the unloading line for powders, like cement and wheat flour, the unloading rate decreases by about 36%. But with a granular product like polyethylene pellets, the decrease in rate may be only 3% if the unloading distance is doubled. Sharp turns and many turns have a detrimental effect on the unloading rate.

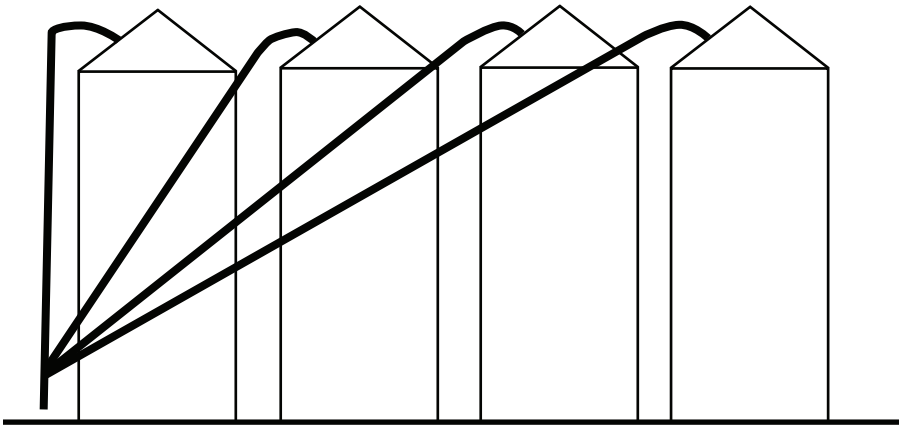


Unloading Pipes with Incline

If you take a pipe and tip it at different inclinations, we find that it takes considerably higher velocities to keep the product moving smoothly at an incline of 15-85 degrees. That is why a pipe with an incline should be avoided.



The worst example I've seen of this type was this application.

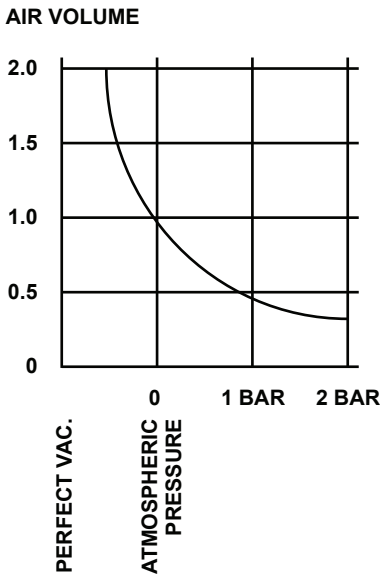


Unfortunately, the product was rock salt which needs a high air volume because it is heavy and has large particle size. The incline made it even tougher to unload.

Air Volume and Line Velocity

The last but trickiest factors that affect the unloading rates are air volume and line velocities. If the conveying medium was water it would be simple. You would just take the water volume and divide it with the pipe cross section and you get the velocity.

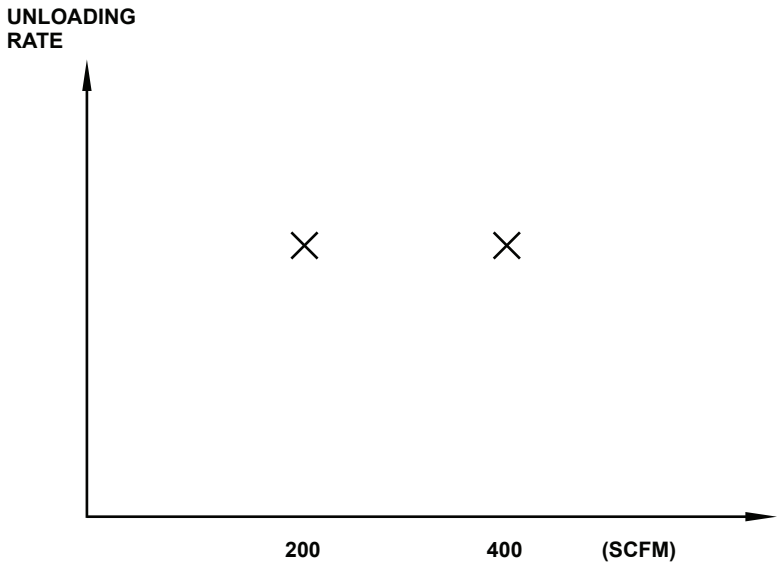
But air is very complicated, it is compressible. By compressing atmospheric air to 1 bar gauge pressure, it is reduced to half its original volume. By compressing atmospheric air to 2 bar gauge pressure, it is reduced to 1/3 its original volume.



The only reasonable way to measure air volume is to measure the volume of air that flows into the blower on the intake side. Even then, the density changes with the barometric pressure, the elevation above the sea level and the ambient temperature. I found that out when they built the Eisenhower tunnel in Colorado. At about 10,000 ft. (3000 m) level where the air density is only 70% of what it is at sea level, the operators could not get up to normal operating pressure nor could they get enough air volume for efficient unloading. That is why we work with SCFM. Which is standard cubic feet per minute.

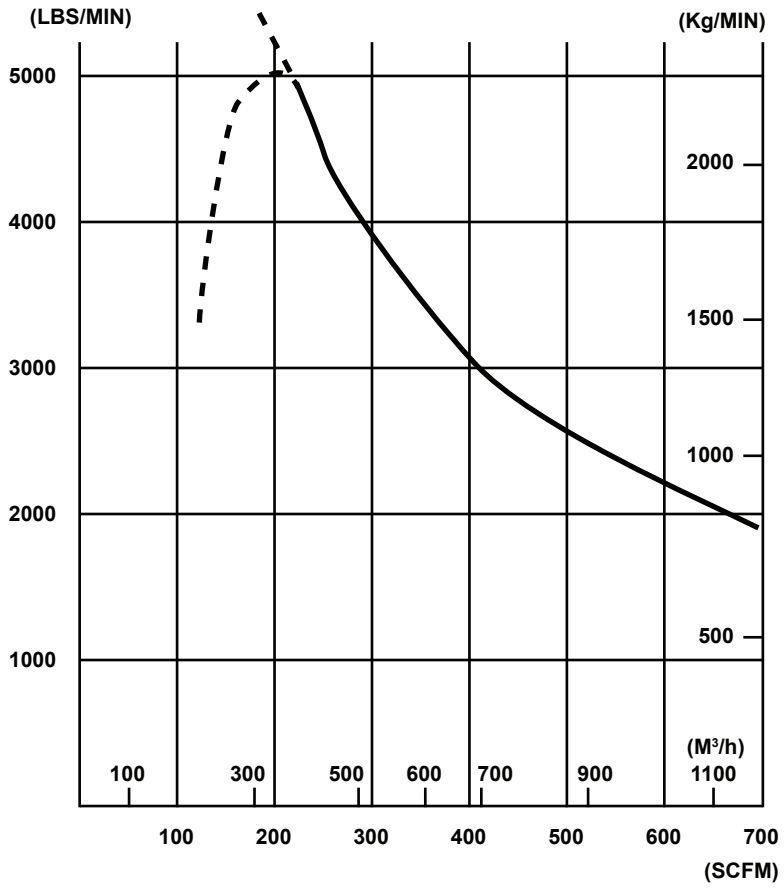
So, why is air volume and velocity important? In the early sixties, when pneumatically unloaded trailers were relatively new, there was a question of what was the best air source. A piston compressor with about 200 SCFM capacity, or a roots type blower with 400 SCFM capacity.

I ran 2 identical tests with the exception of the 2 different air sources. The results were identical. From this I concluded that it made no difference what size air source was used.



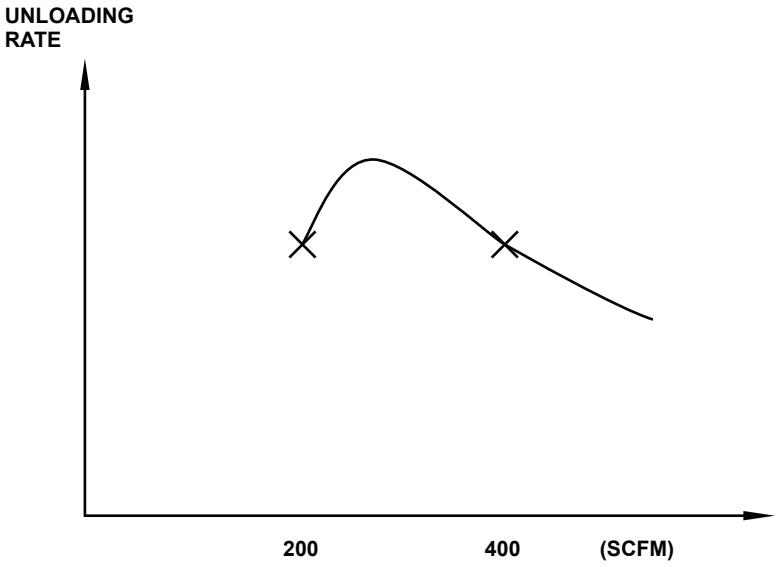
Then in 1965, I conducted a series of 130 full scale tests with various pressures, pipe lengths, pipe diameters, products and air volumes. To my amazement, I found out that air volumes could have a profound effect on the unloading rate, especially when using short unloading lines.

UNLOADING RATE



By changing the air volume and keeping all other things the same, I discovered the unloading rate seemed to follow a hyperbolic curve until the air volume was so low that the line plugged.

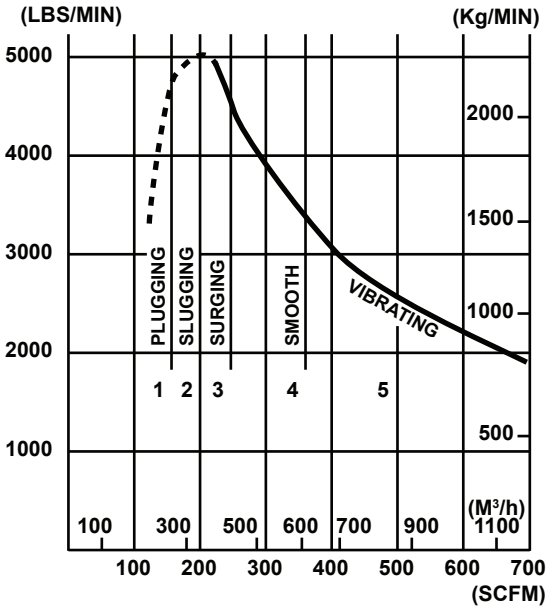
What I had missed a few years earlier now become evident. I had stumbled onto two points on the curve that just happened to have the same unloading rate. One at the low end of the curve and one at the higher end of the curve.



Further analysis of these curves helped to locate five distinct operating zones.

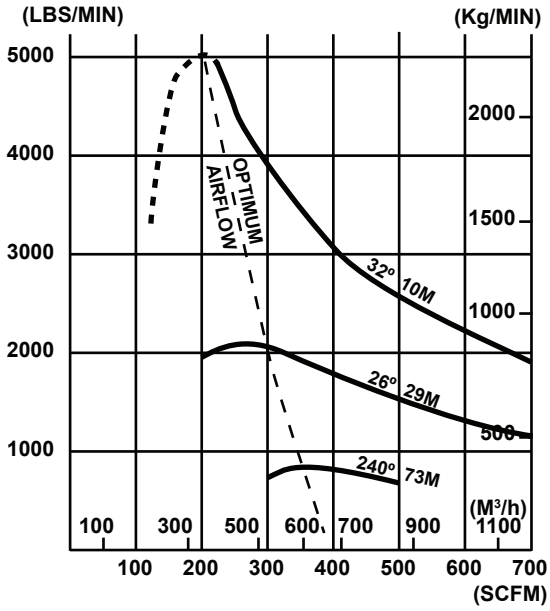
1. **The plugging zone:** The line keeps plugging over and over again, especially in the hose.
2. **The slugging zone:** The flow stops, builds up pressure and then flow starts for a short while again. It is an indication of insufficient air volume for the conditions and risk of plugging the line is very high.
3. **The surging zone:** The flow slows down and then speeds up again repeatedly, but risk of plugging is low. Maximum unloading rate.
4. **The smooth zone:** Unloading is trouble free in this range and risk of plugging is eliminated.
5. **The vibrating zone:** Vibrating flow occurs when air volume is excessive. This results in slower unloading rates, unnecessary pipe abrasion and product degradation.

FLOW CHARACTERISTICS

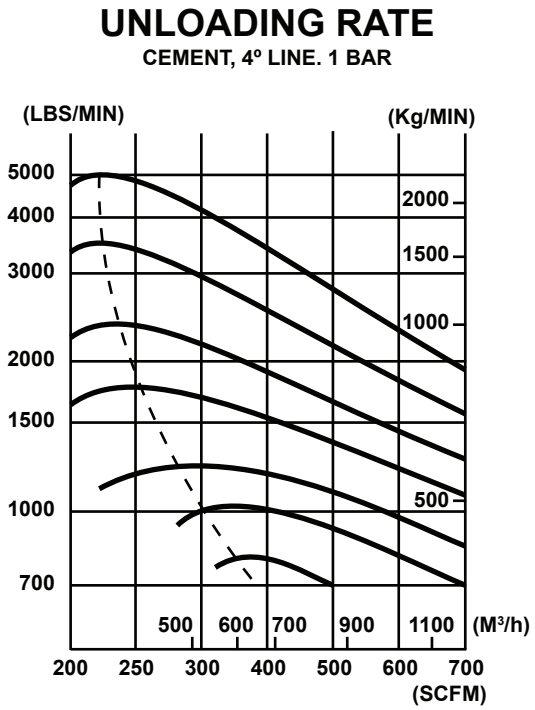


OPTIMUM AIR VOLUME RELATED TO CONVEYING DISTANCE

CEMENT, 4º LINE. 1 BAR



For longer lines, the optimum air volume ranges are not as pronounced. It is apparent that for longer lines the optimum rate shifts towards higher air volumes. If we put these unloading rates on a double logarithmic or percentage scale it is easier to see the shift in magnitude of the optimum air volume for various pipe lengths.

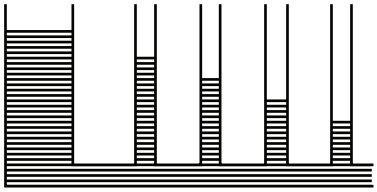


For a short line, the optimum air volume is 225 SCFM for cement in a 4" line using 1 bar (15 PSIG) pressure. For a long line, the optimum air volume increases about 70% to 380 SCFM.

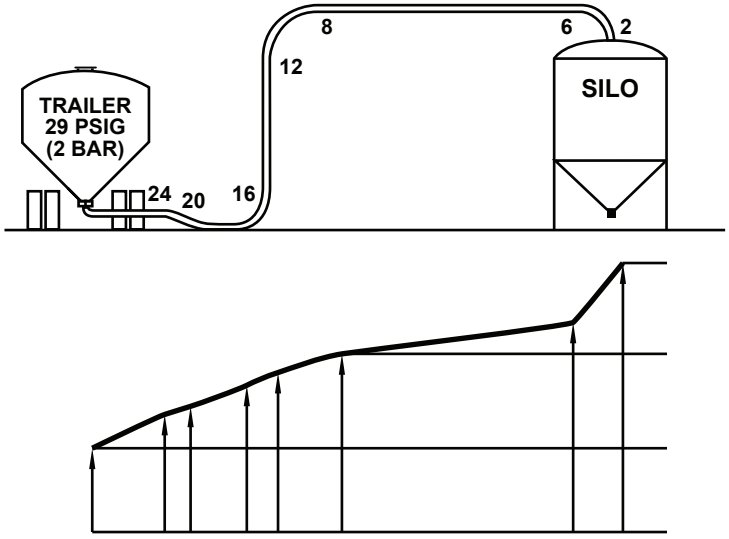
Line Velocity

I remember from my grade school physics class the way they illustrated how pressure decreases down a water line.

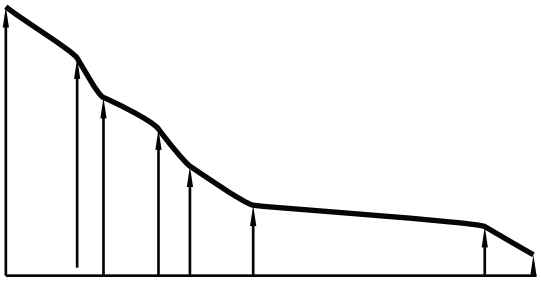
DECREASING PRESSURE IN WATER LINE



We have a similar situation in pneumatic unloading lines.



CORRESPONDING VELOCITY VECTORS

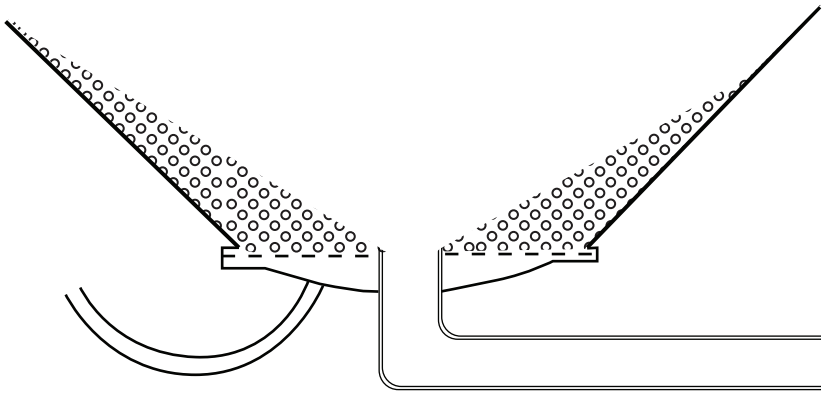


DESCENDING PRESSURE

Since the air is compressed inside the trailer, it will expand again as soon as the pressure decreases and the product goes down the line. As volume increases, so does the velocity. Under 1 bar tank pressure condition, the velocity will double at the end of the line. Under 2 bar tank pressure condition, the velocity will triple at the end of the line.

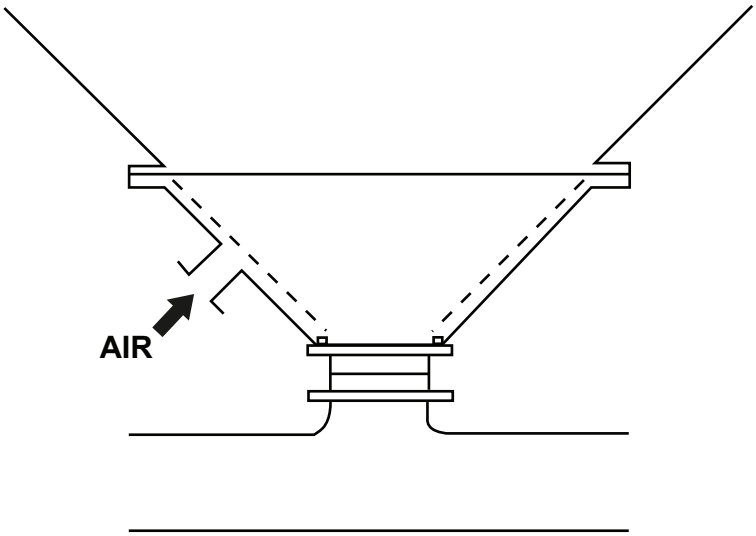
Clean-Out Cycle

Poor Clean-Out
During usage the fabric stretched and ballooned upwards because of the pressure in the plenum. This dammed up the product and resulted in poor clean-out.

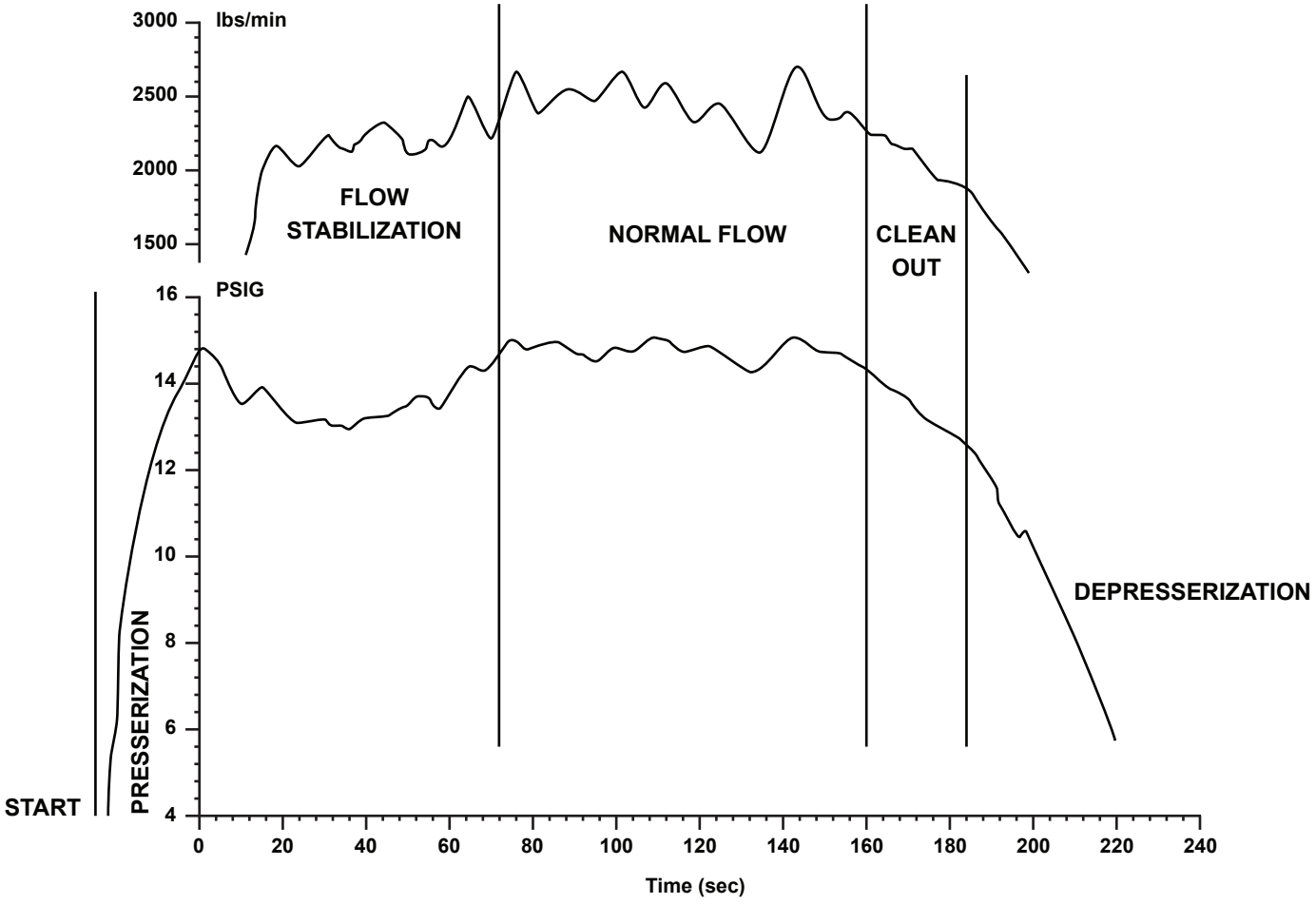


Fabric Aeration In 45 Degree Cone For Versatility Powder, Pellets and Pebbles

Best Unloading, Best Clean-Out
To achieve maximum versatility, the fabric needs to have a funnel shape like the hopper itself so that all products will clean-out well.



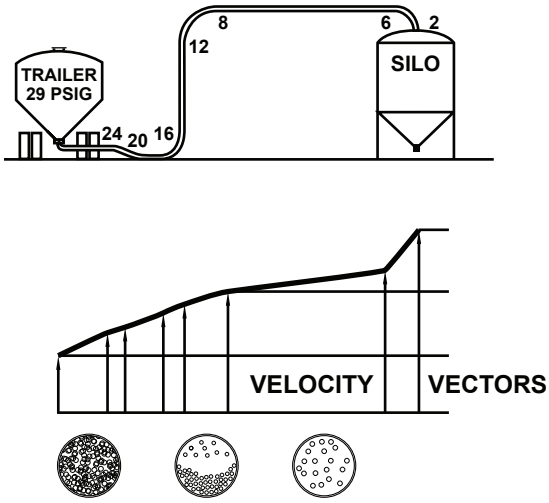
Typical Unloading



Actual Unloading

In which phase do we operate when we unload a pneumatic trailer? When we talk about a powder like cement or flour, we most likely go through all three modes or phases. In the beginning of the line, especially the short distance before the pressure control air is added, we are in dense phase. As the pressure goes down and the velocity increases there will be a gradual conversion to mixed phase. Finally, toward the end of the line, we may be in dilute phase. In fact, the driver does not know what phase he is conveying in and he doesn't have to know. He could actually care less. He is only interested in one thing, get the load off and get it off quick and without trouble.

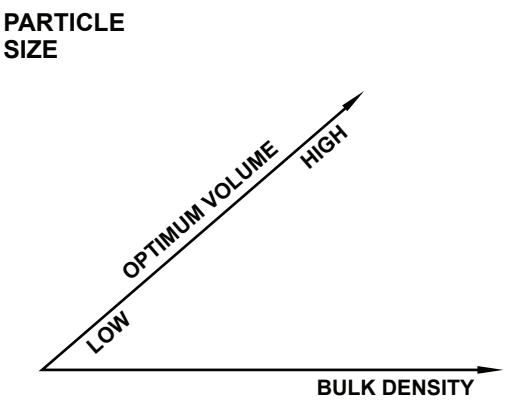
With plastic pellets more air volume is used and the unloading most likely will take place in the dilute phase.

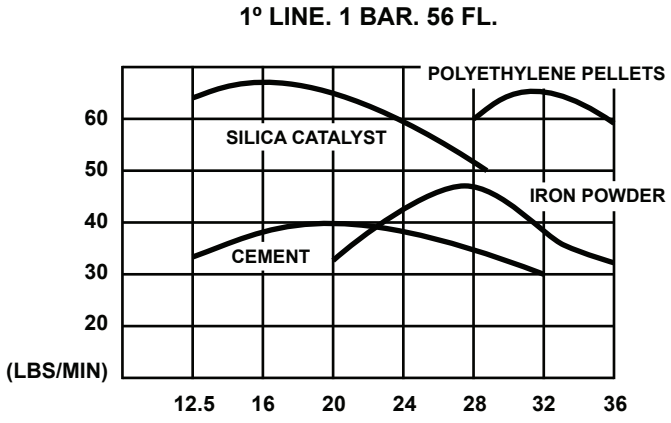


Other Products

Every product has its own conveying characteristics. For example, unloading rate vs. air volume and unloading rate vs. conveying distance. Factors that influence these characteristics are bulk density, particle shape, particle size, particle size distribution, etc.

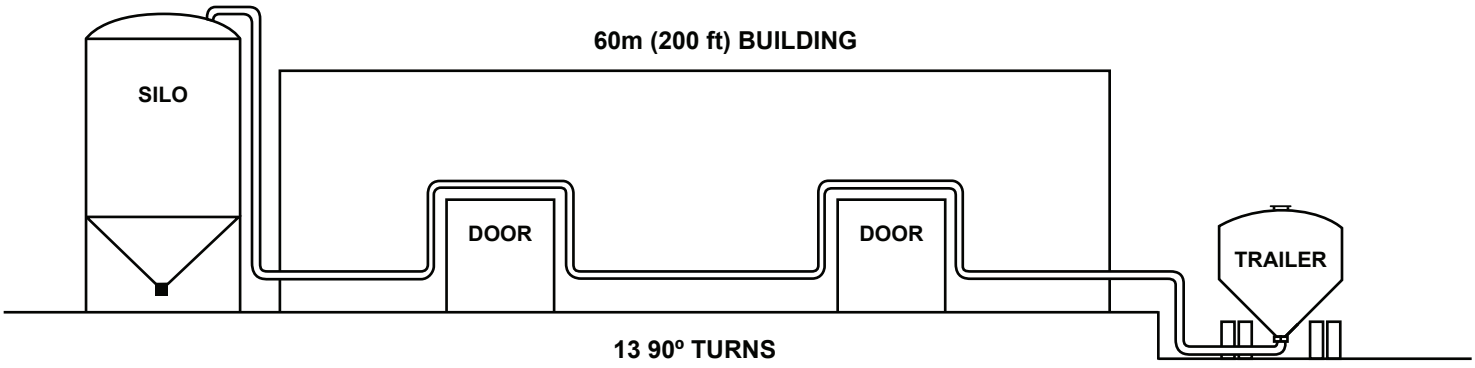
Low bulk density and small particle size like flour or starch means low optimum air volume. High bulk density and large particle size like sand, plastic pellets and pebble lime mean higher optimum velocity.





Pipe Installations

Unfortunately, the trucker never has any say about the unloading facility. All he knows is that he gets a phone call and somebody wants a truckload of material to a new factory. When he shows up to the site, he is expected to unload with whatever piping has been installed. The problem is the piping often is installed by people that have no idea what pneumatic conveying is all about. Often the piping could have been shortened to a fraction of the existing length. Sharp turns, extra turns, pipes on an incline and change of pipe size are unfortunately very common.



One of the worst examples I can remember of a bad pipe installation was at an electric cable manufacturing company. Thirteen 90 degree turns!

System Installations

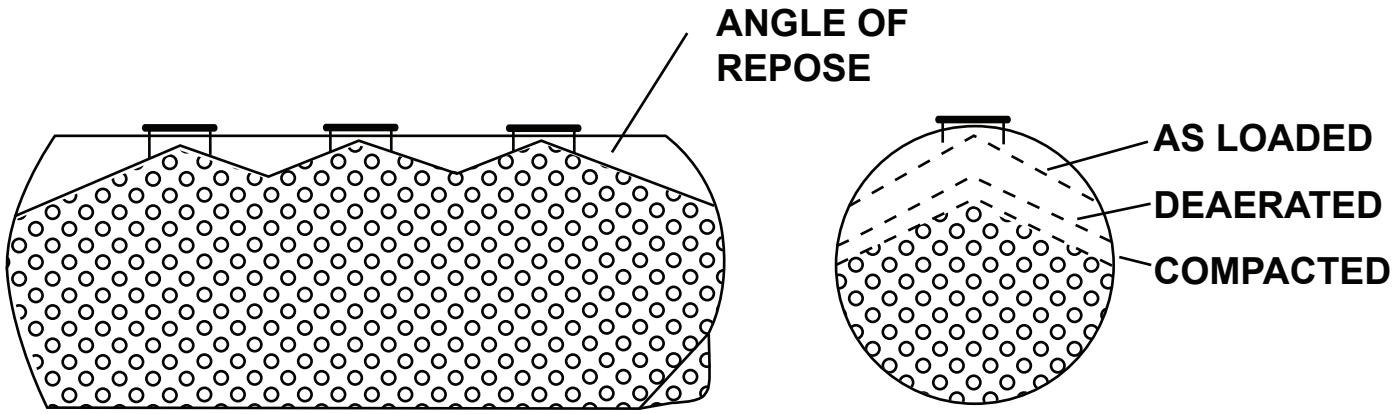
Most trailers are unloaded with a PTO driven air source on the tractor or an engine driven air source mounted on the trailer. The truck operator can then adjust the speed to fit the situation. Some truck delivery installations are provided with a permanent pneumatic air source provided by system engineers. Then we usually have a different problem. Too much air! In our case with cement, usually around 850m cubed per hour (500 SCFM). Why? Because system engineers work completely in the dilute phase area and base the air volume on particle pick-up velocities.

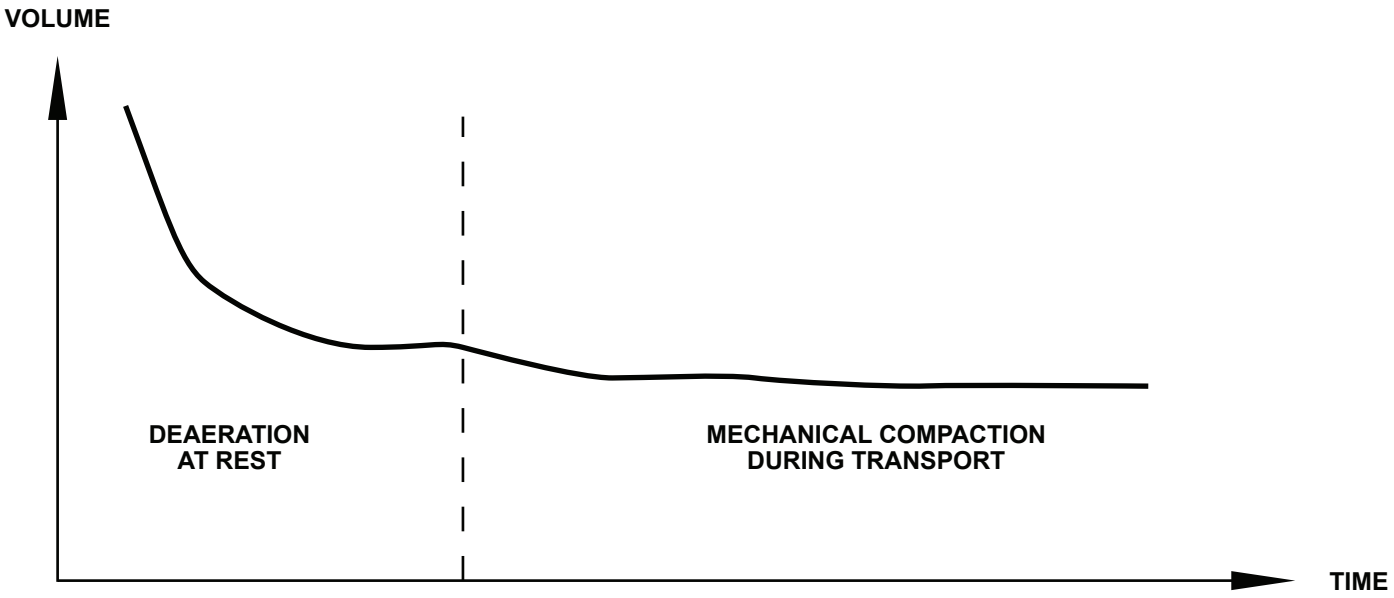
If they use an airlock and stop it, they expect a clean product line. The trucker can work very well with a conveying line that is half full of product during the unloading. During the clean-out stage, all the air will rush out of the trailer through the line at a very high velocity and clean out all the product in the line.

Unfortunately, I have never been able to convince systems engineers to reduce the air volume and the resultant line velocity. If the air source is belt driven, it is sometimes possible to change the pulleys to slow down the air source and in this manner improve the unloading rate.

G. DRY BULK CONTAINERS

Dry bulk tank containers are similar to dry bulk trailers except they are more restricted by the height and length requirements. They have to fit within the ISO envelope. Compared to liquids, dry bulk materials have a voidage between particles of about 50%. Thus, the bulk density is generally lower and would require a container with larger volume. The bulk densities for minerals like sand, barite, Portland cement and salt are between 1.4 and 1.8 bar. Food, feed and chemicals are usually between 0.4-0.8 bar. Additionally, it is also difficult to fill a dry bulk vessel completely by gravity because of the angle of repose and a gradual deaeration as it is being loaded and compacted further when transported.

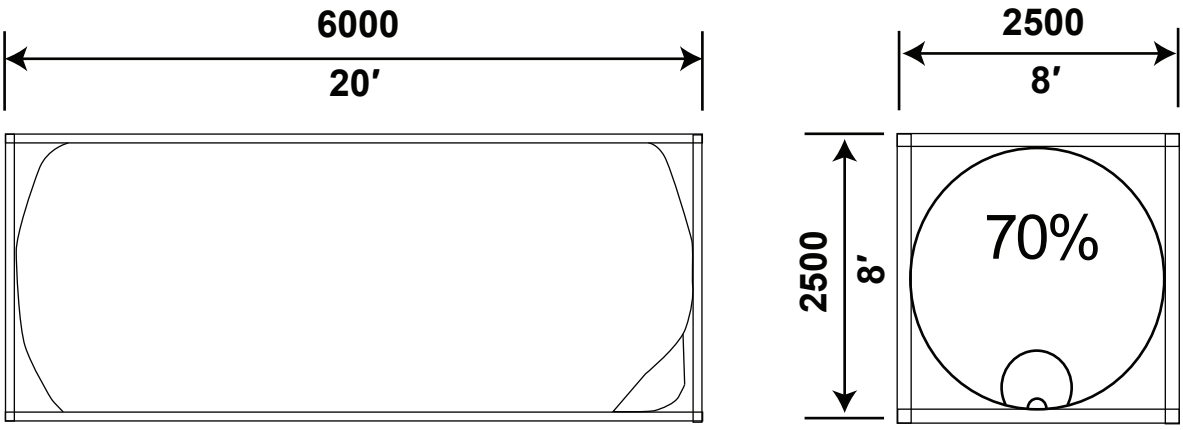




Topping Container

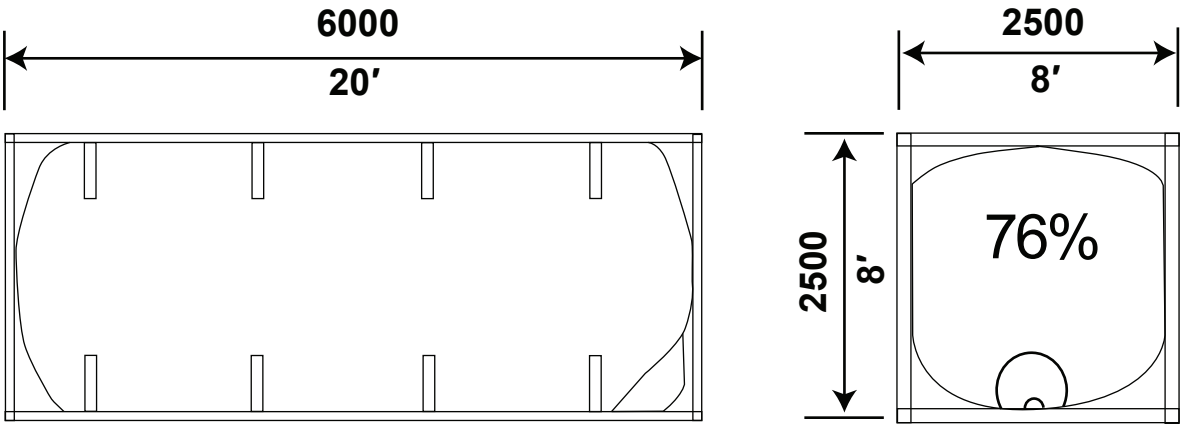
Cylindrical

A tipping dry bulk container looks very much like its cousin, the liquid container. It holds about 70% of the envelope volume. The advantage is that it is a perfect pressure vessel and can be pressurized to 2 bar and is inexpensive to manufacture compared to other shapes. The disadvantage is the need for a tipping device and overhead space.

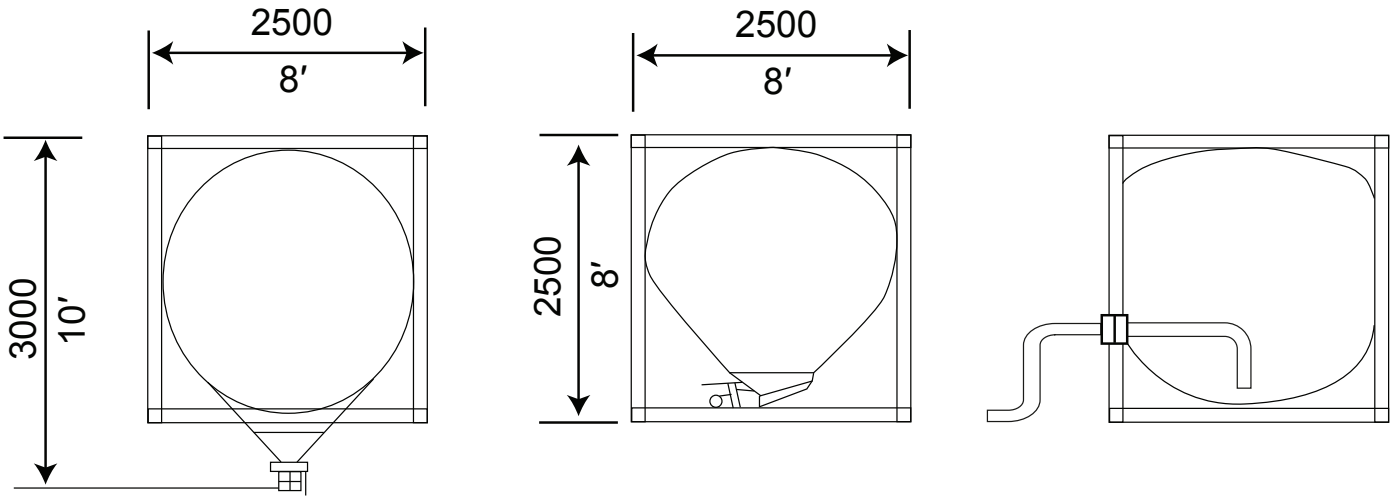


Squaring the Circle

About 75-80% of the volume envelope. Considerably added weight and cost. Because of non-cylindrical form pressure limited to 0.8-1.2 bar.



To take full advantage of the ideal hopper type vessel shape, like trailers that can unload almost any powders, it needs to be about 10 feet high. (3.05 M) Since that is impractical, one has to consider certain compromises.



1) Lower Hopper or Slope Sheet Angles

One has to be extra careful when using square hopper selections. If the slope is 45 degrees in the middle of the slope sheet, the angle in the corner or trough may be as little as 35 degrees. Lower angles may be O.K. for some products like pebble lime and plastic pellets but the low angles restricts the variety of products that can be handled.

2) A Large Flat Bottom

If the hopper is provided with a large bottom with a fluidizing medium and a low angle of 6 to 10 degrees, the overall height is reduced but products that can be handled are limited to aeratable products.

3) A Riser Type Discharge Line

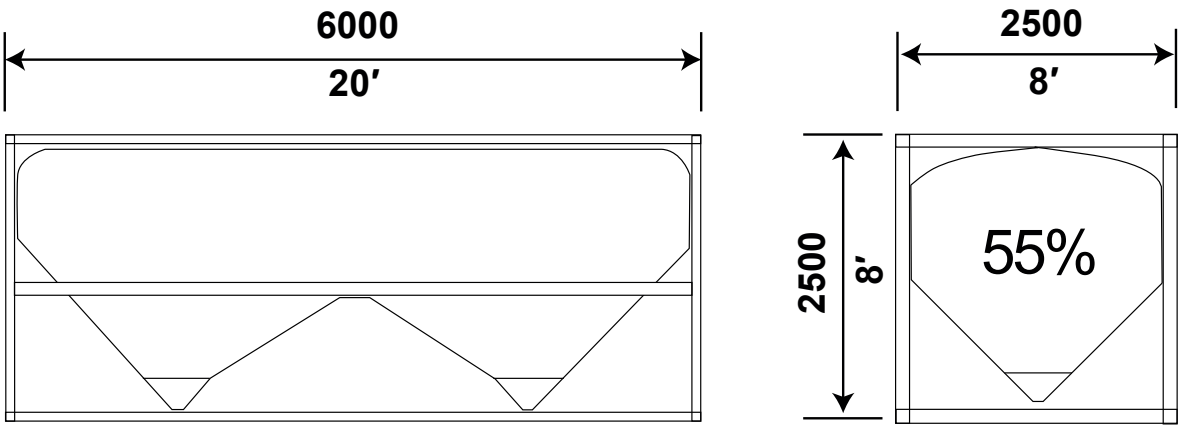
If the product discharge line is mounted inside the container considerable height is saved but also in this case, the solution is limited to aeratable products.

Non-Tipping Hopper Type

Advantage: Non-Tipping (acceptable in U.S.A.)

Disadvantage: Limited Volume
Limited Pressure
High Manufacturing Cost
High Weight

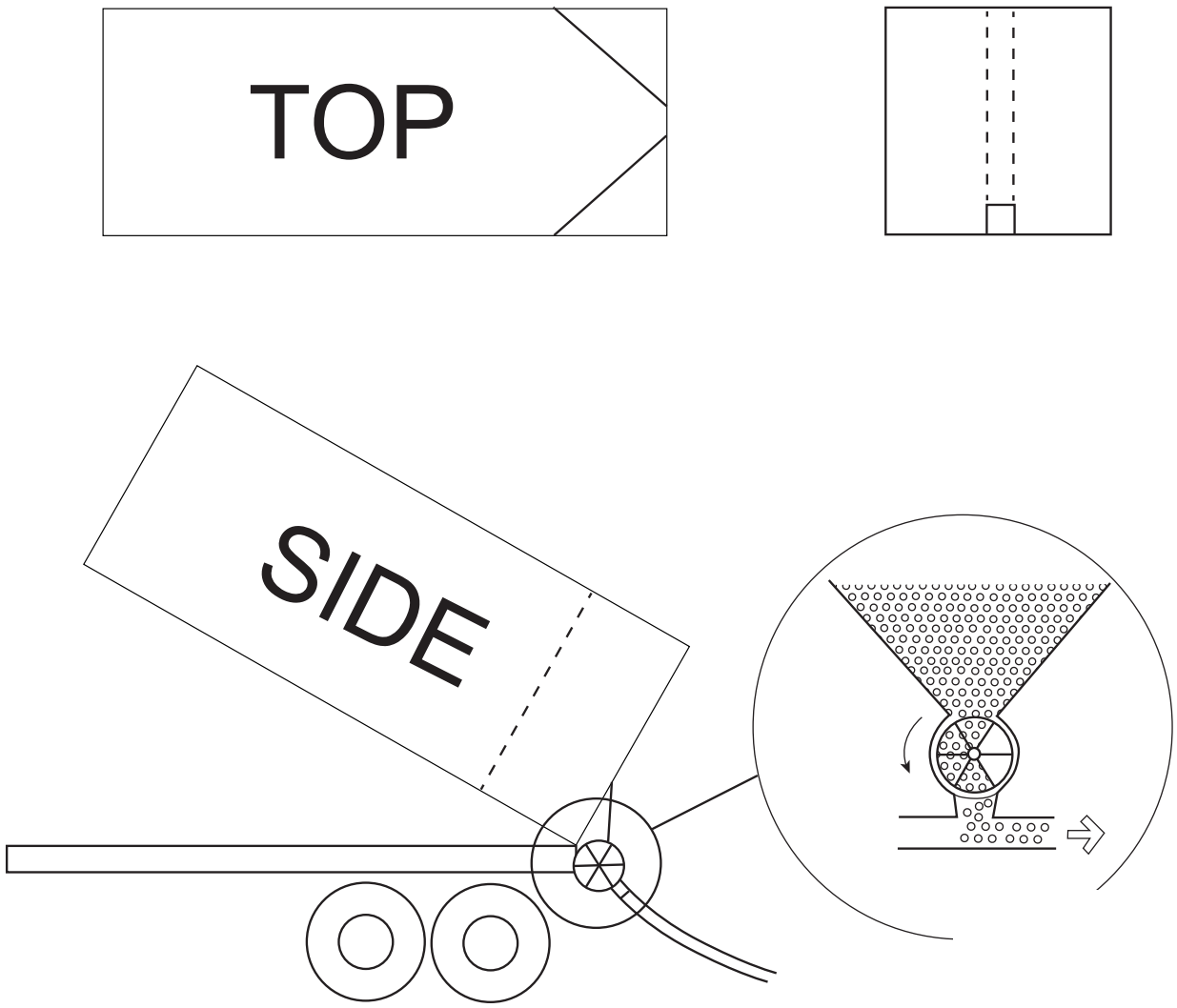
So far, only prototypes have been built.



Non-Pressurized Tipping Container

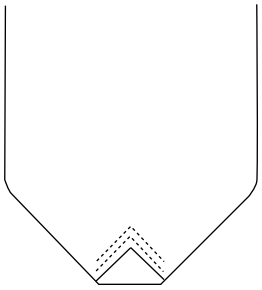
The need for maximum volume of the container has recreated the “original container”, the square box. Of course, since it has flat sides it can not be pressurized. This has necessitated going back to the future by using an exterior airlock arrangement.

The box usually contains a slope sheet at the rear that will create a hopper shape when the container is tipped up. To facilitate gravity flow, aeration devises may be added in this “hopper” area. As the product exits the container it will drop into an airlock (rotary valve) and then it is conveyed by pneumatic means to the receiving silo.

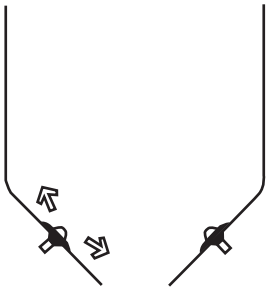


Intermediate Bulk Containers (IBC's)

The biggest apparent difference is the physical size and capacity. They are used where the process is on a smaller scale. They hold about a ton of product. The physical size is usually 4 feet square (1200 mm) nominally so that 2 IBC's will fit side by side on an 8 foot platform. The height varies from 4 feet to 8 feet. Some are stackable. The hopper outlet is fitted with a slide valve or a butterfly valve for dangerous materials.

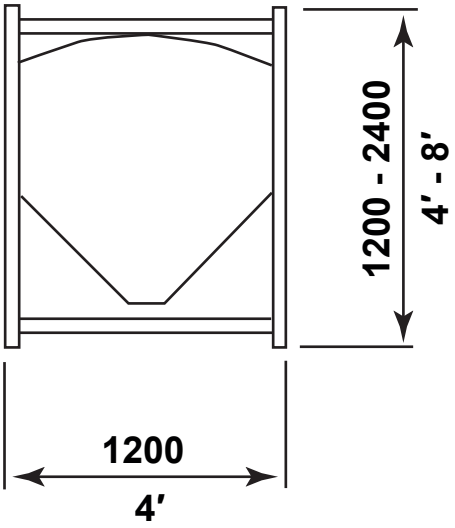


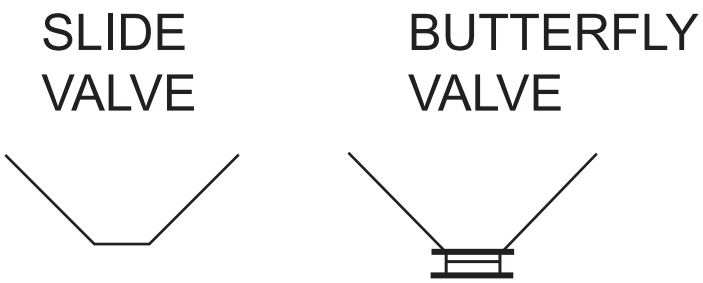
VIBRATION



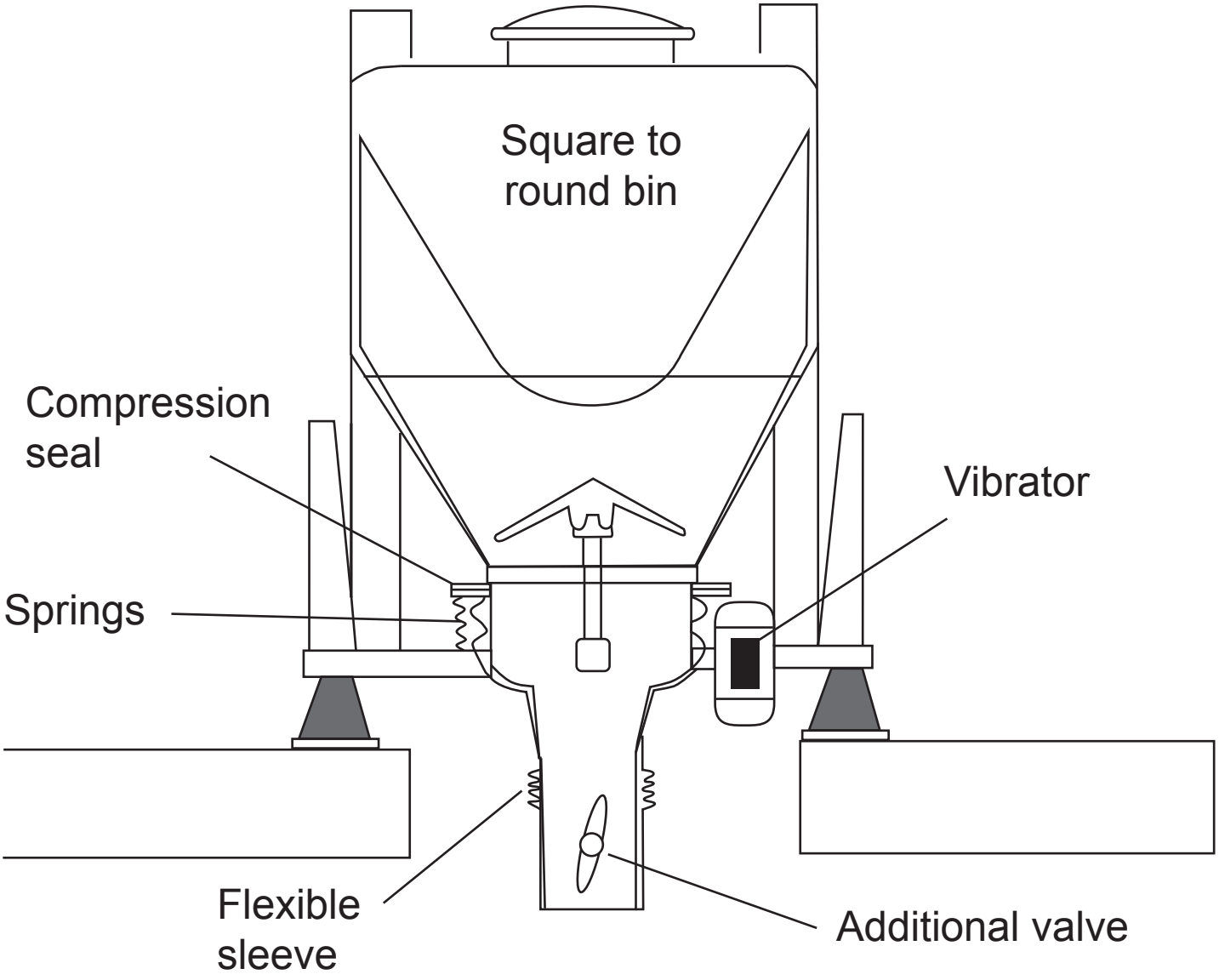
AERATION

Dry bulk powder IBC's are normally not pressurized but many have some kind of vibrating cone or an aeration device, to facilitate gravity discharge. I am not aware of any IBC's that are directly pneumatically unloaded.





FOR DANGEROUS PRODUCTS



Bin Activator type
container system

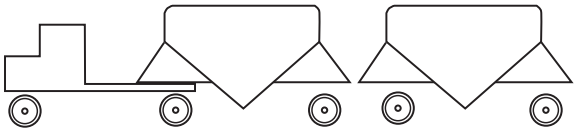
H. ROAD REGULATIONS

Local conditions dictate vehicle configuration.

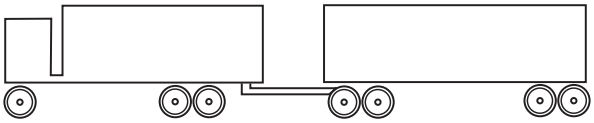
Densely Populated Areas: Shorter Vehicles
Sparsely Populated Areas: Longer Vehicles

EUROPE

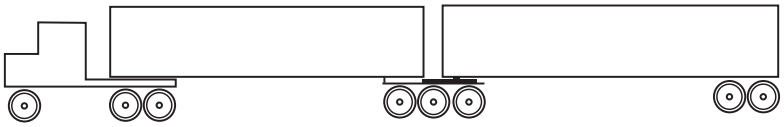
USA (BRIDGE FORMULA)



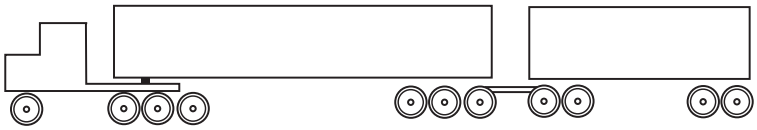
DOUBLES US WEST COAST



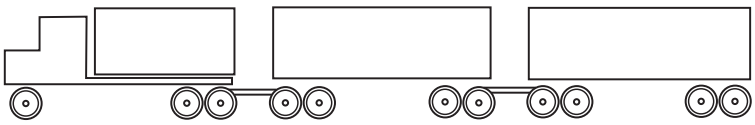
SWEDEN, FINLAND



B-TRAIN CANADA, AUSTRALIA, WESTERN US



DOUBLES – WYOMING, MONTANA, UTAH



UTAH

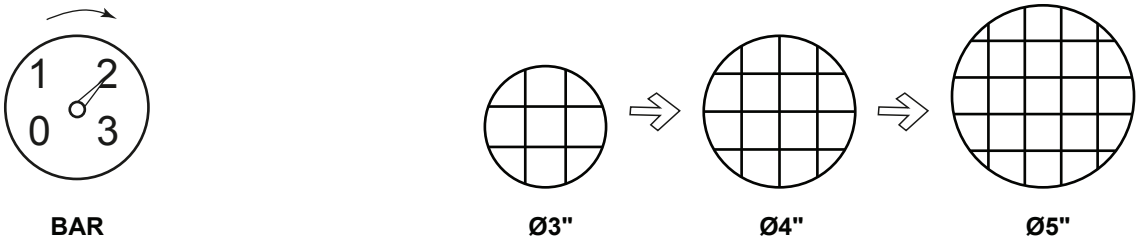
I. WHAT DOES THE FUTURE HOLD?

Now that we have covered how to get the product out of the tank, we will cover how to get it through the line efficiently. We will look into the five most important factors that affect the unloading of a trailer.

1. Faster Unloading
2. Better Clean-out
3. Versatility
4. Combination Outlet
5. 2 or 3 Way Hauls
6. Vacuum Self-Loading Trailers
7. Dust Control
8. Noise Control
9. Using Clean & Conditioned Air or Nitrogen
10. Rail- Truck Transfer
11. Intermodal Containers and IBC's
12. Automated Unloading

1. Faster Unloading

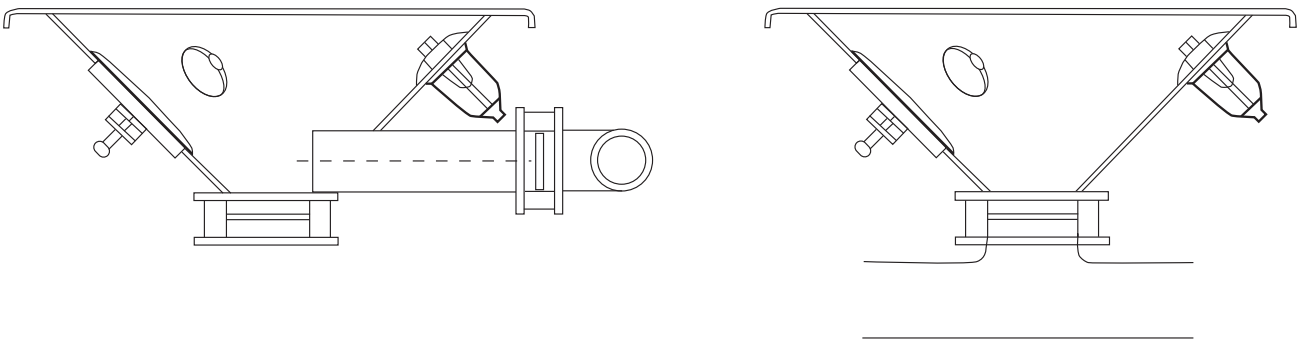
For the United States, it will mean going to higher operating pressures. For Europe, going to bigger unloading lines. For instance, railroad cars in the U.S. have 5" lines as standard and 6" or 8" lines are commonly used for fly-ash and coal powder unit trains. Korea has trailers with 8" lines for PVC.



USA **EUROPE**

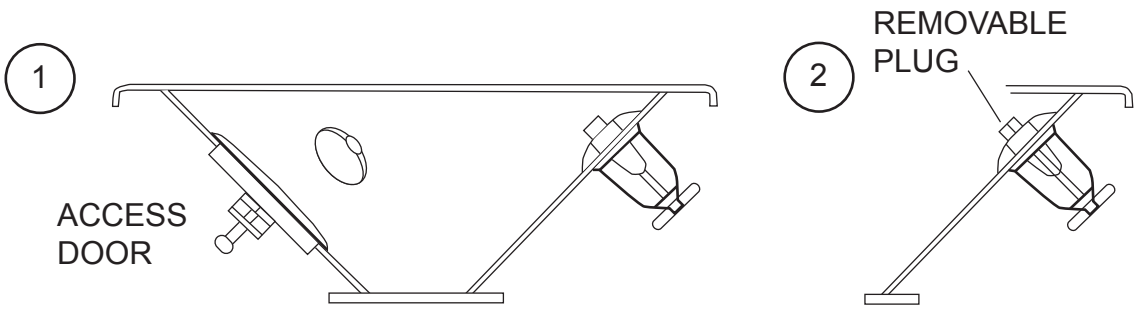
2. Better Clean-Out

A trend toward using a 45 degree cone all the way to the outlet.

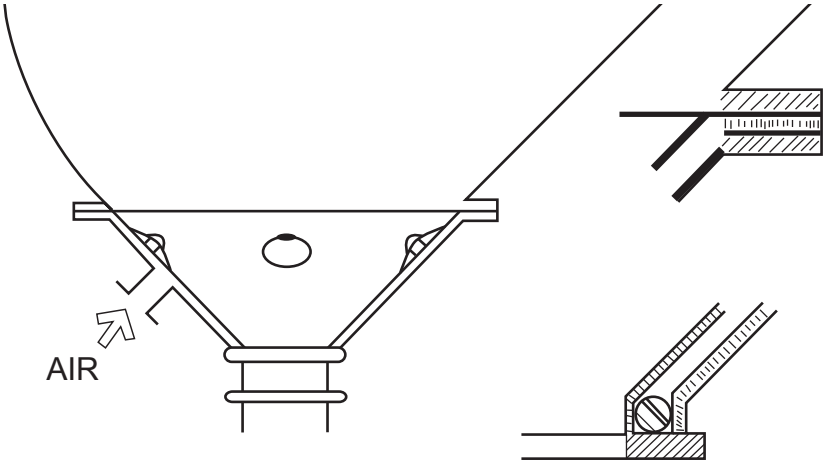


3. Versatility

Trailers that either have removable aeration systems or washable systems.



1. Aeration system removable from outside.
2. Aeration system may be shut off temporarily by plug on inside of trailer.
3. Aeration system may be removed and/or cleaned from inside.

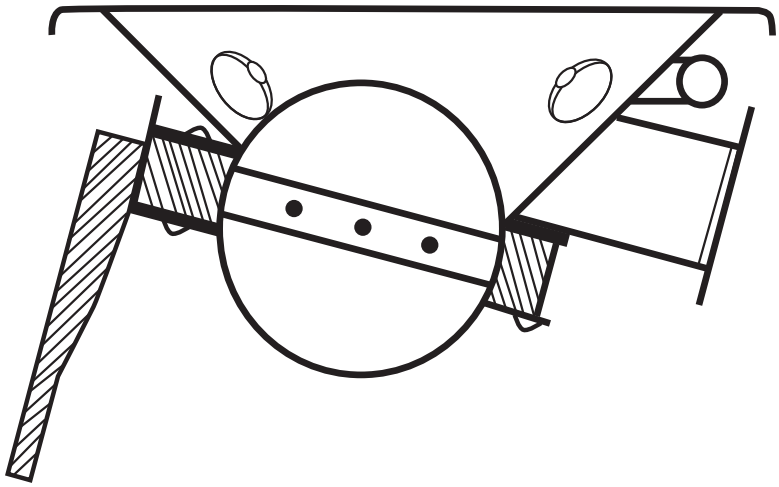


INTERCHANGEABLE AERATION
SYSTEM FOR TIPPING TRAILERS

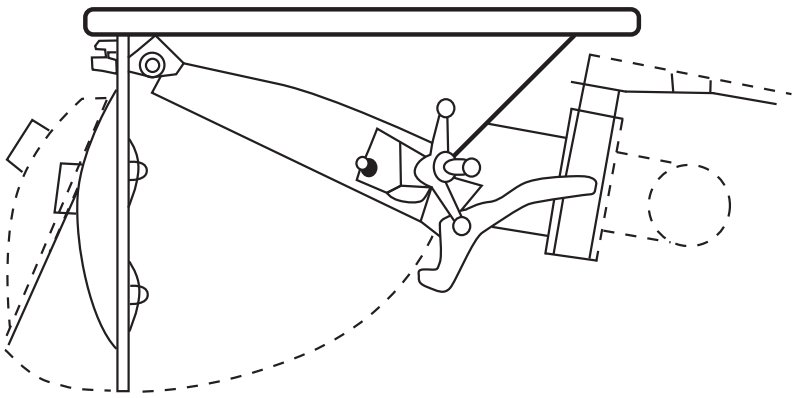
4. Combination Outlets

Outlets that let you unload pneumatically or by gravity. Some outlets have a valve where the gravity flow may be stopped at any time. A combination pneumatic gravity dump outlet has a valve that can be opened, but the gravity flow can not be shut off. Used for grain, sand, fertilizer and feed.

10" or 12" Valve
Gravity flow may be metered or shut off at any time.



16" swing-away trap door
Once opened, it can not be closed until hopper is empty.



Both types of outlets facilitate washing and cleaning, especially the 16" swing-away which is big enough to enter through from the outside.

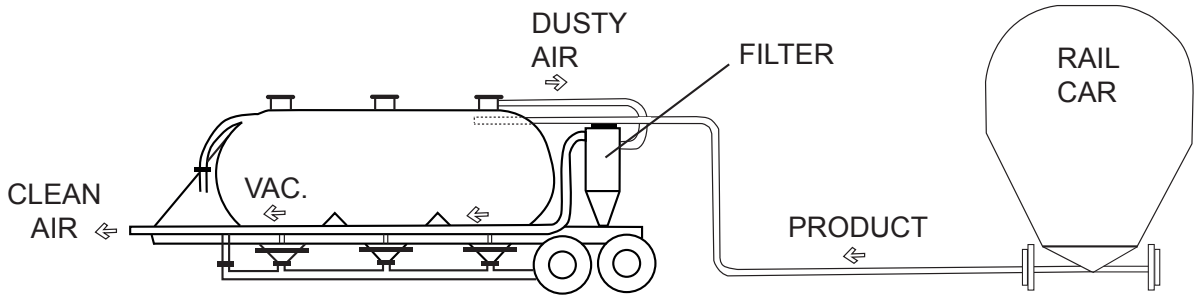
5. 2 or 3 Way Hauls

Every truckers dream. Requires trailers that have the above features for better clean-out, versatility, wash ability and maybe combination outlets. Typical 2 way haul products are grain-cement, foundry sand-cement, and coal-cement.

The best 3 way haul I ever heard of was a 4000 mile round trip.

6. Vacuum Self-Loading Trailers

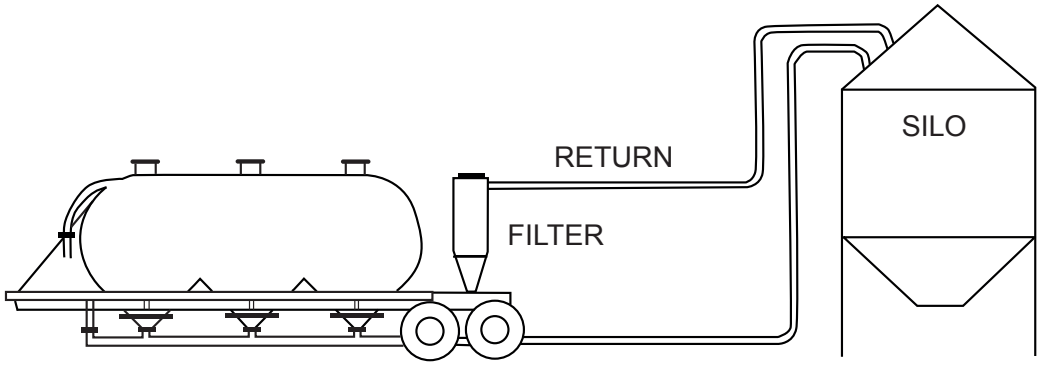
These trailers have big filter systems mounted on the trailer that allows the trailer to be hooked up to the suction side of the blower. The trailer is put under about 1/2 bar vacuum and can thus self-load like a vacuum cleaner. Hundreds of vacuum trailers are used in the United States for local distribution of flour and plastic pellets, by transloading from railroad cars. Vacuum trailers can also be used to clean up accidental road spills.



SELF LOADING VACUUM TRAILERS

7. Dust Control

This is not only an environmental concern, but bakers, for instance, do not want to pay for sugar dust. They tell the shippers, “take it back”. Therefore, sugar trailers are provided with a return filter. The dust can then be reprocessed by the refinery.



RETURN SYSTEM

8. Noise Control

Ever tougher requirement. Will require shielded, insulated and isolated air sources and piping.

9. Using Clean & Conditioned Air or Nitrogen

A) Plastic, Chemical and Food trailers will need high efficiency line filters (5 microns) before the air reaches the product to prevent contamination.

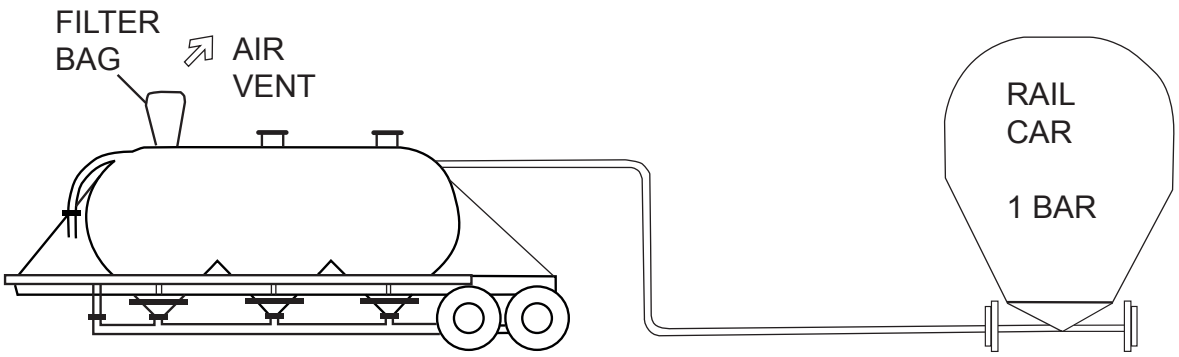
B) Cooling of the air for handling heat sensitive products like plastics and sugar.

C) Drying of the air for handling hydroscopic products.

D) Use of nitrogen as conveying medium for potentially explosive products like coal dust and calcium carbide. These products require that the trailers are loaded using nitrogen or is purged with nitrogen and then transported under pressure. Nitrogen may also be used when ultra pure conditions are required, like with plastics used for photographic film.

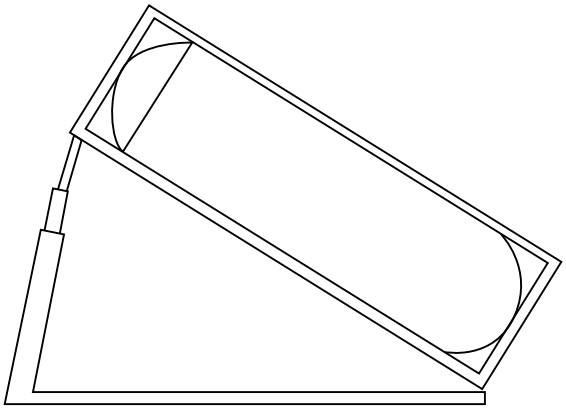
10. Rail-Truck Transfer

Common and growing strongly in the U.S.A. with long distances. Pneumatic railroad cars transfer to pneumatic trailers. Common products are flour, starch, plastics and talcum powder.

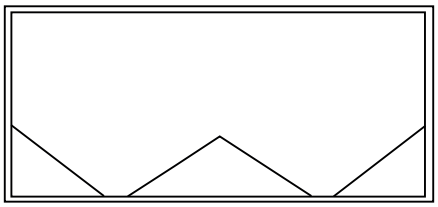


11. Intermodel Containers

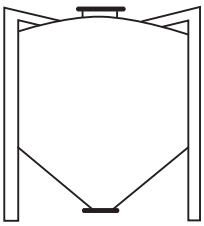
Great Growth Potential.



TIPPING TYPE



HOPPER TYPE



I.B.C.'S

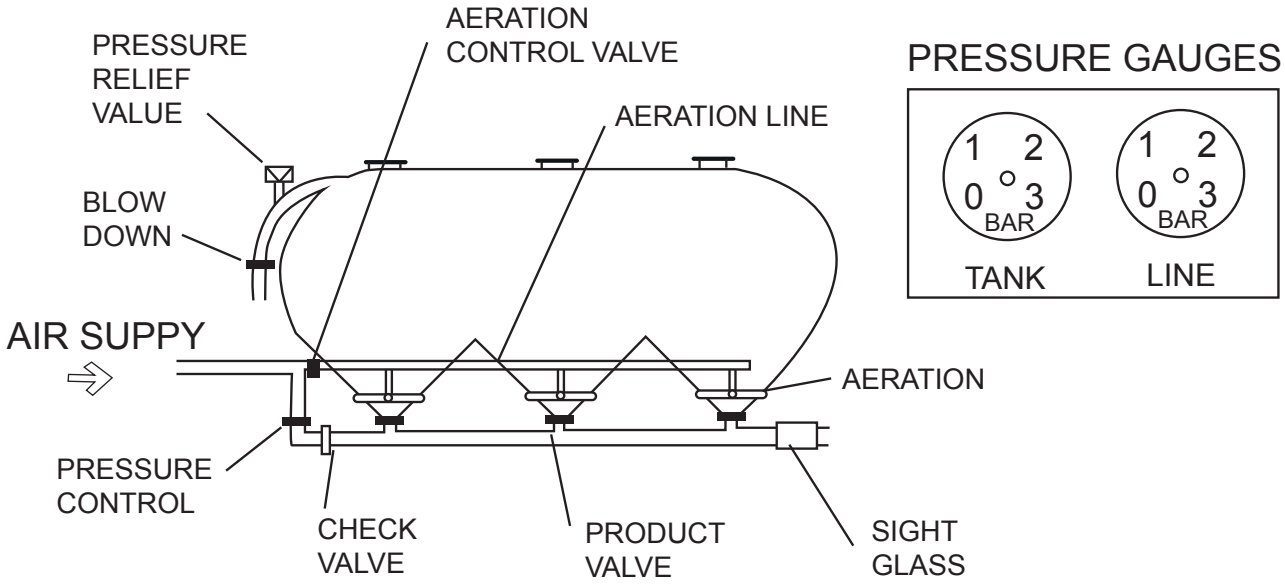
12. Automated Unloadings

Range from automated pressure control to completely automated unloading systems.

J. UNLOADING THE TRAILER

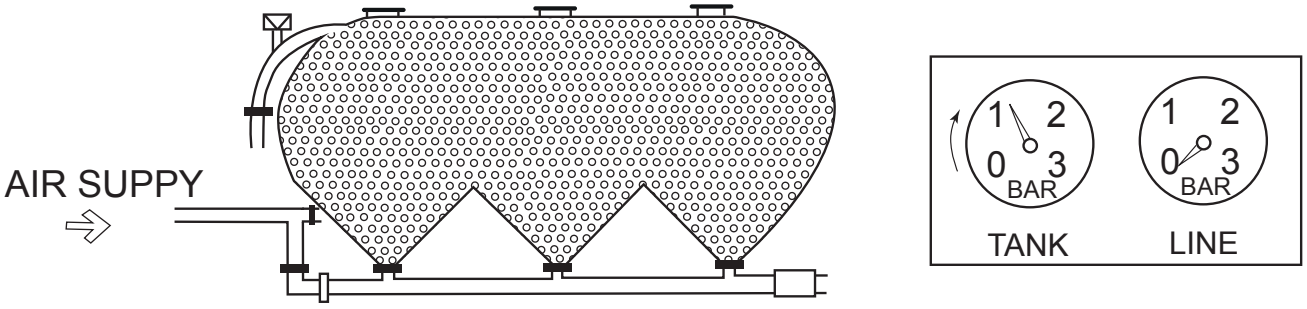
To monitor the unloading, the operator needs two pressure gauges. The tank gauge is connected to the top of the tank to prevent product getting into the gauge line and plugging it. The line gauge is connected to the pressure control line, downstream from the pressure control valve but before the check valve, to prevent the product from getting into the gauge.

A person would like the line gauge connected to a point where you can see the pressure fluctuations and conditions in the product line. The readings on the line gauge will always be lower than those on the tank gauge. Sometimes the line gauge is connected to the air supply line. That is unfortunate because then it does not help you in operating the trailer properly. A sight glass in the product line is also helpful to the operation.

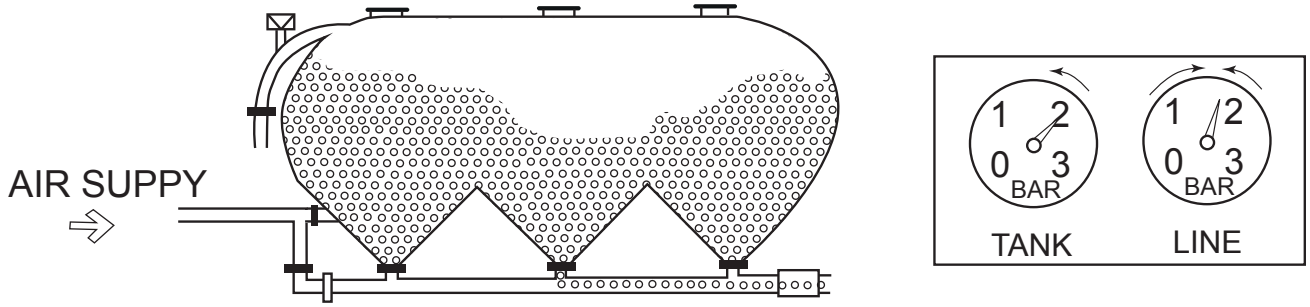


Unloading a Multi-Hopper Pneumatic Trailer

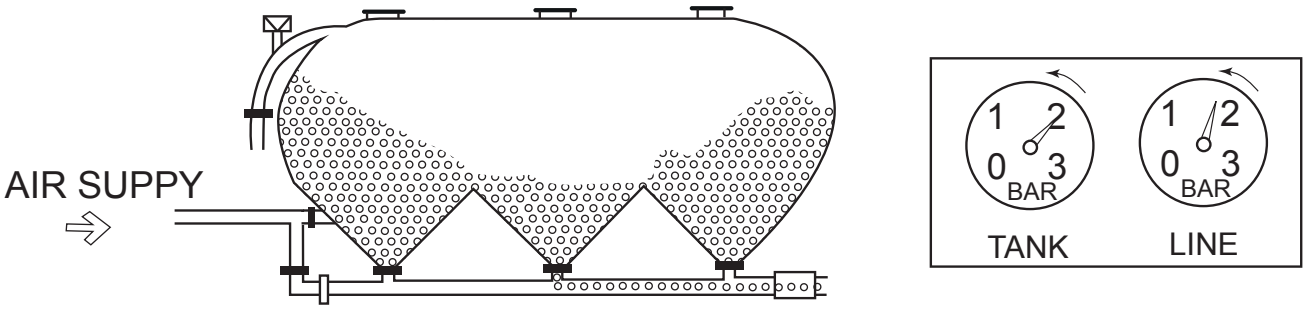
When starting to pressurize the trailer all product valves and all air valves are closed except the aeration valve. When the air source is started, all the air will enter the tank through the aeration devices. Now the product will be aerated as well as the tank pressurized. The Product line gauge will remain at zero.



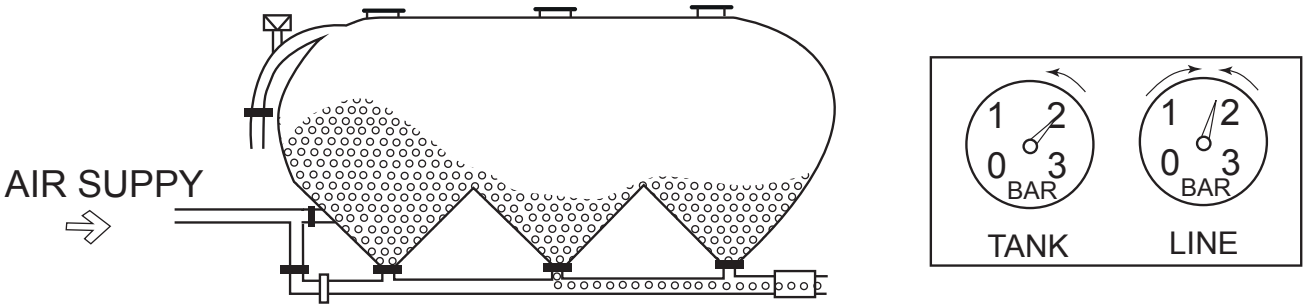
When the tank approaches the normal operating pressure, the pressure control valve is opened about 45 degrees, for a normal unloading line of 80-100 feet (24-30m). If the line is longer open the valve more. Then open one of the product valves gradually. Adjust the pressure control valve when necessary. If the tank pressure decreases, close the pressure control valve a little (5-10 degrees) until the tank pressure stabilizes. Likewise, if the tank pressure increases open the pressure control valve a little.



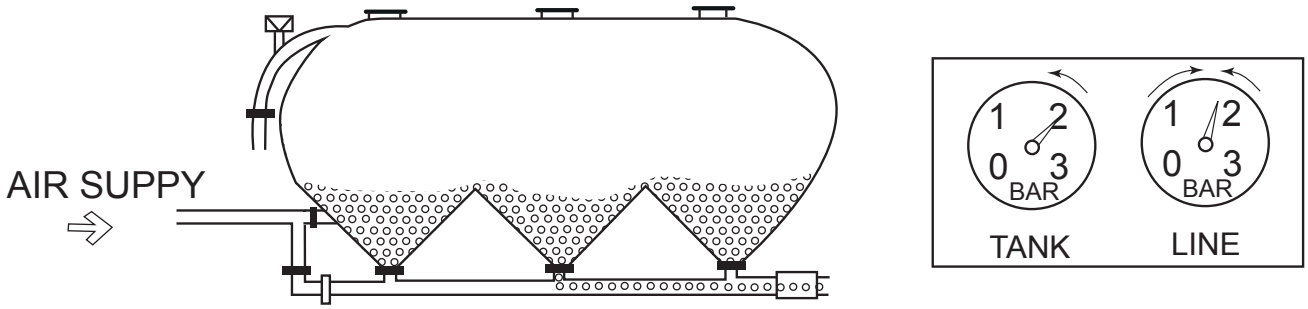
When the product level in the hopper being unloaded gets down to within a couple of feet above the product valve, tank pressure starts falling off. If the trailer is provided with fluidizer discs they will start “snorting” occasionally. It is now time to close the product valve and switch to the next hopper. Notice that I have not shown any individual aeration valve for each hopper. This is not necessary because most of the aeration air enters into the hopper that is being unloaded, because the air takes the shortest distance to the open outlet where it will ultimately escape with the product. This way the hopper that is being unloaded automatically gets most of the aeration air.



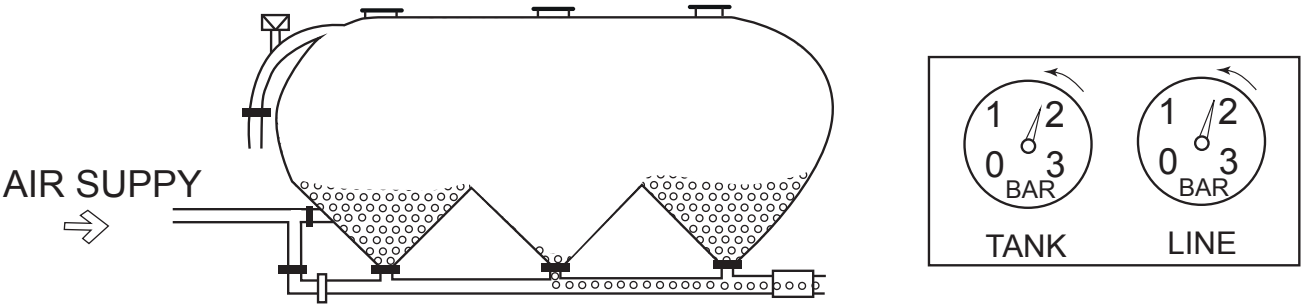
As hopper 3 is getting nearly empty, we switch to hopper 1.



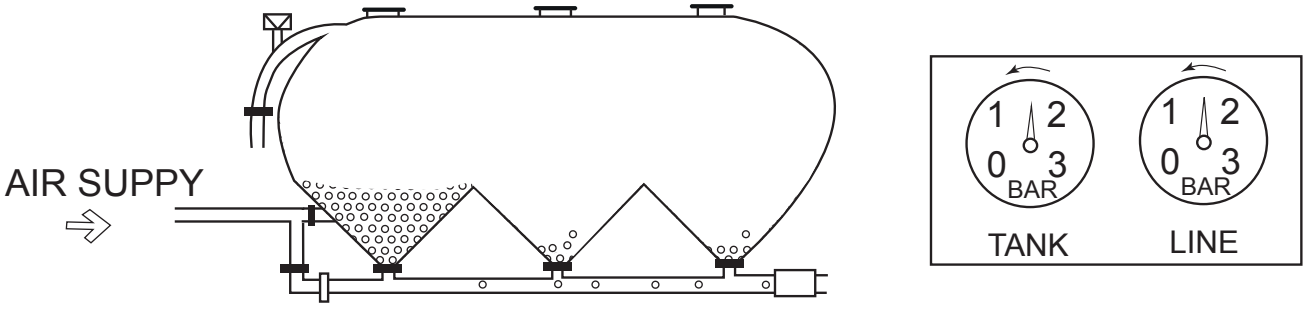
As hopper 1 is running empty, we switch back to hopper 2 for a better clean-out. At this point it is usually necessary to close the pressure control valve even further to maintain tank pressure.



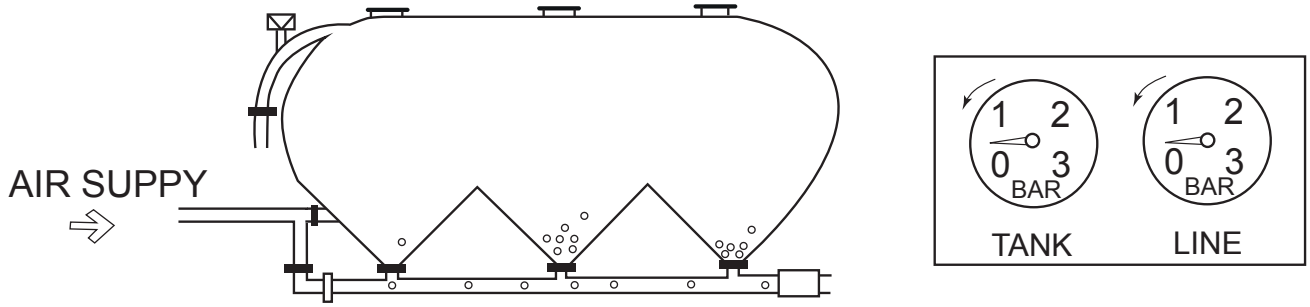
Now things are happening quickly. If the trailer has disc fluidizers, they will start humming continuously. These gentle vibrations will help clean the product off the slope sheets.



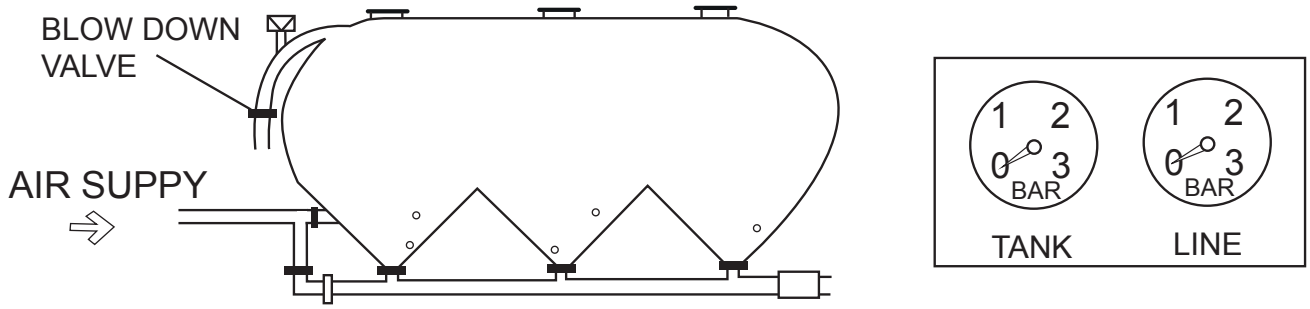
When hopper 1 is running empty, it will be necessary to close the pressure control valve further.



At this point open all hopper product valves for the final clean-out and close the pressure control valve completely. Both the tank and line pressures will fall together.

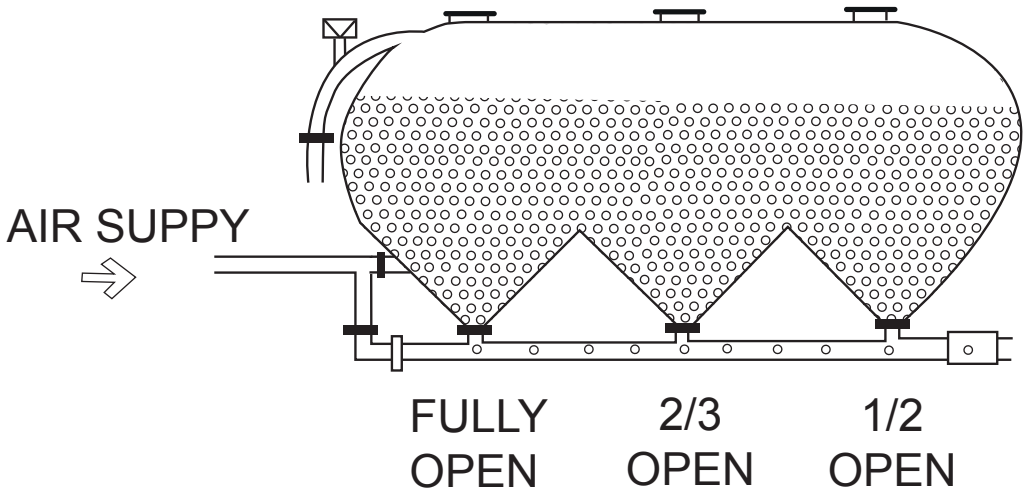


Now the whole unloading is completed. Open the blow down valve to make sure the trailer is completely depressurized. Stop the air source. When no more air is coming out of the blow down line and the pressure gauges show zero, the manholes may be opened for inspection of clean-out.



Repeated Unloadings – Same Site

If the trailer is always unloaded at the same place with the same product, all valves may be open at the same time. The last two hoppers will only be partially open because they are closest to the unloading hose and the product likes to take the shortest distance out. With experience, it will be easy to know exactly what positions the valves should be in. This procedure cuts down on the clean-out cycle since all the hoppers empty out at the same time.

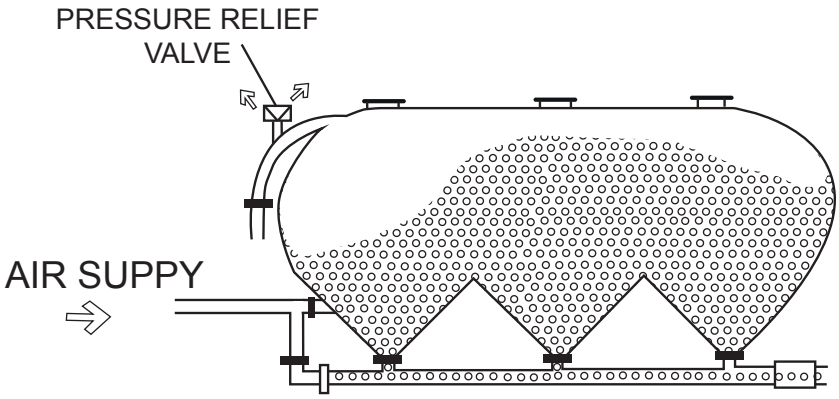


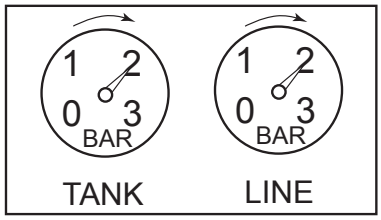
K. PLUGGING AND UNPLUGGING OF A PNEUMATIC TRAILER

Every experienced operator has plugged the line a few times. After all, that is how you become experienced. Most of the time plugging is caused by insufficient air volume. Other reasons may be sharp pipe turns, restrictions in the line, a full silo or sometimes it may be the nature of the product line titanium dioxide that tends to coat the inside of the pipe until it plugs completely.

Signs of a Plugged Line:

1. The unloading hose does not move.
2. The tank pressure and line pressure move up together.
3. Pressure relief opens.

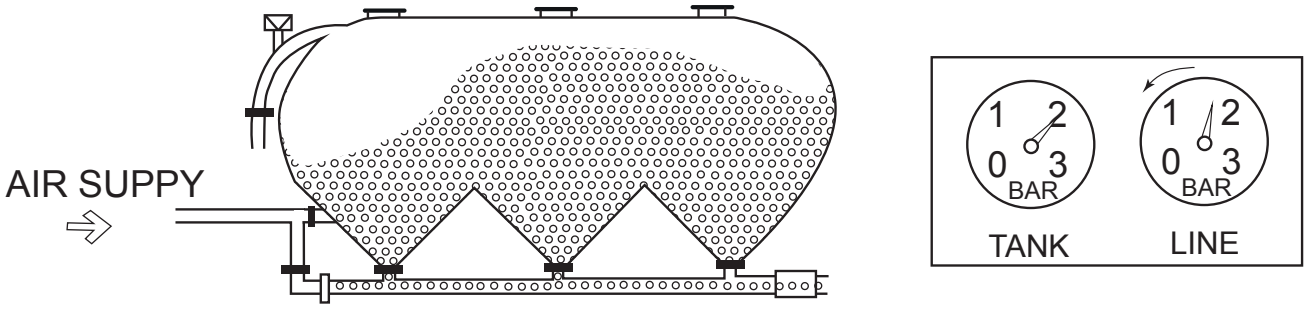




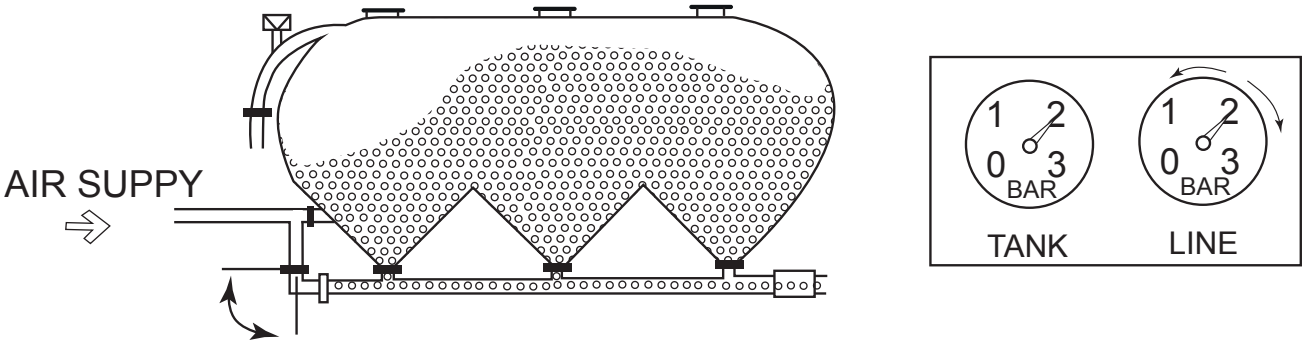
What Do You Do Now?

Do not unhook the hose! This is the last thing you want to do, but do the following:

1. Close the product valve.
2. Close the aeration valve.
3. Open the pressure control valve completely. Sometimes the pressure control air will find its way through the line and blow the line clean.



If the line has not cleared in a couple of minutes, close the pressure control valve momentarily until the pressure relief valve on the air source opens. Then open the pressure control valve quickly. Repeat at least a dozen times. These pressure fluctuations may clear the line.



If the Line Remains Plugged, Do the Following:

1. Stop the air source.
2. Open the blow down inlet to depressurize the tank completely.
3. Close the blow down line.
4. Leave all product valves and aeration valves closed. Open the pressure control valve.
5. Start the air source again. This will put full pressure on the product line. When the pressure relief valve on the blower opens, open the product valve on the hopper with the least product in it. The line pressure will fall quickly. When this happens, the air in the plugged line expands quickly and rushes into the depressurized tank. It may only clear a foot or so of the plug in the line each time. So, it has to be repeated many times until the line gets unplugged. Sometimes, it has to be repeated up to a hundred times. In that case, the tank gradually becomes pressurized again and steps 1 through 4 may be repeated again. If it is not a dusty product like cement or flour, the blow down valve may remain open.