CO_2 and Nitrogen

Dry Ice

Using dry ice to displace oxygen from food storage containers is a very straightforward affair. To prevent leaching plastic chemicals from the container into your food over a long period of time I recommend lining the bucket with a food grade plastic, mylar or brown paper bag before filling the bucket with your product. Be sure to wipe any accumulated frost off of the ice and wrap it in a paper towel or something similar so you don't burn anything that comes into contact with it. Put the dry ice at the bottom and fill the container. Shake or vibrate it to get as much density in the packing as possible and to exclude as much air as you can. Put the lid on, but do not fully seal it. You want air to be able to escape.

Ideally, the dry ice should slowly evaporate and the cool CO_2 should fill the bottom of the bucket, displacing the warmer, lighter atmosphere and pushing it out the top of the container. One pound of dry ice will produce 8.3 cubic feet of carbon dioxide gas so about four ounces per five gallon bucket is plenty. Do not move or shake the bucket while the dry ice is sublimating. You want to keep mixing and turbulence to a minimum. After about three hours go ahead and seal the lids, but check on them every fifteen minutes or so for an hour to be certain that you're not getting a pressure build up. If you don't have to let any gas off, then put them away. A *little* positive pressure inside the bucket is a good thing, but don't allow it to bulge.

WARNING: Dry ice (frozen carbon dioxide) is *extremely* cold and can cause burns to the skin by merely touching it. Because of this you should wear gloves whenever handling it. Also, dry ice evaporates into carbon dioxide gas, which is why we want it. CO2 is not inherently dangerous, but you should make sure the area you are packing your storage containers in is adequately ventilated so the escaping gas will not build to a level dangerous enough to asphyxiate you.

IMPORTANT NOTE: Because dry ice is very cold, if there is much moisture in the air trapped in the container with it, and your food, it will condense. If there's enough of it, it's going to cause you problems. Try to pack your containers on a day when the relative humidity is low or in an area with low humidity, such as in an air-conditioned house. Use of a desiccant package when using dry ice to purge storage containers is a good idea.

Dry ice may be found at ice houses, welding supply shops, some ice cream stores, meat packers or you could look in your local phone book under the headings "dry ice" or "gasses".

Compressed Nitrogen

Types and Availability

Both nitrogen (N2) and carbon dioxide (CO2) are commonly available in the form of compressed gas in cylinders. Of the two, nitrogen is the more inert and thus to be preferred. In food storage, CO2 is mainly used in the form of dry ice (see above) which is often easier to acquire with much less equipment needed to use it. Because of this, I'll be limiting this section to the use of compressed nitrogen. If for some reason you prefer to use compressed CO2, the information given below will work for it as well, though cylinder sizes may differ.

In the U.S. there are about eight principal suppliers of compressed gasses: Air Liquide, Airco, Linde, Air Products, Matheson, Liquid Carbonic, MG Industries, and Scott. One or more of these producers should have compressed gasses available in virtually every area of the United States and Canada.

Locating a source of compressed nitrogen is probably as easy as looking in your local phone book under the headings "compressed gas suppliers", "gasses", or "welding supplies". Other sources might be automotive supply houses, university or college research departments, vo-tech schools, and medical supply houses.

Nitrogen is generally available in a number of forms ranging from gas intended for welding, to various purity assured types, to gas mixtures where N2 would be one of the components.

Unless you are very knowledgeable about compressed gasses and the equipment needed to use them it is *strongly* recommended that you not use any gas *mixtures* in your food storage, but rather to stay with pure nitrogen gas. Use of compressed gas mixtures requires knowledge and equipment beyond the scope of this FAQ.

NOTE: Welding nitrogen is essentially a pure gas, but it has one important caveat. When a cylinder of welding gas is used there is an unknown possibility that some form of contaminant may have backfed into the cylinder from a previous user. Possibly this could happen if the tank was being used in an application where the cylinder's internal pressure fell low enough for pressure from whatever the tank had been feeding to backflush into the cylinder. Alternatively, the tank pressure may have become depleted and was repressurized using ordinary compressed service air. The most likely contaminants will be moisture, carbon monoxide, carbon dioxide, oxygen and hydrocarbons, but there is the remote possibility of something even more exotic or toxic getting into your cylinder. Welding gas cylinders *may not* be checked by the gas supplier before being refilled and sent back out for use. It is this remote, but unknown possibility of contamination that causes me to recommend against the use of welding grade nitrogen in food storage.

The varying types of purity assured nitrogen gas are slightly more difficult to find and slightly more expensive in cost, but I believe this is more than made up for by the fact you know exactly what you're getting. Air Liquide, as an example, offers seven types of purity assured nitrogen ranging from 99.995% to 99.9995% pure with none having a water vapor content over 1 part per million (ppm) or an oxygen content over 3 ppm. Any of them are eminently suited to the task so the most inexpensive form is all you need buy.

As you might expect, compressed gas cylinders come in a number of different sizes. For the sake of simplicity I will address only the most common cylinder sizes since they will almost certainly be the most inexpensive as well.

Again using Air Liquide as an example, it is their size 44 and 49 cylinders that are the most common. There are other cylinder sizes of smaller physical dimensions and capacities. However, the logistics of compressed gas production and transport being what they are, they frequently will cost as much or even more than the larger, more common sizes. The actual gas inside the cylinder is fairly cheap. Filling and moving the heavy cylinders around is not.

Table 1. Air Liquide most common cylinder sizes.

Cyl Size	Cap (Cu Ft)	PSIG	Fill Wt (lbs)	Ht (in)	Dia (in)
44HH	445	6000	339	51	10
44H	332	3500	225	51	10
49	304	2640	165	55	9.25
44	234	2265	149	51	9
16	77	2000	71	32.5	7

Legend:

The "H" suffix means high pressure.

PSIG = Pounds per Square Inch on the Gauge, this does not reflect atmospheric pressure which would be Pounds per Square Inch Absolute (PSIA). PSIA is the absolute pressure of atmospheric and internal cylinder pressure combined.

Although it is not a very common size, I left the #16 cylinder in the above table in case someone really wants or needs to use a smaller cylinder.

Table 2. Cylinder Size Comparison. Abbreviated table. (Alphagaz in Column 1)

Cyl Size [1}	Airco [2]	Air Prod [3]	Liq Linde [4]	Carb [5]	Mg Math [6]	Ind [7]	Scott [8]
49	300	A	T	J	1L	300	K
44L	200	-	K	H	1A	200	A
44	200	B	-	-	-	-	-

44H	-	BY	3K	-	1H	2HP	-
44HH	500	BX	6K	-	1U	3HP	-
16	80	C	Q	M	2	80	B

Legend:
[1] Alphagaz (Air Liquide)
[2] Airco
[3] Air Products
[4] Linde
[5] Liquid Carbonic
[6] Matheson
[7] MG Industries
[8] Scott

Reference: "High Purity Specialty Gases and Equipment" Catalog, copyright 1995, Air Liquide America Corporation, Houston TX USA; pages 6 and 7.

As you can see, the size 49 cylinder from Air Liquide has an equivalent from all eight manufacturers. This size is the one commonly seen being used to fill helium balloons at county fairs and ball games.

Obtaining the Gas and Necessary Equipment

Although you can purchase your own cylinder the most inexpensive way to use nitrogen is to rent a cylinder from your gas supplier. This may require filling out an application, paying a refundable cylinder deposit and buying the gas contained in the cylinder. Tank rental periods can vary, but the most common is for thirty days.

Having rented or purchased the cylinder you must now get it home. Delivery by the supplier can often be arranged or they may assist you in getting the cylinder into your vehicle. The preferred method of transportation is for the cylinder to be chained, clamped or otherwise solidly secured in a vertical position in the transporting vehicle with the cylinder cap in place. Transportation requirements vary from nation to nation, state to state and even city to city so your best bet is to inquire of your gas supplier to find a safe and legal means of moving the tank.

IMPORTANT NOTE: The major expense in using compressed gas is not the cost of obtaining the gas itself, but in the equipment needed to safely handle and control it. Unless you can borrow the appropriate mechanisms they will have to be purchased, new or used, and even the cheapest regulator and gauge is not inexpensive. There is a temptation to forgo the expense and not use a regulator, but I must caution strongly against this. As table 1 above shows, a full cylinder of compressed gas will have an internal pressure of 2000+ PSIG. Normal atmospheric pressure is about 15 PSIA. If the cylinder valve was opened only slightly too far a great deal of very high pressure gas will flow through the delivery hose and metal wand and the potential for serious injury when it began to whip around would be very great. For your safety, get the necessary equipment. If you purchase your own regulator/gauge cluster and/or your own cylinder, there is necessity for periodic maintenance. Regulators and gauges need to be calibrated (using a water deadweight calibrator) and cylinders need to be hydrostatically tested, typically every ten years for both. Your gas supplier can provide you with more detailed information.

The only equipment that will come with your cylinder is the cylinder cap. "Don't leave home without it" and they mean it. All of the common cylinder sizes will use the CGA-580 (Compressed Gas Assembly) cylinder fitting. The downstream side of this fitting can be obtained with different threads, but a 1/4" NPT (National Pipe Thread) nipple is normally needed to mate with the regulator body. The nipple is really nothing more than just a short length of high pressure pipe. The CGA fittings come in a variety of metal compositions such as carbon steel, stainless steel and brass. The best choice is one which matches the composition of the regulator body. If the CGA fitting and regulator are to be used *only* with dry, non-oxygen gasses, in a dry environment then galvanic corrosion can be disregarded so the most inexpensive metal composition can be used even if it is not the same as the regulator. If it is to be used in a wet area, or with oxygen containing gasses then matching metal composition becomes very important.

When the tank is to be returned there *must* be some residual pressure still in the cylinder or the renter might have to pay a surcharge or lose their deposit. This is particularly true of purity assured gasses because the residual gas composition will be analyzed. This is done for the safety of all cylinder users.

The regulator/gauge cluster should be carefully removed using the same procedure that is described below to put it all together. Care should be taken not to damage the cylinder valve threads. Replace the cylinder cap and transport in the same manner as you brought it home.

Putting it all Together

If the fitting and regulator are bought separately then some 1/2" wide Teflon (tm) tape is recommended for assembly since it is a clean and inexpensive way of sealing pipe joints. Looking into the open end of nipple wrap the tape clockwise around the threaded end for 1.5 to 2 turns, working from the open end backwards. If you want to do a neat looking job, the tape may be slit lengthways to make it 1/4" wide, but this is not a requirement. A brass nipple may shrink somewhat during tightening and need a bit more tape than a harder metal like stainless steel would. The Teflon tape should *only* be used on the end of the nipple that attaches to the regulator body, NOT to any part of the cylinder end.

The regulator end has tapered threads and uses them directly for sealing. The cylinder end has straight threads and depends upon the precision mating of machined metal surfaces to seal. The cylinder end threads simply apply the clamping force.

Before attaching the CGA fitting to the cylinder the user should put on safety glasses and good hearing protection. The cylinder valve can then be cracked very slightly to blow out any dust or debris. After closing the valve, inspect the cylinder valve and nipple for any abrasions, nicks, gouges, embedded particles, etc., before attachment is made.

You will need *two* wrenches (not adjustable pliers) to equalize the torque, particularly on the cylinder valve where it should be minimized. Put one wrench on the fitting and the other wrench on the cylinder valve and make the join.

Once the regulator/gauge cluster has been mated to the cylinder, the delivery hose can now fitted to the regulator and the metal wand to the other end of the hose. The wand is nothing more than a short length of metal tubing at least six inches greater in length than the depth of the buckets to be filled. Copper water line works well.

When the joins have been made, a mixture of a short squirt of dish washing detergent and water can be used to check for leaks. Be certain the detergent does not contain ammonia. Pour some on each fitting working from the cylinder end outward, opening each valve and pressurizing as you go. Once the leak check is finished rinse off and wipe down all surfaces to minimize the chance of accidents in the future.

If the gas is not to be used at that time then the cylinder valve should be closed and all pressure should be drained to zero in the regulator and gauge. This should be done any time that the tank is not in actual use. If you have purchased your own cylinder then it is a good idea to also acquire one of the plastic valve plugs, similar to those seen with propane cylinders, in order to protect the cylinder valve threads and keep dust, debris and insects out of the valve.

WARNING: Care should be taken that the cylinder is used and stored in such a way as to minimize the risk of the tank falling over. With the regulator and gauge attached there is an increased likelihood of damage occurring to the cylinder valve should the tank fall. Catastrophic failure of the cylinder valve will turn the tank into a high-energy, unguided rocket with the capability of doing great damage and/or serious injury.

Putting it into Use

Having assembled and tested your gas system, you are now ready to begin the work of packaging your food. You'll need containers, food grade plastic bags that are a bit larger in internal volume than the container, and some clean brown paper bags to fit inside the plastic bags. Next is the dry food you intend to package and a pack of matches or a cigarette. You'll also need to wear the safety glasses and hearing protection you wore when you put the gas system together.

Take the containers you are going to use to store your food in, the bags that will line them and the food you are putting up and place them in some warm (not hot) area long enough for them all to equalize to that temperature. This will mean that the air contained inside them will also be at a warm temperature and make it more likely that it will stay on top when the cool gas from the nitrogen cylinder begins to flow in. The warm gas being on top will be the first to purge from the container, taking a good deal of the oxygen with it.

Line the interior of the container with a plastic bag and then line the plastic bag with a clean brown paper one. Fill the container with the food product shaking to get it as full as possible. Don't forget to add your desiccant package if you're going to use one. You don't want any pockets left between the plastic bag and the container. Once you have gotten it full to just short of not being able to fully put on the lid, gather the top of the plastic bag together. Insert the wand to the bottom of the food, (take care not to tear the bags), and close the top of the plastic bag loosely around it. Now open the cylinder valve and set the regulator to a very slow gas flow and begin to fill the bags with gas. You want the container to fill *slowly* so you can minimize turbulence and mixing as much as you can. It'll take a little while to fill each container, a few minutes per bucket. Just as with dry ice, the idea here is for the cool gas to displace the warmer atmosphere from the container. The bags should puff just a bit. When I think it's full I'll hold a lit match just above the bag in the air that is escaping from it. If it snuffs right out then I let it run for about a minute longer to flush out more of any remaining oxygen and remove the wand.

Tie the bag off and seal the bucket. Again, you want to have the bucket as full as possible so that there'll be only minimal air space. You should monitor the containers for an hour or two after filling to check for any signs of bulging or other pressure build up as the cool gas inside gradually warms up and expands. A slight positive pressure is OK, but serious bulging needs some of the pressure released.

Captain Dave's Note: Captain Dave recommends the use of mylar plastic bags, and suggests heat sailing them rather than tieing them off. Commercial sealers are available, or you can use an electric iron.

NOTE: Although the procedure for flushing a container with nitrogen is straightforward enough, actually getting a good purge of the container is not. Nitrogen flushing works best when the contents of the container are fairly coarse in size so that the gas flow around and through the food is free and unrestricted. Foods such as the larger sized grains (corn, wheat, barley, long grain rice, etc.), legumes and non-powdered dehydrated foods are best suited to this technique. Foods with small particle sizes such as flours, meals, and dry milks will flush with mediocre results.

Because of the difficulties in purging sufficient oxygen from a container to lengthen the shelf life of the food it contains many commercial suppliers have dropped this technique in favor of using oxygen absorbers. There is no reason that inert gas flushing and oxygen absorbers cannot be used together and one good reason that they should. If you are using five gallon plastic buckets as your storage containers, it has been observed that the absorbers can cause the air pressure inside the bucket to drop enough for the walls of some buckets to buckle, possibly leading to a seal breach or a stack collapsing. For this reason, flushing with inert gas (nitrogen or CO_2) might be a good idea, in order to purge as much oxygen as possible so that the pressure drop caused by the absorber removing the remaining oxygen will not cause the bucket to buckle.

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