SPECIFIC EQUIPMENT QUESTIONS

C -- VACUUM SEALING

Vacuum packing is a simple concept. Lower the air pressure (22 inches of vacuum or more) in a container until sufficient oxygen laden air has been removed to slow the development of rancidity and retard the growth of insects. Within reason, the greater the air removed the better the process will work. I have not yet found any controlled studies that detail exactly how much improvement in shelf-life vacuum sealing can give for dry storage foods, but it is widely used in the commercial food industry and I have read a wealth of anecdotal evidence from individuals which matches my own experiences that indicates that it does work.

Some developmental stages of insect life may not be killed by this process, but if you can draw more than 22 inches of vacuum it will at the least force the more resistant stages into stasis. Over time even the hardiest bugs will eventually asphyxiate. Many people vacuum seal their weevil prone grains and when properly done I have heard no reports of infestations. Certainly I have had none.

How you draw the vacuum to seal your containers is up to you. There are a number of electrically or manually operated vacuum pumps on the market, some made for food storage purposes and others that can be adapted to the task. Of the electric home food storage vacuum pumps the only brand that I have found that receives consistently good reviews are the various Tilia Foodsaver models, of which I presently have their Model 750.

Recently Black & Decker and Sears Kenmore have come onto the market with their own line of home vacuum sealers which bear investigation. I'm still collecting reports so cannot say if their machines are worthwhile as of yet. If you have any personal experience with them I'd like to hear from you.

Of the manual pumps, only the "Pump-N-Seal" is actually sold for food storage use. It looks something like a miniature bike pump. It requires you to punch a small hole in the lid, cover it with a piece of adhesive tape and place the pump over the taped hole. You then pump out the container and when you remove the pump the pressure differential sucks the tape down against the hole, effectively sealing it. I've used it and it does work as they claim. I don't care for having to punch a hole in the container lid but others have found no problem with this and it's in common use. It can also be used to seal plastic bags, but I don't often hear of it being used for this as it calls for having to paint inside the bag mouth with a small amount of vegetable oil.

It's also possible to adapt a hand-pumped brake bleeder vacuum pump for food storage use and some have made their own pumps from old automobile air conditioning compressors.

WARNING: To be clear, allow me to point out what vacuum sealing *won't* do for you. *Any food that would need to be refrigerated or frozen to prevent spoilage **before** it was vacuum sealed will still need to be refrigerated or frozen **after** it was vacuum sealed.* Lowering the oxygen content of a storage container can do great things for deterring rancidity, staleness, and insect growth, but if the food has sufficient moisture you'll only be providing optimum growth conditions for some serious oxygen-hating spoilage bacteria such as the notorious *Clostridium botulinum*. No vacuum sealing process suited to home-use can take the place of pressure canning low-acid high-moisture foods.

C.1 VACUUM SEALING CONSIDERATIONS

#1 - Sucking dust or powder into your pump will eventually lead to degraded performance or even damage. To deter this from happening when sealing dry, powdery foods you can try cutting a piece of coffee filter paper to fit inside of the jar adapter fitting so that any air pulled out of the container must flow through the filter paper before going into the pump lines. I have also seen used a clear, see-through fuel filter in the vacuum line between the jar adapter and the pump. This will block all but the finest dust particles and allows you to see when the filter needs changing. Of course, an opaque fitting will work as well, you'll just have to wait until air flow is significantly restricted to know when to change the filter. If the pump flow rate is adjustable, try pumping more slowly to lessen the amount of dust sucked out of the container.

#2 - The harder the vacuum you draw on a flexible container, such as a bag, the harder the bag will press against its contents. For smooth foods such as beans, corn and wheat this is of no significance. For sharply pointed foods such as long grain rice, rye and some kinds of dehydrated foods it may pull the bag against the food hard enough to puncture the material. This is especially the case if the package is will be handled often. For foods such as this consider putting the food inside of a paper bag first before sealing into the plastic bag.

#3 - Combining vacuum sealing with flushing or purging with inert gasses can improve the efficiency of both. By drawing out most of the oxygen laden air from a container there is less for the inert gas to have to displace. This, in turn, means that the final oxygen content in the head gas will be lower than it otherwise would be if

the vacuum process hadn't been used. Combining vacuum sealing with oxygen absorbers means that a lower capacity (and cheaper) absorber can be used. It can also extend the absorptive life of the absorber thus allowing it to remove any oxygen that might infuse through the packaging material or through microscopic leaks.

#4 - All of my most sensitive storage foods such as dry milk powders (especially whole milk), dried fruits and vegetables, oils, dry eggs, etc I now seal in pint, quart, or half-gallon glass canning jars using the jar sealer adapter on my Tilia. This has proven to be an excellent means of preserving oxygen sensitive foods. The jars and lids are reusable and do not absorb odors.

D -- FREEZE TREATING

NOTE: This section is not intended to address freezing high-moisture perishable foods. They are outside the scope of this work and are much more capably addressed in the *Ball Blue Book* or *Putting Food By*. Information on these books may be found in the *Resources Section*.

Freeze treating, like vacuum sealing, is also a simple concept, but it must be done right. The major reason for freezing dry foodstuffs is to kill off any potentially lurking hidden insect infestations. Freezing will accomplish this task if you follow the steps I outline below.

#1 - The foods you want to preventatively treat against insect infestations should be at room temperature or even slightly warm and should have been at that temperature for at least several days. This prevents any insects that might be present from becoming acclimated to cold temperatures which would make them more resistant to being killed than they otherwise would be.

#**2 -** The bigger the package you want to treat, the longer it will take for its contents to fall to the desired temperature all the way through. Freezing the goods in small amounts of five to ten pounds at a time will give a quicker, more certain result than attempting to freeze a five gallon bucket.

#**3 -** Put the product into your freezer and *freeze it to 0º Fahrenheit (-18º Celsius) all the way through the package and keep it there for three days.* If there is enough air humidity in your house to cause condensation on the outside of a glass of ice water it is a good idea

to put the product in a moisture proof container before freezing, otherwise you can leave it the way it came from the store.

#4 - Once the time is up, you can repackage the product into your storage packaging if you have not already done so. Whatever you use needs to be insect proof. Once the food comes back up to room temperature it is as susceptible to outside insect infestation as any other food. Promptly sealing it into your storage packaging will prevent any after-the-fact insects from being able to get into your chow.

There are some other foods that are quite low in moisture, but would benefit from remaining frozen at 0º Fahrenheit or less. Among these are yeast, cultures for yogurt, kefir, tempeh, and herbs and spices amongst others. It is vital they remain quite dry if you are going to store them this way.

E -- OXYGEN ABSORBERS

E.1 WHAT IS AN OXYGEN ABSORBER?

Oxygen absorbers are a relatively recent food storage tool whose arrival has been a real boon to the person wanting to put up oxygen sensitive dry foods at home. The packets absorb free oxygen from the air around them and chemically bind it by oxidizing finely divided iron into iron oxide. This removes oxygen from being available for other purposes such as oxidative rancidity and respiration by insects, fungi or aerobic bacteria. The practical upshot of all this is that by removing the free oxygen from your storage containers, you can extend the storage life of the foods inside. Not all foods are particularly oxygen sensitive but for those that are the absorbers truly simplify getting the job done.

The absorbers themselves have only a relatively short life span, roughly about six months from the time they were manufactured for the types that do not need an external moisture source. They don't suddenly become ineffective all at once, it's just at that point you will begin to notice (if you can measure it) that the absorbers no longer soak up as much as they would when they were new. Better to use them while they're fresh.

E.2 HOW ARE OXYGEN ABSORBERS USED?

In order to make the best use of your absorbers you need to know three things:

#1 – *Is the food I want to put by particularly oxygen sensitive for the time I want to keep it in storage?* Whole grains that have not been polished or hulled such as wheat, corn, and rye are not especially oxygen sensitive. If you intend to use them up in five years or so, there's no great advantage to using oxygen absorbers, unless used to deter weevil infestations. The same for most beans and peas. Processed or high fat grains and legumes such as oats, barley, brown rice, soybeans, peanuts and split peas would benefit from their use if they are to be kept for more than a year. Whole grain products such as whole wheat flour and rolled oats would as well. Refined grain products such as white rice, white flour, degerminated cornmeal will keep fine for a year or so, possibly longer, without oxygen absorbers if kept dry and protected from weevils. Dry milk, dry eggs, dry meats, and many kinds of dehydrated foods and any kind of freeze dried foods would benefit from oxygen absorbers. Foods with an easily transferable fat content should not be used with oxygen absorbers, nor should they be used with foods that are high in moisture or with free liquids in the storage container. These should be preserved using pressure or boiling water bath canning as appropriate.

#2 – *Will the packaging I want to use seal air-tight and is the packaging material itself a good gas barrier?* Obviously if the container won't seal air tight you're wasting your time trying to use oxygen absorbers but the barrier properties of a container stump many folks. Canning jars with good lids, properly sealed #10 (or other size) cans, properly sealed Mylar bags, PETE plastics with appropriate lids or caps, military surplus ammo cans with good gaskets, and many other types of packaging will seal air-tight and provide good barrier properties against oxygen infusing through the packaging material. Non-laminated flexible plastic packaging (bags, sheets, etc.), HDPE plastic buckets and any kind of non-laminated paper or cardboard container have poor gas barrier properties. "Poor" is a relative term, though, and if you're going to use the food up in two or three years, even oxygen sensitive foods can be kept in unlined HDPE buckets if you use an appropriately sized absorber and make sure the bucket is well sealed. You'll be using the food before sufficient oxygen has been able to infuse through the walls of the container to make a significant impact.

#3 – *What is the volume of the container and how much air volume remains after I've filled it with food?* This is important to know if you want to make the most efficient use of your absorbers and be certain your food is adequately protected. Taking the question in two parts, here is how to determine the answer:

A. Absorber capacity is rated by the amount of oxygen in milliliters that each will absorb so you'll need to know what the volume of your container is in milliliters. The table below gives conversions between common U.S. container sizes and their milliliter equivalents.

Pint jar (16 fl oz)	475 milliliters
Quart jar (32 fl oz)	950 milliliters
Half-gallon jar (64 fl oz)	1,900 milliliters
#10 can (112 fl oz)	3,300 milliliters
One gallon jar (128 fl oz)	3,800 milliliters
Five gallon pail (640 fl oz)	19,000 milliliters
Six gallon pail (768 fl oz)	22,800 milliliters
Fifty-five gallon drum (7,040 fl oz)	208,175 milliliters
Fluid ounces x 29.57 = milliliters = cubic centimeters	

Now multiply the volume of your container times the 21% (0.21) of the atmosphere that oxygen constitutes and you'll come up with the volume of oxygen, in milliliters, that your container holds when it's empty.

An example: A quart jar (32 ozs) is approximately 950 milliliters in volume. Multiply 950 x 0.21 (21%) and you get 199.5 milliliters of oxygen in an empty quart jar. This leads to the second half of the above question.

B. Determining remaining air volume in a container that has been filled can be difficult. Foods vary widely in their density and porosity from flour, which will pack tightly to elbow macaroni which is mostly air even if you pack it to just short of crushing. The following are three rough and ready rules that can be used and will work.

i> Foods that have a lot of open space between the food particles (called *intersitial space*) such as macaroni, pasta, instant dry milk, instant potato flakes, many coarsely chunky dehydrated foods, cold cereals, etc. should use *one half* the container volume as the remaining air space. Using the example above with the quart jar, there would be approximately 100 milliliters of oxygen remaining.

ii> Foods that pack more densely such as non-instant milk, dry eggs, flours and meals, grains with small kernels, dehydrated foods with fine particles and the like should use *one-third* the container volume as the remaining air space. Using the example above, there would be 66 milliliters of oxygen remaining.

iii> Alternatively, you could do what many of the commercial storage food packagers do and use the *entire container volume.* This is not as efficient as more closely determining remaining air volume but it does add certainty that your absorbers will soak up all available free oxygen and still leave some capacity to deal with any microscopic leaks or infusion through the packaging material.

NOTES: #1 -- Both Multisorb and Mitsubishi corporations advise that their oxygen absorbers should not be used in a high carbon dioxide environment. This is apparently for reasons that the absorbers will also absorb carbon dioxide as well as oxygen and may run out of capacity before all of the oxygen in the container has been absorbed.

#2 -- If you do choose to use oxygen absorbers in packing your food give some consideration to the sturdiness of your containers. In doing its job the absorber is going be removing the 21% of the atmosphere that oxygen constitutes. Since nothing is replacing the absorbed gas this will leave the storage container with a lower atmospheric pressure inside than outside. If the container is sufficiently

sturdy this pressure differential will be of little consequence. For containers with thinner walls the pressure drop could cause them partially collapse or buckle, particularly if other containers are stacked upon them. Should this occur the entire stack could fall causing one or more to burst. Metal cans and glass jars should have no problems, but some plastic buckets made of HDPE have relatively thin walls which can buckle when the internal air pressure drops. To deter this, a liner bag of Mylar or other high gas barrier plastic should used. Heavier walled buckets won't need a liner unless you're trying to achieve the maximum possible shelf life. Seal the absorbers inside of the liner bag so that the pressure drop with not stress the walls of the container. Other containers should probably be tested or first flushed with an inert gas (N2) before the absorber is sealed in.

#3 -- If the pack of absorbers you need to open contains more than you are going to use in fifteen minutes or so, you should minimize exposure of the remaining packets. This can be done by heat sealing the bag they came in with an iron after expelling as much air as possible or better yet by vacuum sealing the bag. You can also put the remaining absorbers in as small a jar or metal can as they will fit in and closing with an air tight lid.

#4 -- The chemical reaction that absorbs the oxygen releases minor amounts of heat. This heat release is trivial in an individual packet but if they are piled one atop another as you're using them they can warm each other and speed the absorptive reaction. This costs you capacity lost to open room air so it's best to spread the packets in immediate use out on a tray so they lay atop each other.

#5 -- If absorbers are sealed in a package with desiccants some thought should be given to how low the relative humidity will become. Silica gel will reduce humidity to approximately 40% which should not interfere with the absorbers oxidation reaction. Other desiccants, however, are capable of reducing relative humidity to very low levels. This might adversely affect your absorber's ability to carry out its mission by removing moisture from the absorber package that is necessary to sustain the oxidation reaction. If you do use desiccants and oxygen absorbers in the same package, place the desiccant on the bottom, fill the package and then place the oxygen absorber on top of the food before sealing.

F – MOISTURE IN PACKAGING AND FOOD STORAGE

F.1 WHY MOISTURE IS IMPORTANT

Moisture in inappropriate amounts and places is damaging to food. Because of this, much effort is put into reducing the water content of dry foods in order to prolong their shelf lives. Once it is reduced to the desired level the product can

then be packaged for storage. Unfortunately, merely reducing moisture content is not always sufficient. Environmental conditions can play a role as well.

There are four mechanisms by which environmental conditions may cause a moisture problem in your food storage:

1. - The air trapped in the container with the food may have held sufficient humidity to raise the moisture content of the food to undesirable levels.

2. - Even if the water vapor content wasn't too high, a falling temperature level may cause the trapped humidity to reach its dew point causing water to be squeezed out of the air to condense on your food much the same way as dew forms on your lawn on cool mornings after a warm, humid night. This can be a particular problem if the condensation is localized – say, only the portion of the food next to the walls of the container – resulting in excessive moisture in that local area even though the contents as a whole would be at a satisfactorily low moisture level.

3. - The seal of the container may not be sufficiently tight enough to prevent moisture laden air from leaking in.

4. - The packaging material itself may be porous to water vapor to one degree or another. All paper, wood and cardboard has this fault. Depending upon their particular physical properties some plastics do as well. Metal and glass containers have excellent barrier properties though their seals may not.

The solution for moisture problems is multi-faceted.
1 - Make sure the product to be stored is at an appropriate water content for that particular foodstuff. Beans and grains store well at a 10% moisture level, but milk powders, dried eggs and dehydrated or freeze dried foods should be lower for best results. As a general rule, nearly any dry food will store well at moisture contents between 3%-10% with the lower the better. Don't get carried away with this though. Extreme low moisture levels (below 3%) can make some foods difficult or impossible to reconstitute and damage the viability of seeds.

Ideally, the dry foodstuffs you have on hand will have no more than a 10% moisture content. If they do not then you will need to reduce moisture to a level appropriate for the kind of food you are storing.

One of the following methods might be of use in lowering moisture content.

A - The least involved is to wait until the driest time of year for your location making sure there is plenty of free air circulation

around the food product. If this doesn't suit, then turn your air conditioning on a little high. Bring in your buckets, lids, and the storage food. Let everything sit in a well-ventilated place where it's going to get plenty of cool, dry air from the A/C (avoid anywhere near the kitchen or bathroom areas, as they put out a lot of moisture). Stir the food frequently to maximize moisture loss. A few days of cool, constant air flow and low humidity ought to dry things out. Due to its odor absorptive nature, I would not do this with any dried milk products or other powdered foods, flours or meals . This method works best with coarse particles such as grain, legumes and dried foods.

B - Warm, dry air can also be used to lower moisture content and works well if you have large quantities of grains and legumes. This is similar to what is used on farms for drying harvested grain. You'll need a source of forced, warm, *not hot*, air. Place the grain in a drum or barrel and blow the heat from the bottom so that the warm and the moisture it will carry can exit from the top. It's important to not let the bottom product get too hot. You should also monitor the top, center of the drum to be certain the product there is not getting damp from the moisture escaping other areas. Stirring occasionally may be necessary. I've seen this done with an old, drum style vacuum cleaner that put off fairly warm exhaust air and it worked pretty well. Do be sure to clean the vacuum thoroughly so you don't blow the grain full of dust.

C - If the above methods won't do or you have powdery foods to dry, you can put the food and a large quantity of desiccant (see below) in a storage container. The desiccant should be in its own container placed on top of the food and the container lid sealed on. After about a week, unseal and check the desiccant. If it's saturated, change it out with dry desiccant and reseal. Continue to do this until the contents are sufficiently dry. If it doesn't become saturated the first time, change it anyway before sealing the bucket permanently to deter saturation in storage.

If your food products are sufficiently dry you can pack them in storage containers using the packaging method of your choice and have a reasonable expectation of your food staying in good condition. Whether you will need to use a desiccant will be dependent upon the conditions discussed below.

2 - Try to package your goods in a dry atmosphere and do not allow extreme temperature swings in storage areas. Warm temperatures and a high relative humidity when a container is sealed means the air trapped inside the container will have a high dew point. This will lead to condensation should storage temperatures fall below that dew point. An example of this would be a container

sealed on a day that was 70º F and 40% relative humidity. At that temperature the relative humidity would be quite reasonable for all but the most moisture sensitive food. However, should the temperature fall to 44º F the capacity of the air to hold water vapor would have dropped to the point that it could not contain what was sealed in at 77º F and the excess would be squeezed out to condense on the food, i.e. - it will grow moister. Possibly the food will be able to adsorb this moisture without harm and then again, it may not.

3 - Use appropriate packaging materials and make certain it is sealed correctly. If you are going to consume them in four to five years, storing grains, beans and peas in unlined HDPE buckets at normal humidities is fine. If you want to keep them at their best for many years beyond that, the plastic the pail is made of is too porous to water vapor for best results and should have an interior liner of a material with better barrier properties. Dry milk powders should not be kept for more than a year in unlined HDPE, but can be kept for much longer in #10 metal cans, glass jars or Mylar bags. Naturally, even the most highly resistant packaging material is useless if its seal isn't good so be sure you use good technique when making closures.

Lastly, you may wish to consider using a desiccant if good humidity control at the time of packing is difficult or if the storage area is in a high humidity environment or if the packaging material does not have sufficiently high barrier properties.

NOTE: There has been some confusion in the past over the appropriate use of desiccants in food storage which I would like to address here. Any desiccants you may seal in your storage containers (if you use them) are not for lowering the moisture content of the foods therein, but for moderating any shifts in moisture levels caused by those factors I mention above. If the food you want to put up is too high in moisture for good storage this needs to be dealt with BEFORE you seal the packaging. An example of what I'm trying to communicate here would be 10lbs of wheat with a 15% moisture content. That's too high for safe storage and needs to be lowered, preferably to 10% or less. To lower the moisture content of that grain to 10% you need to remove the 5% excess. 5% of 10lbs is eight ounces of water. Good dry silica gel (one of the most common desiccants) will hold 40% of its mass in moisture so to soak up that extra water you would need 20 ounces of silica gel – quite a large amount – all to remove that 5% excess moisture in ten pounds of grain. Fifty pounds of grain at that same moisture level would require 100 ounces or *six and a quarter pounds of silica gel*. Clearly no practical amount of desiccant you can put inside your storage packaging will do for you what should have been done before the food was put by. Desiccants can be used for lowering food moisture content, but this will involve rotating packages of desiccant in and out of the foodstuff until the desired moisture content has been reached. Once the package is sealed any desiccant you leave inside should be there to control moisture fluctuations or to guard against moisture infiltration from the outside.

F.2 WHAT IS A DESICCANT?

A desiccant is a substance with strong *hygroscopic* properties, meaning it will soak up water vapor from the surrounding air. A number of different substances are capable of doing this, but only a relative few of them are of practical use and fewer still are going to be readily available to the average person. Before elaborating on the different types that might be useful for our purposes it's necessary to explain how to choose a desiccant.

The U.S. military has done much of the best research on the use of desiccants in packaging and have largely set the standards by which they are judged. Each type of desiccant has temperature and humidity ranges where it performs best and particular physical and chemical characteristics that may need to be considered in relation to what you propose to do with them.

The most applicable standard for home food storage defines a unit of desiccant as *the amount of desiccant that will adsorb at least 6 grams of water vapor at 40% relative humidity at 77º F (25º C).*

The following table gives the amount of desiccant necessary per square area for flexible containers such as Mylar bags or per volume of area for rigid containers such five gallon pails or #10 metal cans.

Units of Desiccant Needed Per Given Container Volume.

FLEXIBLE CONTAINERS		Desiccant	RIGID CONTAINERS Units of Volume in:		
Area in Sq. Ft.	Area in Sq. In.	Units Required	Gallons	Cubic Feet	Cubic Inches
0.1	30	1/6	1.1	0.14	237
0.3	45	1/3	2.1	0.28	476
0.6	90	1/2	3.2	0.42	714
1.3	180	1	6.2	0.83	1,428
1.9	270	2	12.5	1.67	2,856
2.5	360	3	18.7	2.50	4,284
3.1	450	4	25.0	3.33	5,712

Flexible containers would be Mylar and other plastic bags. **Rigid containers** are buckets, jars, cans, etc.

Table adapted from "Moisture In Packaging: Selecting the Right Desiccant" ©, Multisorb Corp. http://www.multisorb.com

This is all well and good so far as it goes but without knowing how much of a particular type of desiccant is needed to soak up that six grams of water it doesn't do you much good. The next table will reveal all:

Desiccant Needed to Adsorb 6 Grams of Water Vapor	
Desiccant Type	**Mass (weight) of Desiccant Needed**
Silica Gel	15 grams
Indicating Silica Gel	75 grams[1]
Montmorillonite Clay	24 grams
Calcium Oxide (quicklime)	21.5 grams
Calcium Sulfate (gypsum, Drierite)	60 grams
Wood	43 grams [1]
[1]See desiccant descriptions for clarification.	

In order to maximize surface area to obtain optimal adsorption, desiccants are manufactured in granular or powder forms. This presents a problem of keeping the desiccant, which may not be safe for direct contact with food, out of the product while still allowing sufficient air flow for it to carry out its task. Manufacturers call this "dusting" and deal with it by packaging the adsorbent in materials such as uncoated Tyvek, a spunbonded high-density polyethylene material produced by the Dupont corporation. Unfortunately, I have not yet been able to locate a retail source of uncoated Tyvek, just the coated variety such as is used in postal envelopes. Second best, and what I use, is two or more layers of coffee filter paper securely sealed over the mouth of the container holding the desiccant. I've also made "cartridges" of filter paper for use in narrow necked containers such as two-liter bottles. For this I used ordinary white glue. Getting a good seal all the way around requires some care in execution. Brown Kraft (butcher paper) may be used as well.

For coarse granular materials tightly woven fabrics might serve the purpose providing the seams are tightly stitched.

F.3 TYPES OF DESICCANTS

F.3.1 SILICA GEL

The most commonly known and used desiccant is silica gel which is a form of silica dioxide (SiO_2), a naturally occurring mineral. It will work from below freezing to past the boiling point of water, but performs best at room temperatures

(70-90º F) and high humidity (60-90%). Its performance begins to drop off over 100º F, but will continue to work until approximately 220º F. It will lower the relative humidity in a container to around 40% at any temperature in its range until it is saturated. Silica gel will absorb up to 40% of its weight in moisture. Some forms are approved by the FDA for direct food use (check with your supplier to be sure). It recharges easily (see below in the indicating silica gel text) and does not swell in size as it adsorbs moisture.

F.3.2 INDICATING SILICA GEL

In the retail trade, the most common form of silica gel is indicating silica gel composed of small white crystals looking much like granulated sugar with pink or blue colored crystals scattered throughout. This is ordinary silica gel with the colored specks being coated with cobalt chloride, a heavy metal salt. When the gel has absorbed approximately eight percent of its weight in water the colored crystals will turn from blue to pink making an easy visual indicator of whether the gel has become saturated with moisture. *Because cobalt is a heavy metal, **indicating silica gel** is not food safe and should be kept from spilling into anything edible.*

The indicating silica gel will still adsorb up to 40% of its weight in water vapor like the non-indicating type will but once it has gone past the 8% level and the crystals have turned pink there is no way to tell how close it is to saturation. This isn't necessarily a problem, you'll just have to treat like the other non-indicating desiccants and either weigh it to determine adsorption or use a *humidity indicator card*. These cards are made to show various humidity ranges and can be had from many desiccant and packaging suppliers.

When saturated, both varieties of silica gel can be dried out and used again. This is done by heating the crystals in an oven at a temperature of no more than 300° F (149° C) for approximately three hours or until the crystals turn blue. Dehydrating the desiccant may also be accomplished by heating in a microwave oven. Using a 900 watt oven heat the crystals for three minute intervals until the color change occurs. The exact amount of time necessary will depend upon the oven wattage. Spreading the desiccant in a broad pan in a shallow layer will speed the process. Heating to 325° F (149° C) or more, or using a microwave oven over 900 watts can damage the gel and render it unable to adsorb moisture.

If your desiccant is packaged in Tyvek, do not heat above 250° F (121° C) or you could damage the material. This leaves a fairly narrow temperature window since silica gel will not begin to desorb moisture below 220° F (104° C). It's a good idea to use a reliable oven thermometer to check your oven temperature as the thermostats in home ovens are often off by more than twenty five degrees. Start with the packets in a cold oven and raise the temperature to 245° F (118° C),

keeping it there for twenty four hours. Spread the packets so they are not touching and keep them at least 16 inches from any heating elements or flames so that radiant heat does not damage the packaging. Tyvek should not be microwaved.

F.3.3 CLAY DESICCANT

Although not generally found in the retail market, clay desiccant is fairly common in commercial and industrial use. The primary reason for this seems to be that it is inexpensive compared to any other form of desiccant. Some mail order suppliers offer it for retail sale.

The desiccant material is *Montmorillonite clay*, composed primarily of magnesium aluminum silicate, a naturally occurring mineral. After mining it is purified, reduced to granules and subjected to a controlled dehydration process to increase its sorbent porosity. It recharges easily and does not swell as it adsorbs water vapor. It works well at low and room temperatures, but has a rather low ceiling temperature. At 120º F it will begin to desorb or shed the moisture it has adsorbed. This is an important consideration for storage in hot areas.

Subject to a degree of variability for being a natural material, clay desiccant will adsorb approximately 25% of its weight in water vapor at 77º F and 40% relative humidity.

F.3.4 CALCIUM OXIDE

Also known as "quicklime" or "unslaked lime", calcium oxide is a slow, but strong adsorbent. It is efficient at low humidities and can drop moisture vapor to below 10% relative humidity. Qucklime is ***caustic*** so must be carefully handled, particularly with regards to dust inhalation and exposure to skin and eyes. It expands as it soaks up water vapor and this must be taken into account when packaging. It will adsorb up to about 28% of its weight in moisture, but does so slowly over a period of several days rather than a matter of hours like other desiccants. It is most effective when used in high humidity environment where a very low humidity level is desired. It will release a fair amount of heat if exposed to direct (liquid) moisture or extreme humidities.

Calcium oxide can be recharged, but I do not have any details on how to go about this other than roasting at fire temperatures.

For expedient use, quicklime can be manufactured from clean lime stone (calcium carbonate) or pickling lime (calcium hydroxide) available in the canning sections of many grocery and hardware stores.

F.3.5 CALCIUM SULFATE

Also known as gypsum and commercially as Drierite, calcium sulfate is another naturally occurring mineral. It is produced by the controlled dehydration of gypsum $CaSO_4$). It is chemically stable and does not readily release its adsorbed moisture. It has a low adsorbency capacity, only approximately 10% of it weight. It can be regenerated, but apparently not easily so.

For expedient use, gypsum is commonly used in household drywall and Kearny mentions using this source in his Nuclear War Survival Skills. This makes only a so-so desiccant and you'd be much better off to use a more suitable choice but in an emergency it can get the job done.

F.3.6 OTHER DESICCANTS

From: Pyotr Filipivich pyotr@coho.halcyon.com

Simple trick is to dry a piece of wood in the oven and once it is bone dry (more than usual) then put it in your container and seal it. The wood will suck up any available moisture.

Editors note: Wood can soak up to 14% of its weight in moisture, depending on species. Woods with coarse, open grains work the best. I'm not aware at what temperature it will begin to "desorb" or shed its stored water which might be fairly low. Some empirical experimentation would be in order before relying heavily on it.

F.4 HOW DO I USE DESICCANTS?

Before you get to this point you should have already used the charts above and determined how much of the particular desiccant you're interested in you need for the size of the storage containers you'll be using. Once you know that you're ready to put them it into use.

Although they perform different functions, desiccants and oxygen absorbers are used in a similar fashion. They both begin to adsorb their respective targets as soon as they are exposed to them so you want to only keep out in the open air as much desiccant as you are going to use up in fifteen minutes or so. If you'll be using oxygen absorbers in the same package, place the desiccant on the bottom of the package and the oxygen absorber on the top. This is to keep the desiccants from robbing needed moisture from your oxygen absorbers which will hinder their operation.

If your desiccant is pre-packaged, that's all there is to it, put it in the package and seal it up. If you have purchased bulk desiccant you'll first need to make your own containers.

I use indicating silica gel for practically everything. My usual procedure is to save or scrounge clear plastic pill bottles, such as aspirin bottles or small plastic jars. Fill the bottle with the desiccant (remember to dry the gel first) and then use a double thickness of coffee filter paper carefully and securely tied around the neck of the bottle to keep any from leaking out (remember the indicating type of silica gel is not food safe). The paper is permeable to moisture, but it's tight enough not to let the crystals out. I use several winds of plain cotton string for this as both adhesive tapes and rubber bands have a way of going bad over time which might allow the cap to come off spilling the desiccant into the food.

For containers that have openings too narrow to use a desiccant container such as described above you can make desiccant packets with the same filter paper. The easiest way I've found is to wrap at least a double layer of paper around the barrel of a marker pen and use a thin bead of white glue to seal. Slide the packet off the pen and allow to dry. When ready, fill with the necessary amount of desiccant. You can then fold the top over twice and tie with string or staple closed. Take care that the top is closed securely enough not to allow any desiccant to leak out. Virgin (not recycled) brown Kraft paper can be used to make the packets with as well.

The above method will also work other desiccants, subject to whatever precautions the individual type may have.

IMPORTANT NOTE: The indicating form of silica gel (has small blue or pink specks in it) is not edible so you want to use care when putting together your desiccant package to insure that is does not spill into your food.

F.5 WHERE DO I FIND DESICCANTS?

I buy indicating silica gel at Wal-Mart in their dry flower section where it is sold in one and five pound cans for flower drying. I've seen it sold the same way in

crafts stores and other department type stores that carry flower-arranging supplies. You can also buy it from many other businesses already prepackaged in one form or another to be used as an adsorbent. All of the desiccant that I've found packaged this way has been rather expensive (to me) so shop carefully. There are a number of Internet sources available which will probably provide your best route for finding what you want.

Businesses carrying packaging supplies sometimes also sell desiccants. Some businesses commonly receive packets or bags of desiccants packaged along with the products they receive. I've seen montmorillonite clay in bags as large as a pound shipped with pianos coming in from Japan. Small packets of silica gel seem to be packed in nearly everything. Naturally, any salvaged or recycled desiccant should be of a type appropriate for use with the product you want to package.

It is possible to make your own desiccants using gypsum from drywall and maybe Plaster of Paris. Calcium oxide can also be produced from limestone (calcium carbonate) or slaked or pickling lime (calcium hydroxide) by roasting to drive off the adsorbed water and carbon dioxide. I don't have any clear instructions, as of yet, on how to go about this. Please do keep in mind that calcium oxide (quicklime) is caustic in nature and is hazardous if handled incorrectly.

G -- DIATOMACEOUS EARTH

G.1 WHAT IS DIATOMACEOUS EARTH?

Diatomaceous earth is a naturally occurring substance partially comprised of the fossilized remains of diatoms. Diatoms are microscopic sized hard shelled creatures found in both marine and fresh waters. The diatom shells are covered in sharp spines that make them dangerous to exoskeletal insects, but not to animals with internal skeletons. The spines of the diatom skeletons pierce the soft body tissues of insects between their hard exoskeletal plates and it is through these numerous microscopic wounds that the insect loses bodily moisture to the point of desiccating and dying. Creatures with internal skeletons such as humans, cattle and pets have means of resisting such damage and are not harmed. Thus, it is possible to mix a small amount of DE into your stored grains and beans to deter insect infestations without having to remove the dust again before you consume them. *Diatomaceous earth works in a purely physical, not chemical, manner thus has no chemical toxicity.*

As neat as this sounds, in the limited number of controlled studies that I have been able to find it seems that DE is not as effective in controlling food storage insects as properly used freezing techniques, fumigation with carbon dioxide (dry ice) or

sealing in air-tight containers with oxygen absorbers. This is primarily for reasons that most of the insects that cause a problem in grain storage are hard-shelled weevils which have only a limited amount of soft tissue exposure. I now mostly use DE for controlling ants and roaches in areas where I feed my animals and bedding areas. Still, some folks want to use DE in their food storage so the following information is provided.

G.2 WHERE DO I FIND D.E. AND WHAT TYPE SHOULD I BUY?

IMPORTANT NOTE: There are two kinds of diatomaceous earth to be found on the market and only one of them is suitable for use as an insecticide in your stored grains. *The type you DO NOT WANT FOR FOOD USE is sold by swimming pool suppliers as a filtering agent.* DE to be used for filtering has been subjected to a heat treatment that dramatically increases it's crystalline silicate content which makes it unsuitable for use with your foodstuffs. *The diatomaceous earth that is needed for use in food storage has not been heat treated and has a crystalline silica content of no more than 1-1.5%.* It is commonly sold in hardware and garden stores as an "organic pesticide" and is available from a number of storage food dealers. A few of these suppliers are listed in the *Resources* section.

I have always purchased my DE from my local hardware store and have had no concerns about its safety. However, a number of correspondents have reported to me that their local suppliers keep their DE in the same area as their chemical pesticides. This causes some concern about possible contamination and I no longer recommend using DE from these sources. Since the actual amount of DE (by weight) that is necessary to protect grains is fairly small I recommend ordering yours from suppliers who will guarantee their product is *food grade* as stipulated by the US FDA. This will insure you receive a product that has no deleterious contaminants and is safe to use.

From: higgins10@aol.com (Higgins10)
Originally posted in: rec.gardens

Good afternoon all. Diatomaceous earth is approved by the USDA as an animal feed additive, however I have found out that there are vast differences between various forms of diatomaceous earth. Some DE products may not be effective in controlling insects, while others may be harmful to humans and pets. The most important differences between individual forms of DE is the shape of the diatom, content of Crystalline Silica, and the purity of the Silica Dioxide. The World Health Organization cautions that DE with a crystalline silica content of three percent or higher is dangerous to humans, (and probably pets and birds as well).

Diatomaceous Earth used in swimming pool filters has close to a 60% crystalline silica content. I know of a product called Organic Solutions (insecticide) which is approved by both the EPA and USDA and has a crystalline silica content ranging between 0.36% to 1.12% according to its labels etc. It is classified as Amorphous Fresh Water Diatomaceous Earth (whatever that means). However, all literature I have read assures it is safe for both humans and animals and seems to be very effective at killing insects. I stumbled across all this info. while shopping in the mall. If you're interested in reading it too, go to the Organic Solutions website at http://www.BuyOrgs.com. Hope this helps answer the question and always use environmentally safe products! Higgins10

From: kahless@ns.waymark.net
Date: Sat Aug 24 14:08:48 1996
To: Dunross (A.T. Hagan) Private e-mail

[previous text deleted]

I have always purchased DE at the local feed store. It's cheaper there than at the garden and hardware stores. The feed store I buy at has DE available in bulk, but they'll package up a smaller amount if that's what you want. My package in the garage doesn't have a brand name but says "Nitron Industries" at the bottom. The label recommends 7 pounds of DE for each ton of grain. Ha! As if I had "tons" of grain in storage 8-D

I've been using DE for grain storage for about 15 years now but flea control only for the past 6 years. The only fleas we've seen in that period of time is the ones that hitch a ride in with friends pets. A very light dusting afterward takes care of that problem. Miracle stuff as far as I'm concerned since we'd had an awful time with fleas before we started using DE. Much much much cheaper and as far as I'm concerned the advantages FAR outweigh the risks.

Sam
(hope that was helpful)

G.3 HOW DO I USE D.E. IN FOOD STORAGE?

To use, you should mix thoroughly one cup (8 fl ozs) of DE to every forty pounds of grain, grain products or legumes. This works out to approximately one cup of DE to every five gallon bucket of food you want to treat. You need to make certain that every kernel is coated so it is better to do the mixing in small batches where you can insure more even coating. Both the grain and the DE should be quite dry when doing the mixing otherwise you'll get an uneven distribution.

WARNING: DE is a powdery dust which you need to take steps to keep out of your lungs and eyes. A paint or hardware store filter mask and a pair of goggles will do the job. It's a good idea to do the actual mixing outside in a slight breeze otherwise you'll get DE all over everything. Even whole wheat flour dust can cause lung irritation if you breathe in a sufficient amount.

Being inactive and usually covered in a hard shell, DE works poorly on insect eggs or pupae. It has more effectiveness on larvae and adult insects with a fair amount of soft tissue exposure.