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## "EXPLORING THE VERSATILITY OF 'FREE-FALL PROCESSING®' "

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# EXPLORING THE VERSATILITY OF “FREE-FALL PROCESSING®”

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## **1. ABSTRACT**

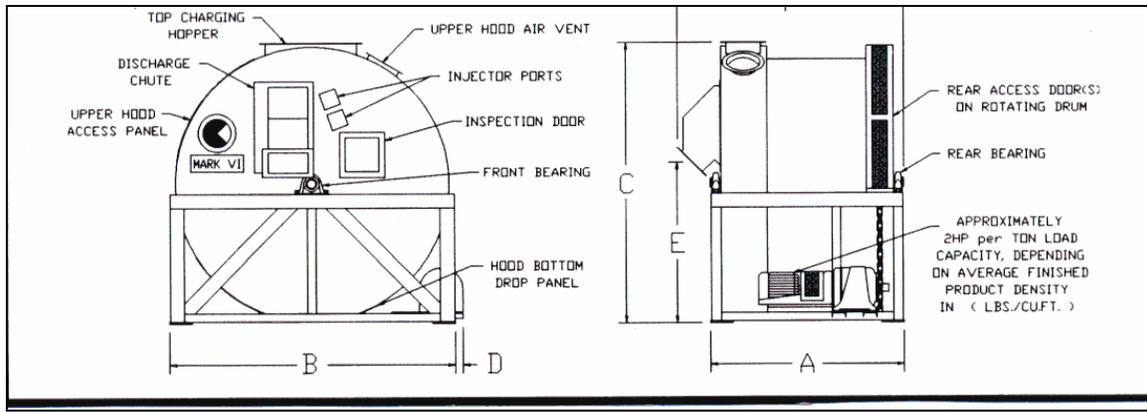
Many industries benefit from the gentle, rapid distributive mixing that is unique with the Rollo-Mixer® solids processors by Continental Products Corp. The Rollo Mixers ability to agglomerate, granulate and encapsulate is novel to the processing industry as well. Continentals “Free-Fall Processing®” method of applying liquids to solids allows for uniform distribution of liquid additives as the surface area is exposed in Free-Fall. The relationship of the droplet size to the particle size is critical to create the desired finished product; whether it is De-dusting Carbon Black, Impregnating Agricultural Chemicals, or Encapsulating Enriched Rice.

Although each of these processes involves a liquid being sprayed onto a dry powder or granular, that is where the similarity ends. All of the liquids we work with have varying viscosities and spray characteristics. The dry particulates vary in particle size and density and have differing material and flow characteristics. Even though the liquids and dry raw materials have different personalities, the approach is the same with “Free-Fall Processing®”. That’s what makes this challenge so much fun.

## **2. BACKGROUND**

Continental Products Corp. is a family owned company started by my father in 1960. The Continental Rollo-Mixer® was invented to mix Dairy Feed, a challenging formula which involves mixing dissimilar particle sizes and densities (pellets, oats, flaked corn) with black strap molasses. Since then, we have adapted our mixing & coating technology to many industries around the world.

We work directly with our customers on each application to help them improve the quality of existing products, as well as accelerate the transfer of developmental products to production. For the past 25 years, I have been directly involved in several hundred product trials which we conduct at our test facility in Wisconsin. We have a number of test units on hand with the most common being our model No.31-10/90s. (10 cu.ft. capacity). Typical test batch sizes range between 150 and 400 lbs., depending on the finished bulk density of the product.



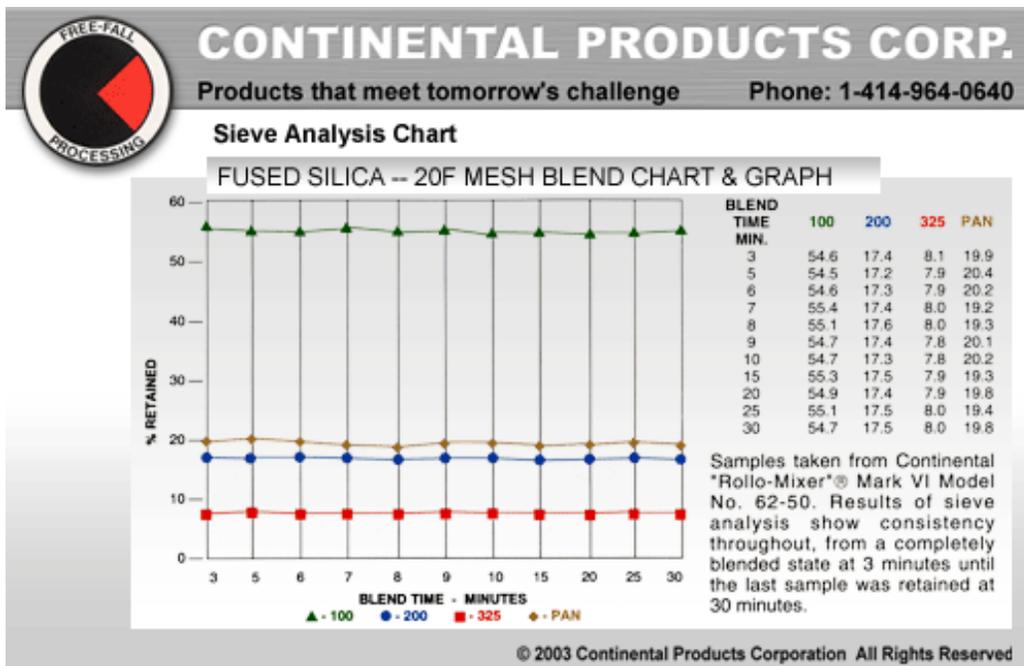
**Figure 1. Front & Side View of Continental Rollo-Mixer® Mark VI.**

### **3. MIXING**

The secret to mixing or blending materials is dividing and combining heterogeneous ingredients into a homogeneous state. The Continental Rollo-Mixer® is a unique horizontal rotary drum mixer which rotates at approximately 3 Rpm. The rotating drum is suspended by two pillow block bearings mounted to a stationary frame, with proprietary internal flights and baffles.

The Rollo-Mixer® creates over 25 divisions in one revolution, without generating any friction or fracture. The gentle mix action is likened to rivers of materials that course into and flow through one another as material is constantly tumbling, turning, folding and cross-mixing. Once material is mixed (typically in 2 to 3 min.) the product stays mixed and continues to blend throughout discharge. The Rollo-Mixer® will not damage or degrade product because there are no augers, ribbons or paddles in its design. Materials flow by gravity in all planes. This is especially important when you are trying to create a certain size particle or simply maintain the integrity of the ingredients in the formula.

Load-in and discharge points are fixed in place, so you can maintain a dust free environment during the loading, mixing, coating and discharge cycle. The mixer has a unique turbine section which allows material to be lifted at the front end of the mixer and free-fall. This falling curtain exposes all of the product surface area in a short period of time, which is vital to achieving an even distribution of liquid additives into or onto dry particulates.

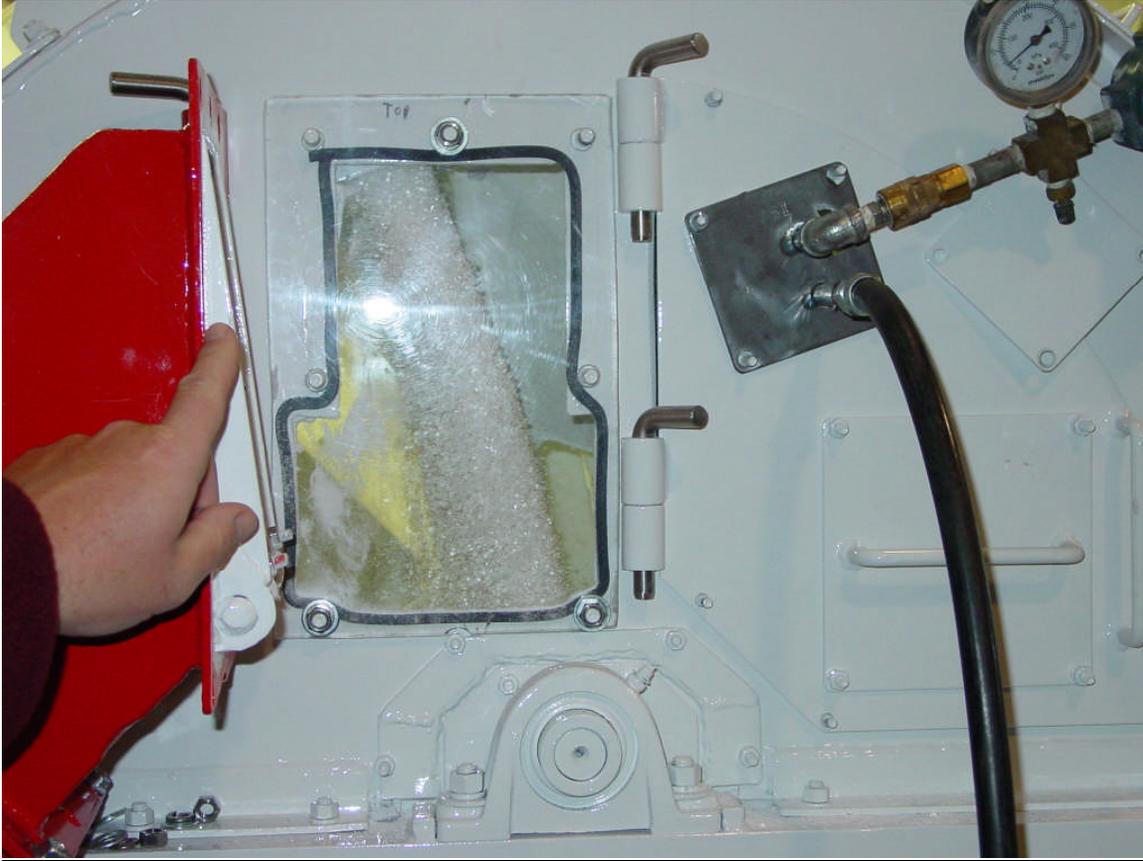


**Figure 2. Sieve analysis results of Fused Silica Blend**

**4. "FREE-FALL PROCESSING"**

There are several processes which fall under the category of "Free-Fall Processing®". We will review six different applications that involve agglomerating, granulating, encapsulating, impregnating, surface coating and de-dusting. The factors that separate these processes into their categories are really defined by the physical characteristics of the powder or granular being coated, and the function of the finished product.

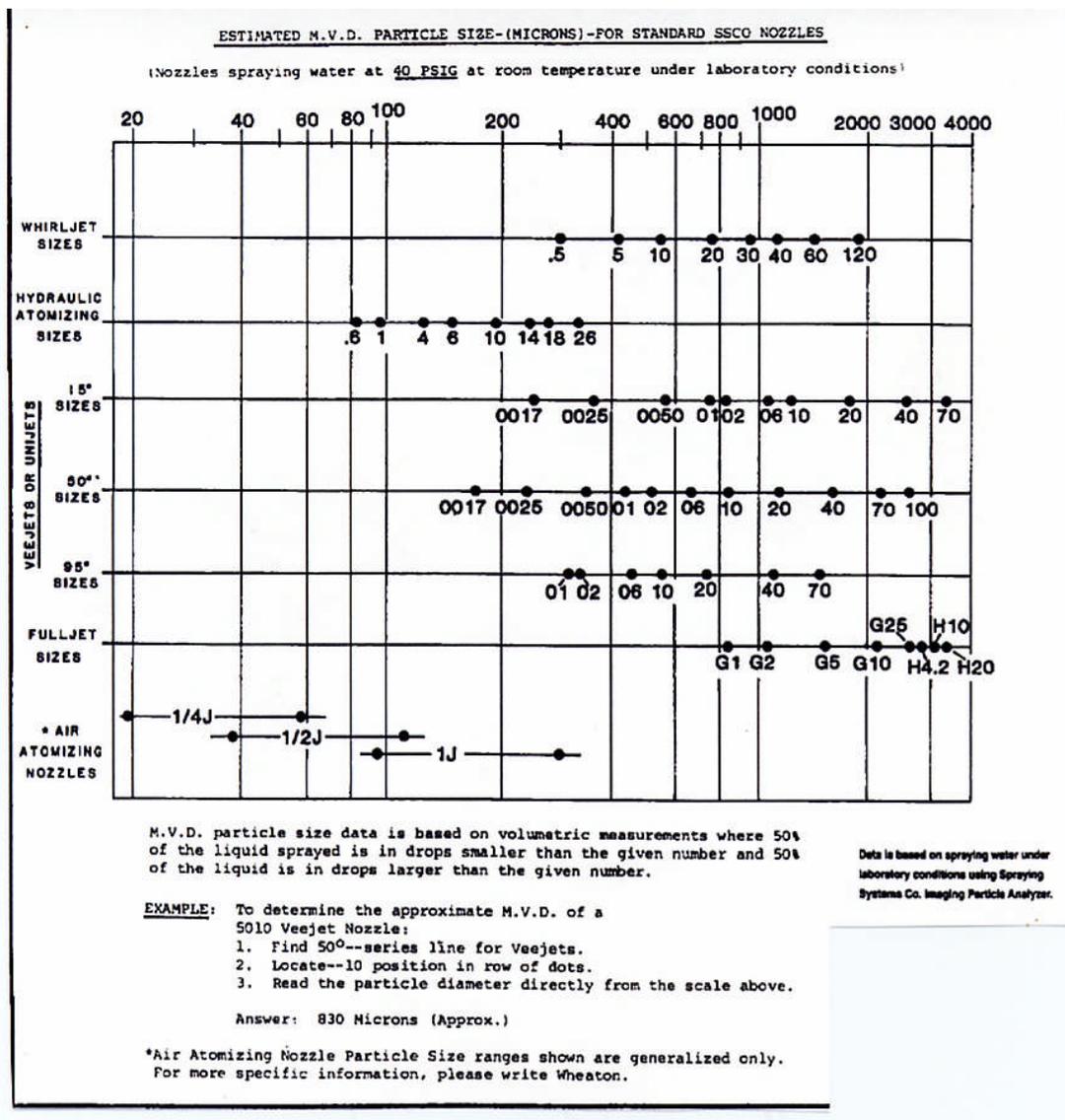
One of the many benefits of the Rollo-Mixer® design is being able to actually watch the coating process take place. Most processing equipment, by its very design, does not allow you to see what's going on inside. During customer tests, we will mount plastic window panels on the stationary front hood and the rotating drum at the rear of the mixer. Besides being able to watch the ingredients go into a mixed state, this also allows us to see the liquid being applied into the falling curtain as well as note the angle of repose of the product as it's flowing in the Rollo-Mixer®. Visibility is a key factor in helping us learn how products behave and adapting our coating technology to suit the application.



**Figure 3. View of Polycarbonate flake in Free-Fall**

#### **4.1 AGGLOMERATING**

I would define agglomerating as the binding together of more than one ingredient into a single, larger particle. In this application, we are trying to create a liquid droplet that is larger than the particle being sprayed. This combination works well for agglomerating powders into a larger particle size. Over the years, we have worked with Spraying Systems Co. of Wheaton, IL. SSC manufactures a wide range of spray tips and accessories for spraying liquids and we have done extensive work with their t-jets and air atomizing nozzles. Different spray tips create different droplet sizes and that's why it is so important to identify the particle size and droplet size you are working with.



**Figure 4. Spraying Systems droplet size chart - 1981**

A classic example of this is agglomerating dried milk for the calf and swine industry. One of our customers in Iowa has a 150 cu. ft. capacity Continental Rollo-Mixer® which is used for blending and agglomerating milk replacers. The goal is to make an agglomerated product that easily dissolves in warm water. Terms typically used to describe this are “instantizing” or “wetting out”. Once all of the raw materials are loaded into the mixer, the operator begins spraying the fat/emulsifier solution into the falling curtain and thus binding the mixed ingredients together into a slightly larger particle. It is important to define the variables that are involved in creating the proper spray pattern. The spray parameters are defined in **Figure 5**.

Mixer Speed:	60 hz
Nozzle Type:	H1/4 VV 4015
No. of Nozzles	2
Tip Pressure:	40 psi
Spray Pattern:	Horizontal - Elliptical
Spray Time:	10 minutes
Binder:	Fat/Emulsifier Solution
Binder Temp:	160 ° f
Product Temp:	64 ° f
Wet ability Temp:	80 °f

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**Figure 5. Spray set-up parameters.**



**Figure 6. Spraying liquids into the Free-Falling Curtain**

## 4.2 GRANULATING

There are many forms of granulating powders. Some that involves high energy compaction and some like the Rollo-Mixer® that is low energy granulating. I have found over the years that a high energy process will typically create a higher density finished product. Low energy processes often times create a lower density product. Our approach is simply spraying a binder onto a powder, in free-fall, so as to granulate it into a larger particle.

We have a customer in Ohio who blends 2500 lb. batches of Red Dye No.40, which is used in many colored soft drinks and food applications. Their goal was to use their existing Rollo-Mixer® as a granulator as well as a blender and avoid a major capital expenditure. Two 165 lb. batches of dye were recently sent to our test facility in hopes of granulating the red powder with water as the binder. The objective was to make a granule that is quick dissolving, free-flowing and dust-free. Similar to agglomerating dried milk but this time we were coating only one dry ingredient.

Our 10 cu.ft. test unit was set-up with viewing windows and a variable frequency drive. We slowly loaded the 100 micron dusty powder into the Rollo-Mixer® at rest. The bulk density of the powder was 25 lbs./ft<sup>3</sup>. Since the goal was to create a slightly larger, uniform granule, we decided to use an air atomizing spray lance assembly. This type of internal mix spray nozzle gave us a uniform droplet size which would result in a uniform particle size. We didn't want any lumps or balls in the product. The water was put in a 5 gallon capacity pressurized spray tank which was mounted on an electronic scale.

Before we sprayed any water in the Rollo-Mixer®, we played with different combinations of air and liquid pressure outside the machine to determine the optimum spray pattern, rate and droplet size. This gave us full control of the water being sprayed and allowed us to take samples in progression at 3%, 4%, 5% and 6% moisture.

SIZE RANGE (MICRONS) MEDIAN VOLUME	SUBJECT IN PARTICLE SIZE	PARTICLE TO FALL 10 FEET (SECONDS)
5000 to 2000	Heavy Rain	.085 .0.9
2000 to 1000	Intense Rain	.0.9 1.1
1000 to 500	Moderate Rain	1.1 1.6
500 to 100	Light Rain	1.6 11
100 to 50	Misty Rain	11 40
50 to 10	Wet Fog	40 1020
10 to 2.0	Dry Fog	1020 25400
1.0 to .01	Fumes	Suspended** In Air
.01 to .001	Smoke	Suspended** In Air
Below .001	Molecular Dimensions	-

The fascinating part of this test was that at 6% moisture, you could see inside the entire drum assembly, which told us that it took 6% water to thoroughly granulate the powder. After drying a sample, we poured one teaspoon of the micro-granulated powder into a glass of water and it instantly dissolved. The customer was thrilled. Because of "Free-Fall Processing®", our customer can now use his existing Rollo-Mixer® as a granulator as well as an efficient batch mixer.

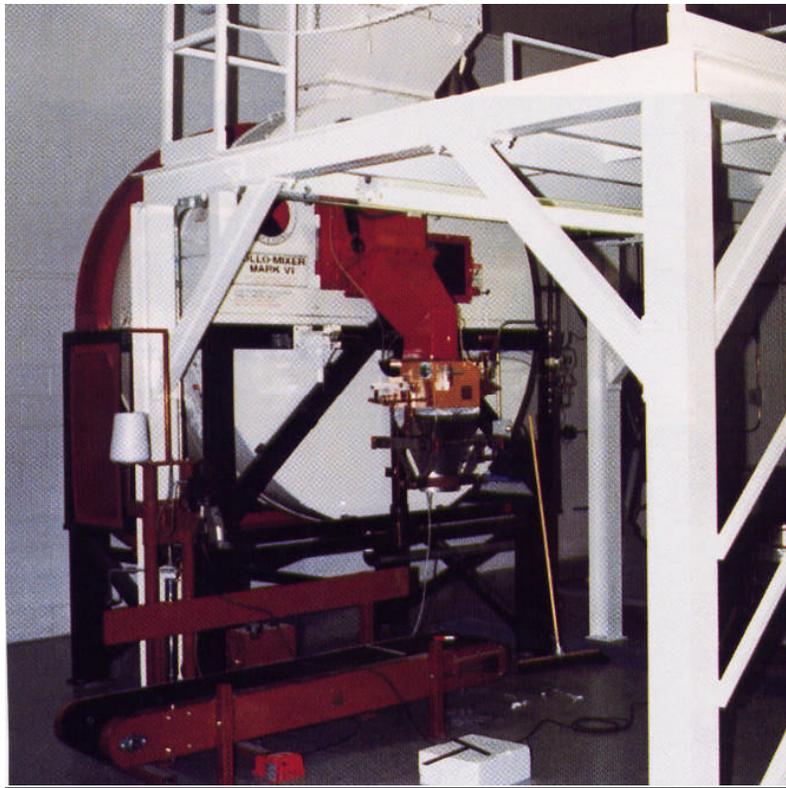
### **4.3 ENCAPSULATING**

Most coating applications have some form of artwork involved in the process. “Free-Fall Processing®” allows us to transform that artwork into a science. Encapsulating powders to granules with a binder is an exciting process the Rollo-Mixer® is well suited for, because it requires a combination of mixing & coating in one.

Eleven years ago we installed a simple, energy efficient system for a customer who Encapsulates Enriched Rice. The process involved mixing 80% California Rice with 20% Niacin/Thiamin Vitamin premix, which have two entirely different particle sizes and densities. The binder was a clear liquid “Hydroxypropylcellulose”. The goal was to encapsulate or encase the vitamins onto the rice by spraying the binder in free-fall. Because of the gentle, distributive mix action of the Rollo-Mixer®, the vitamin powder and rice particles are uniformly mixed, so you are spraying the food glue into a uniform free-falling curtain and sealing the vitamins around the rice.

The viscosity of the “Hydroxypropylcellulose” binder is similar to a light oil and is easily sprayed with T-jets. The liquid spray lance assembly had three SS4004 T-jet spray tips at 40 psi, which resulted in a droplet size of approximately 600 microns. These tips are designed to deliver 0.4 gallons/minute with a 40 ° spray pattern.

The system we designed consisted of a Mark VI Continental Rollo-Mixer®, Model No.74-86/35s along with a bag dump station for the raw materials, a 30 gallon spray tank for the liquid binder, and an automatic bagging scale with sewing conveyor. This entire Blend/Pak system ran on only one 10 Hp. Motor, and required minimal floor space.



**Figure 7.** Model No.74-86/35s - Encapsulating & Packaging Enriched Rice

#### **4.4 IMPREGNATING**

I would define impregnating as applying a liquid additive into an absorbent powder or granule. The adaptability of “Free-Fall Processing®” is even more evident when you consider we have some customers who spray as little as ¼% liquid into a carrier and others apply as much as 70% liquid into highly absorbent precipitated silica. Every porous particle has its own level or threshold of liquid it can absorb called insipient wetness. This is the point where it cannot take any more liquid and becomes a wet slurry.

One of the best examples of impregnating granules is common in the Agricultural Chemicals industry. The leading manufacturer of Fire Ant Bait in the United States uses the Continental Rollo-Mixer® to impregnate granular carriers with an insecticide. It is important that the liquid AI (Active Ingredient) is evenly sprayed throughout all of the surface area of the carrier, so that the COA’s (Certificate of Analysis) are consistent and on target. The AI’s are so potent and concentrated that they measure final product analysis in parts per million

We recently sent our 10 cu.ft. test unit to our customer’s plant to help them launch a new product for the insecticide market. Two carriers were used for the test; “Biodac”, a cellulose paper byproduct and “EcoGranule”, a custom absorbent carrier which is adaptable for specific impregnating applications. The assay called for 50ppm + or – 10%. In each of the four batch’s we ran, the granular carrier was loaded into the top of the Rollo-Mixer® from a super sack, impregnated with the insecticide solution, sampled, and then discharged back into a super sack. The lab results were exceptional: Batch 1. = 48 ppm. Batch 2. = 49 ppm. Batch 3. & 4. = 51 ppm. “Free-Fall Processing®” enables our customers to deliver the exact amount of AI into the carrier without having to over formulate or rework the product.

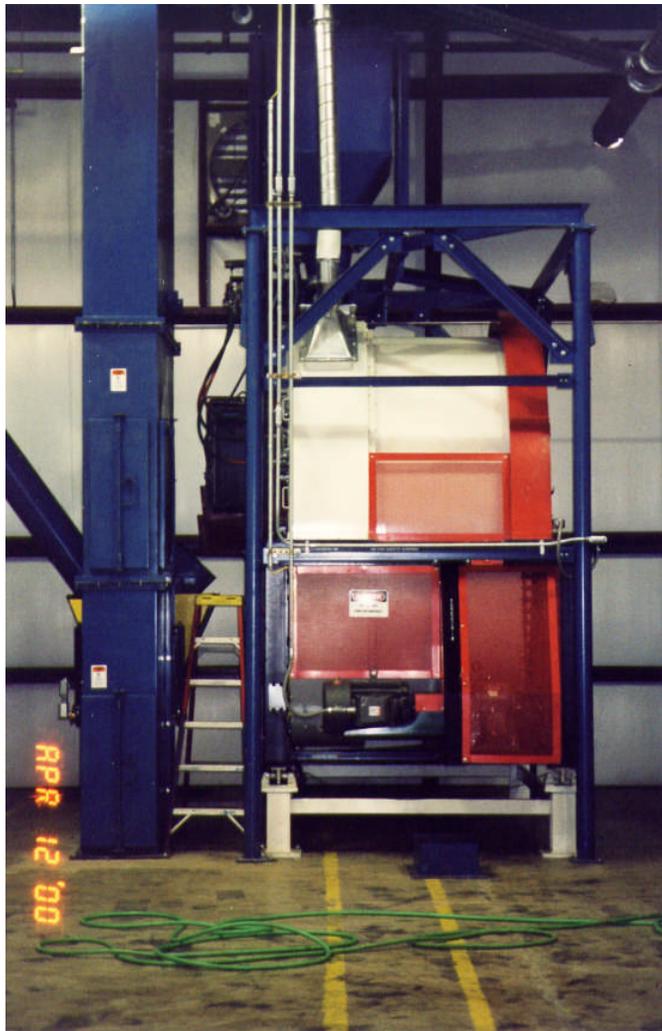
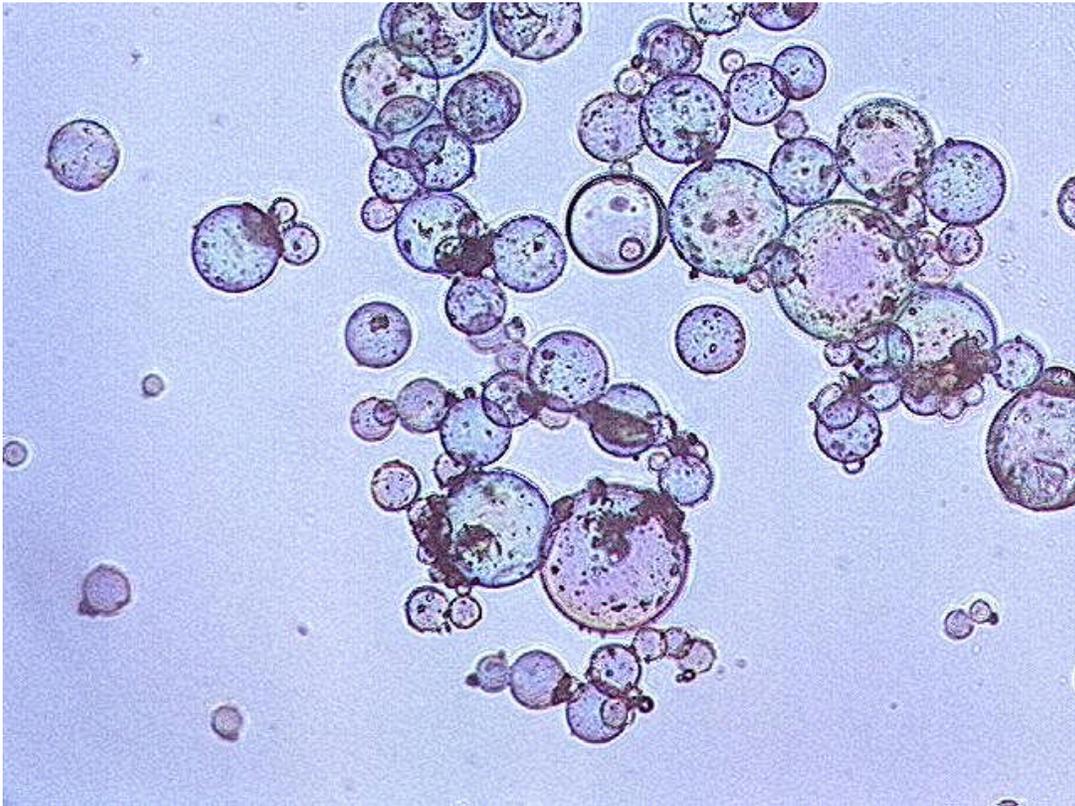


Figure 8. Model No. 98-200 –Impregnating Carriers

## **4.5 SURFACE COATING**

We have been involved in many surface coating applications over the years, but none like the glass bubbles we successfully coated for our customer in 1999. This is an ideal model for surface coating because we are spraying a liquid onto a surface that does not absorb – in essence the opposite of impregnating. These hollow, spherical glass bubbles are only 2 to 10 micron and weigh only 6 to 10 lbs/ft<sup>3</sup>. They are used in low density filler applications for the automotive, petrochemical and aerospace industries.

The goal was to evenly distribute a low inclusion (.025 %) liquid solution throughout all of the surface area of the bubbles. The amount of surface area to coat is enormous. We loaded the bubbles into the Rollo-Mixer® and heated them up to 175 ° f. Coating a hot surface area vs. an ambient surface often times will permit the liquid to migrate and form around the particle. The liquid was sprayed with a 1/4J SU22 air atomized spray lance at low pressure. The fog like spray pattern delivered the 1.5 lbs. of solution in 5 minutes. Once we completed the coating cycle, we cooled the bubbles to 80° f, and discharged them into boxes. “Free-Fall Processing®” exposed all of the surface area of the glass bubbles without damaging any of the fragile particles. Note the speckled coating on each bubble. **See Figure 6 below.**



**Figure 9. Surface Coated Glass Bubbles Magnified 750x**

## **4.6 DE-DUSTING**

In 1983, we replaced a 4 ton ribbon mixer (50 Hp. Motor) with an 8000 lb. capacity Continental Rollo-Mixer® (10 Hp. Motor) to blend and de-dust vitamin-mineral premixes for the Animal Health Industry. These products are very dusty and require a dust suppressant such as mineral oil to attach the fine dust particles to the minerals. With “Free-Fall Processing®”, we were able to reduce the amount of oil applied per batch by 50% and achieve a uniform dust free product. The ribbon mixer required \$12.00 of oil/ton and the Rollo-Mixer® cut that fixed cost to only \$6.00/ton. Not only did the customer realize over \$60,000.00/year in mineral oil savings, they also lowered their energy bill by 80%.

## **5.0 CONCLUSION**

One of the things I enjoy the most about designing process systems is the variety of applications our Rollo-Mixer® gets exposed to. And the versatility of “Free-fall Processing®” has uncovered numerous possibilities; everything from de-dusting carbon black with hot wax to coating polycarbonate flake with 70% polyethylene glycol. Our mixing and coating technology is unique and therefore capable of creating products that give our customers a superior product at the lowest cost of operation. I have not found another machine that can uniformly mix ingredients in 2 to 3 minutes at only 3 rpm.

As you can see, there is a wide assortment of binders available to accomplish all of these processes. The key is to find the right binder for the application. The control you have with “Free-Fall Processing®” allows you to define the variables and efficiently make a consistent uniform product – every time.

I would like to acknowledge the contributions of my Father D. Coyne Callaghan, and my brothers: D. Coyne Callaghan Jr., Thomas A. Callaghan, and John P. Callaghan.

### References:

Spraying Systems Co. - Wheaton, IL, Spray tip droplet size chart /graph, 1981

“Biodac” is a trademark of Grantek, Inc – Green Bay, WI

“Ecogranule” is a trademark of Cycle Group, Inc. – Mocksville, NC

“Free-Fall Processing®” is a trademark of Continental Products Corp. – Milwaukee, WI

“Rollo-Mixer®” is a trademark of Continental Products Corp. -Milwaukee, WI