PLASTIC COATED PUSH BUTTON CONTAINERS*

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We push a button to ring the door bell, to summon an elevator or call our secretary. These are signal buttons. We push a button to light a lamp, ventilate a room or get a quick sun tan. These are appliance buttons. We push a button to kill flies or other insects, to decorate a Christmas tree, to lacquer and set our hair, to apply a fragrance advertised as "Bait to capture your true love"—and if they only knew how badly we wanted to be captured: these are aerosols.

"Aerosol" is a term applied to products that are pressure-propelled. Fundamentally, pressurized products are packaged with liquefied gases, such as Du Pont's Freons, General Chemical's Genetrons and Penn Salt Chemical's Isotrons. These are the same agents used as coolants in refrigeration and air conditioning units. The pressure-propelled type of package made its first appearance early in World War II as a container and dispenser of insecticides. Postwar developments put the aerosol container into civilian use as a better dispenser for a wide variety of liquids and semi-solids. But, there was one major drawback, the fact that many chemicals and food products are highly corrosive in contact with metals. Or, metal has a detrimental effect on the chemicals or products contained therein. This was the problem that presented itself to the Wheaton Company in 1951. Some number of failures, many thousand dollars and 6000 miles later a new aerosol container was filling the atmosphere with air deodorant, liquid fertilizers, sun tan oils and spot removers, blow torch fuel and cold relief remedies. The new aerosol container is a plastic coated glass bottle. It will withstand internal pressures far in excess of the normal 15 to 25 lb. loading pressure. It further offers the flexibility of design and decoration found only in glass or plastic cosmetic containers.

The coating of glass bottles has two fields of application—the non-pressurized and pressurized. In the non-pressurized field we refer to this as an industrial coating. It is used to make a package break resistant, add color, warmth of feel, prevent fragmentation and, with an added opacifier, a

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visibility screen, or with a special chemical, an ultraviolet screen. This coating is usually applied in a somewhat thinner section than that used for the pressurized containers. In the pressurized or aerosol container the main function in addition to the others just mentioned is to prevent violent shattering or fragmentation.

Since the use of the container and the products contained are beyond the control of the manufacturer, and as is the case with most aerosol bottles, the contract filler will be handling the containers as well as the customer; therefore, to avoid split responsibility the customer should assure himself in conjunction with his contract filler that the container meets his requirements.

In a pressurized container you are concerned with a pressure retention factor as well as a design that will permit coating; in a non-pressurized container the concern is only design. Hence, it is possible to have a wider design latitude in a non-pressurized container than in one for aerosol.

The ultimate in design for a pressure container is a perfect sphere. The opposite is large flat areas.

Let us assume that a design has been selected, the molds have been made and the job is ready to run. At the start of every job the standards department checks one bottle from each cavity, recording the findings. Any deviations in specifications are then corrected by the operator. Set-outs are then taken at the hot end every hour and checked against the bottle specifications.

After annealing, bottles are inspected by the packers who wear gloves and handle only two bottles at a time. This is most important to prevent scratching or abrasion of the glass surface. The visible defects are sorted and discarded at this point. Bottles are also discarded at this point that have been designated as rejects by the standards department's finding on the hot-end set-outs.

All checks, breaks or fractures are major defects. Stones and surface blisters are all rejectable. Distribution of the glass must be good.

Two further tests are performed by the standards department after the bottles have been annealed. The first is a hydrostatic pressure test using equipment such as is manufactured and sold by Preston Laboratories or its equivalent. Five bottles from each section of equipment are tested at 150-lb. internal pressure every half-hour. Any bottles breaking at 150-lb. pressure require that all bottles produced on that cavity for that half-hour be rejected.

Because of the hold down pressure required by certain valves, periodic checks are made on a Dillon Dynamometer for a head compression test of 450 lb.

The bottle coating is a specially compounded polyvinyl chloride that is applied by dipping. The coating thickness can be varied within limits to provide the most economical jacket that the product manufacturer feels will suit his requirements.

Always maintaining care to avoid contact of one bottle with another, an operator places the bottles in position for the dipping operation.

After the plastic coating has been added, a statistical quality control check is made. Four bottles are taken every hour. The coating is stripped and weighed for a gram weight check. In stripping the coating, four evenly spaced cuts are made running vertically along the bottle. A micrometer reading is taken to ascertain the evenness of distribution of the coating.

A visual inspection at this time is made for cosmetic defects such as faulty coating, pock marks, splash back and burn marks. Removable blemishes are wiped off and bottles are then screened or packed.

At this point I might digress to discuss the various factors which enter into a determination of jacket weight; these are size of container, which includes volume and glass mass, mass of the liquefied propellant portion of the pack and the potential expanded volume of the liquefied gas-pressure, headspace and total mass.

Assuming the glass thickness to be constant, the forces required to break a glass container vary inversely but not proportionately with the surface area of the glass. Small cylindrical containers are considerably more resistant to breakage than containers of more complicated shape and greater surface area.

As sizes and surface areas increase, the contents of the container increase, each adding another factor to the determination of the final jacket weight.

The liquefied propellent portion of the formula has a direct bearing on the fragmentation pattern of the glass and upon the possibility of rupture of the plastic jacket. This is, of course, related directly to the expanded volume of the gas at atmospheric pressure, and to the pressure of the expanding gas upon the walls of the container and plastic jacket.

Headspace plays a relatively obscure but important part in the determination of jacket weight. It has been found experimentally that an optimum headspace can be found below which there is no appreciable difference in fragmentation or break pattern, but above which there is considerable difference. Unfortunately, this optimum headspace cannot be predicted except on bottles of essentially the same shape. However, increase of headspace is advocated only as a last resort in the production of commercial containers.

The pressure of the liquefied gases has a bearing on the speed at which the liquid volume becomes a gas and speeds at which stresses are placed on the plastic vary the reaction of the plastic. For instance, it is conceivable that stresses can be placed on a flexible material like rubber with such velocity that the rubber becomes brittle and will break rather than stretch. Polyvinyl chloride exhibits these same characteristics.

In the manufacture of glass aerosol containers, attempts are made to stay as close as possible to the size and shape indicated as desirable by the customer. From an engineering standpoint we are able to suggest modifications in bottle designs which will, in the majority of cases, adapt a non-pressure designed bottle to a glass aerosol (which we consider to be a container that will withstand a minimum hydrostatic pressure of 150 lbs. per square inch for one minute). At this time bottles are produced on a single section of equipment. When the bottle design has been proved to be suitable for aerosol—from the hydrostatic standpoint—we then proceed with drop-testing to determine if peculiarities in a break pattern can be established. Such peculiarities—if encountered—are brought to the attention of the customer, who evaluates the container according to his standards and rejects or accepts the bottle.

When the bottle goes into production a statistical quality control, as outlined previously, is maintained to insure that bottles are being produced to meet the standards specified.

The bottles are then run through our bottle coating line where they are:

1. Subjected to pressure test before coating.
2. Coated.
3. Decorated.
4. Vented.
5. Packed for shipment.

Testing the coated bottles involves the following:

1. Simulated customer pack is drop tested at 100°F. to determine if coating thickness is adequate.
2. Weight of deposited coatings is recorded periodically.
3. Weight distribution of plastic jacket is observed for check on machine.

There are several factors which make drop testing of bottles subject to considerable variance in evaluation of data. Primarily, because breakage takes place so rapidly no one can observe the break without the aid of high-speed, stop-motion photography. This automatically produces a large measure of subjective conclusion even among scientific personnel who strive to be objective in the evaluation.

It is often helpful to drop a bottle filled with water to establish a reference point for evaluation of aerosol drop-testing.

A bottle containing a liquid non-pressurized and non-plastic coated will shatter upon dropping. The distance the glass fragments are thrown depends upon the size and shape of the bottle, the total weight of the package, the height from which it is dropped and the surface upon which it is dropped.

The same container, empty, dropped under identical conditions will produce substantially different results.

The difference can be explained partially by postulating that the residual inertia of the liquid mass is translated into a force which acts against the walls of the container creating a new fragmentation pattern without increasing the possibility of bottle breakage, *per se*.

If we assign a category empirically to the typical break pattern of an empty bottle, we would find that a non-pressurized bottle filled with liquid would fall in a different category.

If we take an identical container filled with a pressurized liquid, like soda water, and subject it to the same test under identical conditions, we find another category must be added to the two above.

Then taking the same container and using an aerosol fill in it, under identical conditions, we find we must create a fourth category. The fragmentation patterns of each of the above are substantially different and statistically significant.

Safety evaluation of an aerosol package without an adequate industry-approved method of evaluation is practically an impossible task. Until such time as a "tool" is produced which will measure hazards objectively any method now in use by anyone approaches something like attempting to measure a mile with a foot rule. Because there are no accepted, industry-wide reference points it often becomes a management decision to decide on the relative safety of a glass aerosol. These decisions are of necessity made with a minimum of data and practically no reference points. For this reason a CSMA subcommittee, under the chairmanship of Dr. Joseph Lann of the Kinetic Laboratory, E. I. du Pont de Nemours and Company, is attempting to provide a method of objective evaluation of hazards involved in glass aerosols.

The proposed test is under evaluation by nine cooperating laboratories to determine reproducibility of results and to consider the statistical approaches for drawing objective conclusions.

In brief, the proposed test uses a paper tent into which the bottles are dropped from varying heights onto a $^1/_4$-inch steel plate embedded in concrete. The mean height from which the bottle must be dropped to produce breakage and fragmentation is determined. Hazard is determined by perforations in the paper tent.

Assuming results of the cooperating laboratories to be sufficiently in agreement, tentative minimum standards will be proposed to the industry. This should give the aerosol packer and merchandiser a yardstick by which he can measure his product in an increasingly competitive market.

Maximum safe pressure in glass aerosol formulations depends upon a number of variables; no definite pressure can be stated as maximum safe pressure.

Glass pressure packaging is still new. The Interstate Commerce Commission has not as yet provided regulations dealing specifically with glass aerosols. In order to remain in this non-regulated category, we, at Wheaton, have recommended that no package be formulated at a pressure over 24 lb. at 70° F.

However, a blanket statement that 24 lb. at 70° F. constitutes a safe package cannot be made. A 10-cc. pharmaceutical vial may be perfectly safe at over 24 lb., whereas a 4 oz. hair spray container with a large proportion of propellent may not be safe at a pressure of 18 lb.

Because the glass aerosol is a non-regulated package, there is no necessity for following the prescribed hot water test method to bring the contents to 130° F. This is significant in that components which can be unstable at such temperatures need not be subjected to this heat. It is advisable to use a water test for the determination of leaking packages but the temperatures need not reach 130° F., within the container.

This is fortunate because the heat transfer through the plastic jacket and the glass is very slow in comparison to heat transfer in metal containers. The temperatures reached in a bath will not permanently affect the quality of the plastic jacket. Elevated temperatures will affect any plastic material merely through increase in entropy but there is no permanent effect.

Please bear in mind that none of these packages are dangerous at normal room temperatures. Expansion and pressure increases created by increased temperatures (100° F.) can cause fracture of the plastic jacket under certain conditions where the jacket thickness is insufficient to resist elongation past its plastic limit.

As has been mentioned before, the proportion of propellent to product is of considerable importance. A rapid computation of expanded volumes of propellents at 100° F., using basic gas laws will show that expanded volumes of propellent are proportional to the liquid mass. Pressure, *per se*, enters into this computation as an acceleration factor.

The thickness of the plastic jacket enters the computation as a resistance to tearing, elongation, abrasion and cutting.

The bottle shape enters the computation as a factor upon which the fragmentation pattern is based. The fragmentation pattern determines the possibility of long sliver-like particles piercing and, upon being pierced, rupture of the jacket depends upon its proximity to the elongation limit. The case of a toy balloon can be used as an illustration. When the balloon is only partially blown up, with only little pressure in it, piercing the balloon will result in pressure release without violent rupture of the rubber. On the other hand a balloon freely distended will tear itself to pieces upon being pierced because it is close to the elongation limit of the rubber upon full distension and contains a volume of gas which is seeking to expand further. The same thing happens to a tire when a blowout occurs, but the possibility of the same thing happening with a tubeless tire is considerably smaller because the wall thicknesses of a tubeless tire are considerably greater than the wall thickness of the tube and the walls are less close to their elongation limit.

The larger size containers, generally hair sprays, tend to be formulated with higher propellent proportions than colognes. For this reason pressures should be lowered, and the plastic jacket should be of sufficient thickness to insure elongation without rupture.

The venting of these heavy jackets is of primary importance. Experimentally it has been found that excessive venting causes rocketing effects. Insufficient venting, on the other hand, may result in rupture of the jacket and allow glass fragments to escape.

We have experimented with many different venting systems and have found that large holes in the bottom of the container provide a positive venting area, and if they are of sufficient area the jacket will not approach the elongation limit. In addition to the obvious advantage of a large venting area the vents do not deface the jacket which is again an important item in packaging.

Slit vents, though relatively inconspicuous, do not have the positive action of round holes unless they are quite long. When slit venting is used, it has been found that expansion of the jacket is accompanied by actual tearing of the slits, which is undesirable. Therefore, it is preferable to use round holes.

High cost propellents are not necessary to obtain the desired spray patterns in hair lacquers. However 30:70 ratios require high coating weights.

There should be only one reason for using high cost propellents in hair lacquers. The low cost propellents are considerably more active in degrading essential oils than the high cost propellents, even though there are many that are resistant to change. For the house which would like to carry out the family theme in odorants, it cannot be too strongly emphasized that there is no adequate substitute for shelf testing to determine possibility and degree of degradation under normal storage conditions.

Glass has long been recognized as one of the most resistant materials for packaging purposes. Chemical changes will take place even in glass, but the changes for the most part are on a micro scale and are difficult to detect even with advanced analytical techniques. There may possibly be instances which might present special formulating problems due to container attack but these should be rare compared with problems encountered in metal packaging.

Why should we consider aerosol packaging? There are several advantages, both real and apparent, which offer the merchandiser an opportunity to sell his product. First, although by no means the most important, is the novelty value. The American public has been schooled by advertising into accepting a new product almost because it is a new product. The aerosol pack has captured the imagination of the public because it caters to the inherent laziness of man.

However, there are real advantages connected to cosmetic aerosol packaging. There is a tremendous apparent increase in usable volume. In the case of foam products—such as shampoos, although the volume apparently increases, the actual liquid content is quite small. The problems connected with excessive defatting of skin and hair are lessened considerably.

In the case of foamed lotions, the small liquid content promotes fast absorption, even though the large apparent volume gives one the feeling of luxurious extravagance.

It is interesting to note that in certain quarters of the fragrance industry it is well considered that aerosol will soon be the only recognized method of packaging colognes and perfumes. The reasoning behind this is the advantages offered by this type of packaging—no evaporation, no oxidation, no contamination and no degradation of fragrance because of the completely sealed package. The current industry offerings of colognes, perfumes, deodorants and hair sprays are overshadowed by the future possibilities.

Far from being a gadget, the aerosol container is contributing more and more to that feeling of luxurious extravagance; helping to make this the push button world today that was the planner's dream yesterday.