AEROSOL PRODUCTION EQUIPMENT 11

THE ESTABLISHMENT of a major aerosol filling and packaging facility can be an enormously complicated enterprise, and one that is quite costly as well. In the U.S.A. high-speed aerosol lines rated at 160 to 280 cpm will cost about $1.0 to $1.5 million each, depending upon the degree of automation. Added to this will be the value of hydrocarbon gas-house facilities, propellent bulk tanks, compounding equipment, piping and so forth, plus any extra machines added to the production line to enable it to handle a greater diversity of products. The total cost can then rise to over $2.0 million for a first-rate facility.

The initial consideration in designing a line is to consider what product(s) will be run and how much production is needed per year. A comfortable production cushion is generally built in to allow for peak periods, where seasonal sales, special promotions, introductions or other factors may double the average requirement. Many captive lines and a few lines operated by contract fillers are set up to run only one product type, such as shave creams, antiperspirants or hair sprays. These lines are relatively simple and can be run very efficiently. In one line that ran a disinfectant/deodorant almost exclusively, shift production figures ranged only about 1.5% from the average and percentage yield figures for both components and chemicals were extremely high, usually within 1% of theoretical.

A few lines in the U.S.A. and many lines throughout the world are designed to run only CFC propelled aerosol products. They are not outfitted with the sophisticated gas-houses that are needed for hydrocarbon propellents. At least one line was designed specifically to run only a carbon dioxide spray product at high speeds. Over ten years later the marketer decided to add a hydrocarbon type product and was forced to purchase and install a complete new production line. Most contract fillers are preempted from filling whipped creams, because of the need for high-speed gasser-shaker equipment, food-grade compounding and handling equipment, a suitable area for conducting food-compounding and food-filling operations and finally, the need for a large cooler in which to store finished merchandise. On the same basis, only a few specialty houses can effectively fill very small drug and cosmetic aerosols, since special fillers, clinchers and other machines are required. In the U.S.A. there are only 20 to 22 aerosol lines capable of clinching 20 mm or other size ferrule-type valves onto bottles and aluminum tubes. The filling of paints and coatings is generally regarded as a specialty business. With perhaps two exceptions, the 300 million per year U.S.A. production of these products is handled by a large group of small to moderate size establishments.

The larger fillers usually have several lines, with each one made as versatile as is reasonable, and with each line complementary to the others, in order to insure a maximum level of product adaptability, consistant with equipment costs and other factors. Yet even for these fillers many relatively unusual products must be turned down because they cannot be adapted to the lines that are available. A listing of the different kinds of aerosol products follows, as looked at by plant engineers and other production people:

a. Aerosol glass and tube lines — for 13 mm ferrule-type valves.
b. Aerosol pharmaceuticals — with "white room" capability and CGMP compliance.
c. Food aerosol lines — for whipped creams, requiring coolers and so forth.
d. Food aerosol lines — for spray products.
e. Food aerosol lines — for piston-can products, requiring gasser-plugger machines.
f. Paint and lacquer lines — with clean-up versatility
g. Aerosol co-dispensing product lines — "Y-shaped", rare in the 1980s.
h. Miniature plastic aerosol lines — purse size spin welded base type; now rare.
i. Compartmented can lines — for Sepro Cans, Alucompack Cans and others.
j. Large plastic aerosol lines — for OPET bottles, with undertucked valve cup sealing.
k. Lines for DME (DMO) propellent aerosols — with Class C electrical system in gas houses.
l. Lines for highly viscous products — caulkers, gel cosmetics, toothpastes, etc. (In some cases only the concentrate is viscous.)

These twelve representative product types illustrate the diversity of aerosol formulations and packaging forms now on the market.

Every new product makes its own particular set of demands upon compounding equipment, production facilities, or the establishment in general. For example, in the case of a 100,000 unit run of an antiperspirant, the relatively small amount of concentrate had to be made in a rather large mixing tank, relatively far away from the production line. Despite attempts to minimize losses, the dished tank bottom, handling system, filler bowl and other components held back so much product that the loss was almost 20%. Had the run been 200,000 units the loss would have been only 10%, and so forth, showing one attribute of volume on costs.

Production facilities can often be modified slightly to accommodate new product requirements. The addition of some 600 to 1000 pucks can transform a regular (tinplate) can line into one capable of handling aluminum cans. For very large concentrate fills a double-bank Cozzoli Machine Co. filler may be modified to fill half the concentrate amount through each 8-nozzle bank. However, by doing this the filling speed of the machine drops to 50% of normal. To fill a powder spray, a Diehl-Mateer or similar auger-type powder filler must be added to the line. Filamatic fillers (National Instrument Co.) are sometimes added to lines if some small ingredient must be added accurately. For a gel-type cosmetic, a case-shaker was inserted at the end of the line to mix the gel and propellent phases together.

In many instances these "minor modifications" severely downgrade the production capacity of the line. If a filler expects a line to generate a certain gross income during a shift, an action that reduces overall line speed to 50% of average will also cause the services charge to double. Sometimes these speed reductions are not fully anticipated. A Chicago filler was asked to drop a mixing-ball into a rather unusual product. Not having done this before the filler merely charged for the cost of two or three additional people. But when the time came for production it was found that this operation was the limiting one. People couldn't drop balls into cans quickly enough. After a few unprofitable shifts, the firm purchased an automatic ball dropper and the problem was resolved.

With U.S.A. aerosol production at 70% of the peak 1974 level (prior to the CFC/ozone controversy) filler undercapacity is not normally a problem. It may become so in the future, since in the past two years a capacity of over 200 million cans per year has been lost, due to fires, plant closings, Chapter 11 bankruptcies and other causes. If a marketer needs more product than his captive facilities can produce, he has the option of employing a contract filler to provide the extra temporary volume needed. These marketer situations are brought about by peak load requirements, and also by strikes, large constructions, fire, serious equipment failures and other problems. Peak loads can usually be anticipated and can sometimes be handled by stockpiling or overtime work, both of which are increasingly expensive these days. On the other hand, smaller marketers sometimes carry "contingency thinking" too far and invest large amounts of capital in an oversized production line. Here we can only suggest, "If you have a bag of peanuts, don't buy an elephant — it may become a white elephant!"

Basic plant layout must be considered carefully. Usually it is a matter of positioning an aerosol line within an existing building, or readjusting equipment to accommodate an addition to the building. There is nothing quite like an ample warehouse for raw materials and filled stock, yet this panacea is very elusive. Boards of Directors and stockholders always consider capital requests from the standpoint of Return on Investment (ROI), and warehouses are not money-makers — at least not directly. Because of this, many marketers and fillers find themselves leasing or renting available space around town, and paying premiums for local transportation, travel time and shipping wear. Uncrowded warehouses allow better segregation of raw and filled stock, approved and rejected stock (in accordance with CGMP concepts) and filled stocks of similar appearance. Warehouse transport becomes more efficient and damage to goods decreases. At this time, experimental facts are emerging to suggest that flammable aerosol products require extra sprinkler protection beyond the 0.3 gpm/ft² (12 liters/m/m²) in use for General Purpose Warehouses. Where floor-standing piles of two or three palletloads high are involved, alcohol-based products seem to require about twice this sprinkler density, liquid petroleum liquid based products appear to require about three times this much, and antiperspirants apparently require about four times this flow rate. In addition, special Viking "high challenge" 160°F (71°C) thin band sprinkler heads must be used for quick response and maximum effect. In time it is thought that many warehouses will install heavy duty sprinkler equipment under roof, according to needs and insurance company demands. If this takes place in time, then a further segregation of filled stock will be necessary for most warehouses. Whenever segregation is required the warehouse becomes less space-efficient.

The U.S.A. warehouse approach is toward one large room for smaller structures and a few large rooms for larger ones. Individual areas amounting to 30,000 to 80,000 ft² (2,790 to 7,435 m²) are not uncommon. On the other hand, the European approach is to divide warehouses into much smaller units with areas ranging from 1,000 to 10,000 ft² (93 to 930 m²) and use not more than 60% of the floor space for actual product storage. Walls between the areas are usually of one-hour fire resistance and often are fitted with self-closing fire doors.

The floor plan for a typical European type aerosol filling plant is illustrated in Figure 1 (Page 376).

The main building is rectangular and has an area of about 36,500 ft² (3,400 m²). The space allocated for the two production lines is only about 4,700 ft² (435 m²), or about 13% of the total plant area. This particular plant was designed to produce only one product; as a result, the production lines are identical and the size of the compounding area is quite small. There is no space allocation for drums of "drain out" concentrates — product left over from previous production runs — as there would be in a plant producing a number of aerosol products. The free area to the left of the production lines is normally used for staging those components brought out of the warehouse to be used in the filling operation for that day. Any rework would normally be done in that area as well.

One measure of plant efficiency is the in-plant distance that an average component or chemical must be transported before it leaves in the form of finished merchandise. In Figure 1 the average distance is 340 ft (104 m), or 84% of the length-plus-width of the structure, which is considered good. A figure of 100% length-plus-width is considered average, and many plants calculate out to 125% or more, which means extra man-hours for lift-truck drivers, and more wear and tear on both lift-trucks and stock.

The lay-out in Figure 1 could probably be improved by enlarging the quality assurance and plant offices, combining them with engineering and other plant-related offices and situating the lot above the maintenance workshop and rooms to the right. A stairway could provide access to the plant or the outside. The plant general manager could then overlook the production area to monitor the progress of the operation.

In larger aerosol plants a more or less square construction is probably best. The production block should have the compounding area located about midway between banks of production lines, such as three aerosol lines, compounding, two aerosol lines and a liquid line. A departure must be made if the plant fills foods and/or drug products, since in these cases separate compounding facilities for each such line will be required to prevent cross contamination. If widely divergent products, such as insecticides and hair sprays are to be run in a plant, it will be highly desirable to physically separate the lines with a wall or partition.

The chemical compounding area should be laid out for maximum flexibility, especially where the filler expects to encounter new formulations in the course of time. Bulk tanks of solvent should be located inside or outside, depending upon freezing point. Outside tanks should be surrounded by a low wall of reinforced concrete, an embankment or berm, able to contain the contents of the largest single tank in case of rupture, fracture or overfilling. Inside tanks should likewise be within a low concrete barrier and have the floor fitted with a drain.

As a rule, solvents can be stored in plain or lined steel tanks and piped into the compounding area with ordinary steel 1½ " to 2" (38 to 51 mm i.d.) pipe. Brass or bronze valves can be used except for ammonia solutions or amines. Where food or drug products are involved these metals are no longer acceptable. Commodities like corn oil (for frypan release sprays) and isopropyl myristate/palmitate (for antiperspirants) require stainless steel #304 or #316 tanks and piping.

If the filling plant produces only anhydrous household products, such as insecticides or paints, then the use of plain steel tanks and steel piping may be marginally acceptable, but otherwise, stainless steel is strongly recommended. A minimum of # 304 stainless steel should be used for all tanks, piping, pumps, filters,

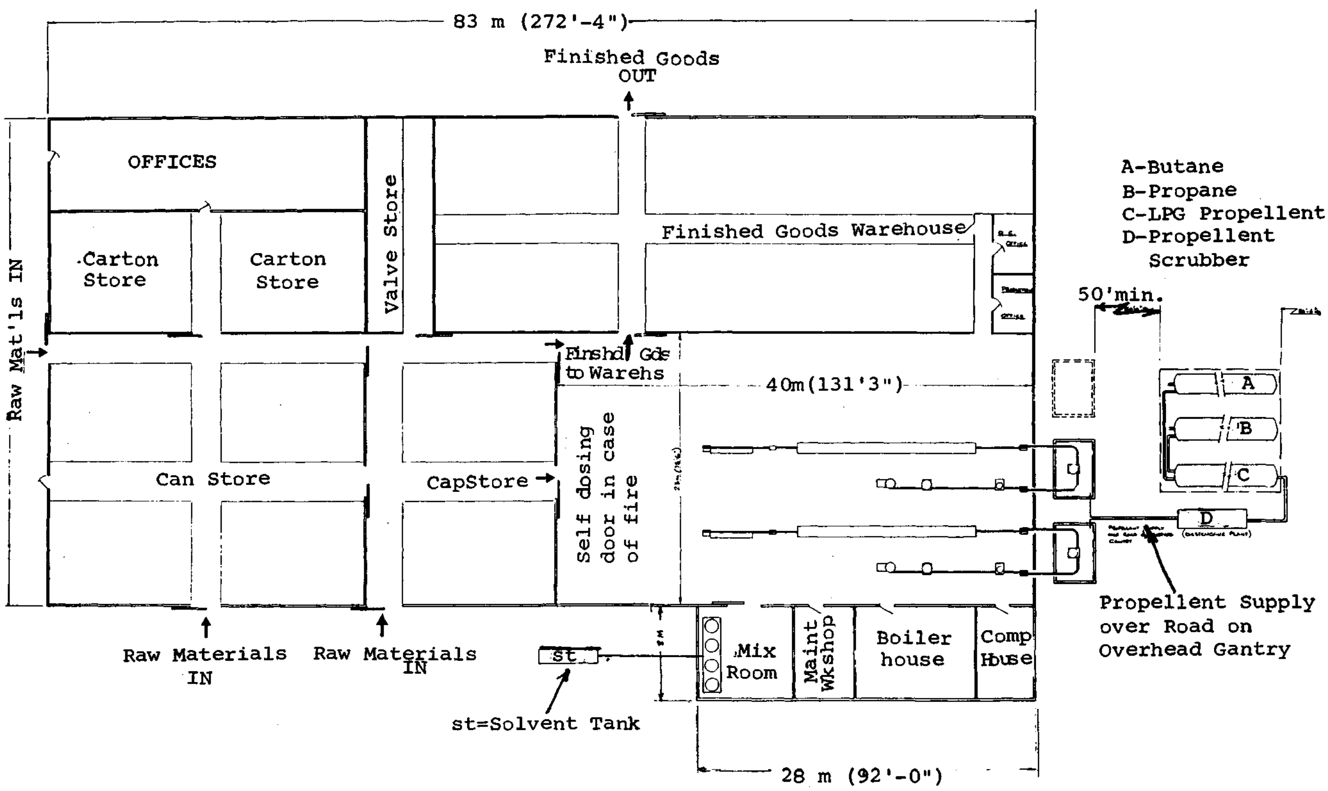


Figure 1. Floor Plan for a Typical European-Style Filling Plant with Two Aerosol Filling Lines and Provision for a Third Line

homogenizers and other equipment. Hoses of reinforced neoprene rubber or Tygon (PVC) with Dracon braiding may be used for temporary connections, provided they are compatible with the product being transferred.

Equipment made of #316 stainless steel has become increasingly popular for food and drug products. It is an alloy much like that of #304 but also contains 2% molybdenum, and thus has greater chemical resistance to moderately acidic sulfates, phosphates, citrates or certain other anions. It commands a premium of 10% to 25% over #304 in price and delivery times are often longer. For food products, tanks should be provided with a No. 4 (Food Grade) finish for better durability, drainage and cleaning. In the case of food items special quick-disconnect #316 piping is also required. It may be noted that #316 is not immune to food products. For instance, saline vinegar solutions such as Worchestershire Sauce will cause perforation of Schedule 10 (thin wall) #316 tubing after two or three months of use.

The medium to large fillers routinely install 2500 to 4500 gallon (9460 to 17,000 liter) compounding tanks — although one filler (now defunct) had a giant 25,000 gallon tank used especially for the preparation of a window cleaner concentrate. When full, this tank had a gross weight of 215,000 lbs (94,000 kg). Ideally, tanks should be set upon balance platforms with the tops protruding a few feet above a mezzanine operations area. The weight is then shown on a 24" (610 mm) dial, also protruding through the mezzanine deck, close to the point where additions to the tank are made. For example, the dial may have a "face range" of 2,000 lbs (907 kg), but an additional 18,000 lbs (8,165 kg) may be cranked in, using counter-poise weights, and this additional weight shows in a small box on the dial face and must be added to the amount showing on the dial itself. The scale capacity of 20,000 lbs (9,070 kg) is the equivalent of 2,400 gallons (9,070 liters) of water or 3,040 gallons (11,500 liters) of anhydrous alcohol at ambient temperatures.

In some operations, water and certain solvents are added to compounding tanks by means of ordinary or temperature-correcting gallon-metering equipment. In others, batches are made up to various heavy scratch marks on the inside of the tank. This last approach is more accurate than one might guess. Where the accuracy of a 20,000 lb (9,070 kg) scale is about ±20 lbs (9.1 kg), the accuracy of gallonmeter and "to the scratch" additions is in the order of ±60 lbs (27.3 kg) for equivalent amounts of product.

In weighing materials into tanks the contents of full bottles, buckets and bags are often recorded using the net weight listed on these containers. Partial container amounts are weighed separately on a small scale and then added to the tank batch. The contents of 55 gallon (200 liter) drums are added most efficiently by raising the drum on a special hoist and pouring them into the batch tank.

Food and drug products (in the U.S.A.) must be compounded using Current Good Manufacturing Practice (GMP) techniques. Everything must be weighed or measured in accordance with a Master Formula Card and reported on an Individual Batch Production Record, which is signed by the batchmaker and countersigned by a second person who was present and verified the weights or measures. This practice is a good one and is being increasingly applied in the preparation of cosmetic products.

Tanks should be equipped with heating and cooling jackets, preferably of the dimple-jacket types, which are now fairly standard. The least expensive dimple-jacket designs are those with the jacket girdling the lower sidewall of the tank. The more desirable types provide jacket coverage of most of the side wall and also the bottom shell or cone. According to requirements, the dimple-jacket connections are made to cold water, hot water (as from a steam-heated tube-and-cylinder heat exchanger) or straight boiler steam. Many water based concentrates require both heating and cooling. The heating step may be done as a preliminary to forming an emulsion. The emulsion must then be cooled down to 110°F (43.3°C) or so to facilitate the addition of perfume, formalin and any other volatile or sensitive ingredients.

Almost all compounding tanks are vertical and are agitated by variable speed, top-entering stirrers. Ideally, motors should be at least 5-HP, since a viscous product may come along that may require the full capacity of such a motor to stir it properly. Side-entering stirrers are certainly used, but they have several disadvantages. When the tank is 30 to 40% full they tend to throw the liquid about and unduly aerate the product. Aeration is not a problem for most products, but for gels and oxygen sensitive compositions it is certainly contraindicated on a tramp ingredient basis. Side entering agitators commonly leave quiet areas near the bottom of the tank on the far side.

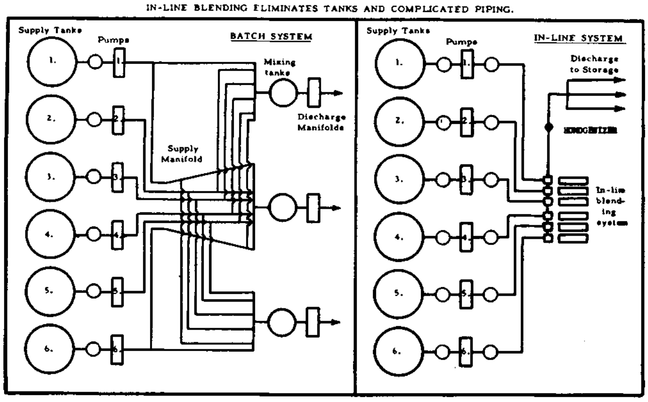
In larger operations, compounding tanks should be available in different sizes, and agitation systems should utilize stirrers ranging from small propellers to wide sweeping or even wall scraping blades. The larger blades are useful in the preparation of more viscous items. Some propeller shafts carry two or three propellers at different heights. They may extend down to the bottom of the tank and may even be socketed into a female fitment there. Rotational speeds of from about 40 to 240 rpm will cover most requirements.

The compounding area should be well lighted and well ventilated. Many aerosol chemicals are noted for their toxicity (a better phrase might be "physiological response factor") or for their flammability, making vapor build-ups rather dangerous. If practical, explosion-proof motors should be used throughout. Someday this may be a requirement under developing OSHA regulations for plant safety. Floor drainage should be provided, either by round drains or via narrow channels covered by gratings. In many instances, an extensive wastewater purification program must be carried out. This may involve the conversion of many acres of ground into settling lagoons, aeration ponds and other water collection areas to facilitate bacterio-chemical clean-up and thermal equilibration programs. Analyses for BOD, COD, pH, trace elements and other factors are made frequently to control the operation of the system.

One factor that truly characterizes an aerosol filling plant is the presence of large quantities of propellent — sometimes 300,000 gallons or more at a time. The largest inventories are normally carried by the leading contract fillers, as they struggle with the task of providing an ever-increasing diversity of pure and mixed propellents to their customers. The aerosol industry in the United States has been slow to change over to in-line propellent blending, preferring to do their own batch blending or else have their suppliers undertake this for them. However, in-line blending, despite the expense and other problems, must come. The advantages can no longer be denied or discounted.

Figure 2. Propellent Blending System
Schematic diagram for batch and in-line propellent blending systems. In-line blending eliminates tanks and complicated piping for mixing chemical products.

IN-LINE BLENDING ELIMINATES TANKS AND COMPLICATED PIPING.



Economic justifications for in-line blending are many. Foxboro, which has installed many propellent blending systems, claims a 25% reduction in tankage is typical. In addition, blending time is reduced over 50%.

There is a wide range in the cost of blending equipment, depending on the quality of the equipment and the number of optional devices included. Mechanical, electronic or pneumatic controls are used to maintain the proper ratios between the individual components of the product. Keene Corporation (Greenville, Tenn.) supplies a basic mechanical system which costs about $9,800 per stream and which has a blending rate of 0.1 to 250 gpm. Digital Blending Systems, Inc. (Providence, RI) offers a moderate size electronic blender for two components for about $25,000 or so. Foxboro Corporation (Foxboro, MA) and the Fischer & Porter Company (Warminster, PA) also supply electronic systems. Blending accuracies normally range between ±0.25 to ±1.0%, although minimum expense installations can go to ±1.5%

Other economic advantages result from reduced propellent inventories, less labor, lower propellent loss, fewer chances for human error, reduced analytical requirements, more accurate blending and simplified piping arrangements. Aerosol plants which do no blending usually have losses of 7.5 to 8.0% propellent per year. Those with bulk tank blending facilities usually lose more than 9.0% per year. There is always the odd blend left over from a packaging run, which may not be used again for several months. In a high quality operation this would either be saved or blown to the atmosphere in order to free up the tank. In a low quality operation the blend is sometimes added to much greater volumes of similar propellents or blends on the basis that the difference will not be apparent.

The magnitude of propellent losses may seem surprising to some, but it is factual, having been reported in plant after plant. Most of the loss occurs at the gassing machines. Depending upon the gassing adapter, the amount of propellent lost to the atmosphere when separation of the head from the can takes place will amount from 0.07 to 2.8 ml. Adapters that make a direct connection to the valve stem cause the least loss, but all the liquefied propellent, under a liquistatic pressure of 800 to 1000 psig (5.52 to 6.90 MPa), must pass through the stem orifice and tailpiece orifice. This may have a severely limiting effect upon production rates. In addition the valve button will have to be tipped onto the stem later on, and possibly oriented to the dip tube curvature.

One of the least efficient gassing adapters is a standard design with a large rubber boot that makes a seal at the bottom of the valve mounting cup and depresses the valve stem liquistatically. In the case of a typical pedestal opening of 0.130" (3.3 mm) the actuating pressure exerted by an 800 psig (5.52 MPa) liquistatic propellent pressure calculates to 10.6 lbs (4.82 kg), which is more than enough to open both vertical and toggle-action valves. A substantially improved adapter design for through-the-valve (T-t-V) gassers is one that effects a seal near the top of the side wall of the valve cup pedestal by the inward compression of a small neoprene "O"-ring. An instant later the "X"-slotted top of the adapter cavity actuates the valve button or valve stem mechanically, to allow gassing to occur. At the end of the injection phase the stem is allowed to move upward to reseal the valve, after which the connection with the cup is broken. By working in this fashion much less propellent loss results when the gassing head lifts off the container. In addition, valve shut-off is more positive and this results in more accurate propellent weights.

These two adapter designs can be compared with respect to loss difference by filling the respective cavities with water and measuring the increase in weight. The difference amounts to about 1.2 ml. While this may not seem too significant, for isobutane A31 it amounts to 0.66 g/can at about 70°F (21.1°C) and if 100,000 cans are run during the shift the loss from this cause alone will be 66 kg or 31.7 gallons of propellent at a current (1982) cost of $34.50.

Other losses of propellent arise from leaking molded cap seals in the gassers, the venting of pipeline contents to the air before changing propellents in the gas house, leaks at pump seals and so forth. In the U.S.A. at least, no heel credit is given for the small portion of propellent returned to the supplier in commercially emptied tank trucks and tankcars. Because of this most fillers attach a compressor to the exit line of the emptied vehicle and suck out the remaining material, down to a 23" Hg° (-77.7 kPa) vacuum or so. In a typical tank truck of 9200 gallon (35,000 liter) capacity, isobutane A-31 gas at 70°F (21.2°C) will weigh 576 lbs (261 kg). If 76.8% of these vapors can be drawn out by the filler, the net gain is 95.4 gallons (361 liters) of liquid, for a current (1982) value of $104. This analysis assumes an absence of residual liquid, but in fact there always is a certain amount of this also, which would be vaporized and the vapors partially withdrawn, adding to the savings.

The Aerosol Production Line

The average aerosol production line is composed of ten to twenty pieces of equipment linked together by conveyors. Perhaps the simplest operation would be to stretch everything out into a straight line, but this might run into several hundred feet and make it difficult for supervisors and maintenance men to get from one end of the line to the other. The more practical approach is to use a layout with a minimum of corners and to provide these corners with small rotary discs to carry the cans around and eliminate dead-plate problems.

Aerosol lines are usually categorized according to speed rating in terms of number of units per minute. Four classifications are considered, as illustrated in Table I.

There are many circumstances under which a high speed aerosol line will be able to operate only at a fraction of its nameplate capacity. This is more commonly encountered by contract fillers than marketers, since fillers must try to handle many kinds of products and packaging requirements on a limited number of lines, some of which do not "fit" as well as others.

In one instance, a 160 cpm rated line was slowed to 78 cpm because nitrous oxide (N_2O) had to be injected by means of an Autoproducts, Inc. (formerly Andora Automation, Inc.) gasser-shaker. In another, it was slowed to 105 cpm because the gel-type concentrate had to be shaken mechanically into the propellent phase and four Red Devil (single case) shaker machines were all that were available. In a final example, the same line

TABLE I

Production Line Ratings According to Speed In cpm

	Production Speeds (cpm)			
Type of Container	Slow	Moderate	High	Very High
Tinplate cans	0 - 50	50 - 125	125 - 200	200 - 500
Aluminum cans	0 - 30	30 - 80	80 - 125	125 - 175
Glass bottles	0 - 25	25 - 75	75 - 110	—
Plastic coated glass	0 - 25	25 - 70	70 - 100	—
Plastic	0 - 25	25 - 75	75 - 110	—

was reduced to a speed of 120 cpm because there was not sufficient length on the packaging line for people to perform a complex assembly operation any faster than this rate.

Viscous concentrates, large filling weights, excessive quality assurance requirements, paper labeling and other factors also reduce line speeds. Paper labeling will lower rated speeds by 6 to 10% as a rule, but "problem" labels, such as those which are a little too tall, will force larger reductions. Some years ago, the through-the-valve (T-t-V) filling of valves occasionally caused slow-downs due to reduced gassing rates. This was particularly true for certain valves with a restricted tailpiece orifice. By now there is such a diversity of pressure-filling valves, with gassing rates of faster than 300 ml per second, that the limitation has just about vanished.

In one unique situation the removal of perchloroethylene from a cleaning product, and replacement with additional odorless petroleum distillate, caused the concentrate volume to be so large that the head space in the can was reduced to below the critical level of 15v% that must be available for efficient "instantaneous impact gassing" of CO_2. During the summer months, the product could not be run in this manner without first cooling the concentrate to enlarge the headspace in the can. The production rate became a function of how rapidly the available refrigeration unit could draw the concentrate from ambient to about 40°F (4.4°C).

Figure 3. Plastic Container Carrier Pucks

Tinplate cans can be run at very high speeds, partly due to the fact that they are ferromagnetic. They can be held down and guided by magnetic can handling equipment when necessary, as for instance in most hot tanks. In addition, they are cylindrical, which greatly aids can handling.

There are a number of aerosol production lines in the U.S.A. which operate at about 280 cps, plus a few which use the Kartridg Pak 18-head Under-the-Cap (U-t-C) gasser to reach speeds of about 360 cpm. Reportedly the fastest aerosol line in the world is a captive line in Holland, with speeds variously reported as 450 to 550 cpm.

Aluminum cans and tubes often require insertion in polyethylene or nylon pucks for both stability and magnetic hold-down. Two puck suppliers are mentioned in the chapter on metal aerosol containers. Figure 3 shows several pucks distributed by Terco, Inc. (Schaumburg, IL).

Some aluminum tubes are so tall (height/diameter = 8) that pucking is mandatory to prevent fall over. But in other cases, lines that are designed especially to handle more reasonably proportioned tubes can do so without the need for pucks. D.H. Industries Ltd. (England) conveyor systems, for example, are engineered to very close tolerances for aluminum tubes, to prevent bouncing and moving about. Delrin starwheels are used for in-feeds, as well as converging and diverging operations with a typical clearance of only 0.008" (0.2 mm), and deadplates are very small and adjusted for the smoothest possible transfer. The feed worms are kept as close as possible against the backup plates. Variable speed drives and photoelectric controls are also useful in such lines.

In the case of plain glass aerosols, it is important to maintain the pristine exterior surface of the glass. For this reason pucks are strongly preferred, although they are not always used, especially in the case of round bottles on manually-operated or low speed lines. Plastic coated glass can be handled about like aluminum; without pucks if a sufficiently sophisticated transfer system is used.

Aerosol production lines can be categorized according to design, as summarized in the following listing. Speeds in terms of units per shift are also included.

a. Laboratory units. 800 to 2,500 ups.
b. Manually operated lines. 7,500 ups.
c. Single indexing, in-line assemblies. 14,000 ups, or 35 upm
d. Double-indexing, in-line assemblies. 28,000 ups, or 70 upm.
e. Rotary operations. 14,000 ups and higher. (Single and double indexing)

The so-called laboratory units can be used with surprising effectiveness for simple operations. It is thought-provoking to see certain plant operations in Mexico, South America and Africa, where one or more moderately sized rooms are set aside for the filling of glass or aluminum tubes by one or two people. To make a typical cologne, the concentrate is added volumetrically to the empty unit with a buret, filled every few minutes from a copper tube extending out through the wall of a refrigerator. Very cold CFC propellent is then added to a preset gross weight. The container is then crimped, allowed to warm up and bulk-packed for shipment to the marketer. One person can do as many as 1250 units per shift on crude lines of this type, making direct labor costs roughly comparable with those of much larger aerosol lines.

The manually operated lines consist typically of a lever-operated filler, a crimper and a gasser, mounted separately on a work table, sometimes followed by a three-basket hot tank. The lines are unusually air-operated. One is illustrated in Figure 4.

If the program is simple, two people can often produce between 6,000 to 8,000 units per shift. On the other hand, if paper labeling or other auxiliary operations are required, either more people will be needed or the operation will have to proceed more slowly.

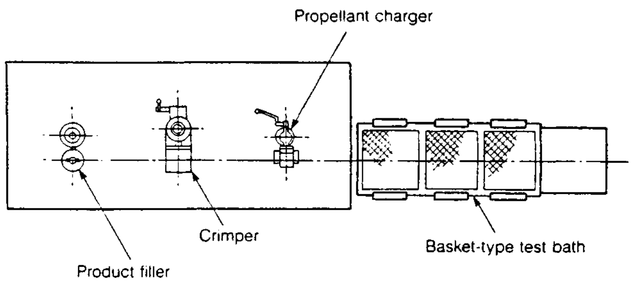
The individual operating units can be of many makes and descriptions. One good way to combine the crimping and gassing operations and gain a large measure of packaging latitude is to use a single-head Kartridg Pak U-t-C gasser. It is not inexpensive. With the vacuum pump, Grayco high-pressure propellent supply pump, and sometimes other accessories, it can cost about $16,000.

Single-indexed lines are available in both in-line and rotary styles. Sometimes the two forms are mixed, so that an in-line filler will be used with a rotary gasser. Straight line indexing lines require more space than rotary equipment. But maintenance is generally easier, since there are fewer filling, crimping and gassing heads, especially when comparing larger lines.

The best drives use the so-called Geneva design, which provides accurate container positioning with a smooth, fast, non-jerky transfer motion. It is much better than the air-cylinder crank operated drives. Electric operated drives are always preferred over air-operated types, regardless of the actuating mechanism. Most indexing machines have an electrical inter-lock control circuit, that prevents recycling until the slowest component has completed its operation. This system results in automatic adjustment to the maximum production rate of the machine, without regard for container volume, concentrate viscosity or several other factors. It also insures against slack-filled units by making adequate time available for each operation. To eliminate production problems the fillers and gassers should be provided with container-sensing valves that provide a no-container, no-fill operation.

A single-indexing, single-line, in-line system will produce up to about 35 units per minute. A double-indexing, single-line, in-line set-up will produce twice that rate, by conducting operations on two units at once for each operating step. The fastest in-line assembly is the double-indexing, double-line, with operating units on both sides of a common frame or machine table. These lines have nameplate ratings of about 120 units per minute, but can often be coaxed to go about 20% faster than that by means of various drive adjustments. However, they may wear out more rapidly on that

Figure 4. Manual Production Filling Line
Product is transferred manually to each step of the operation.



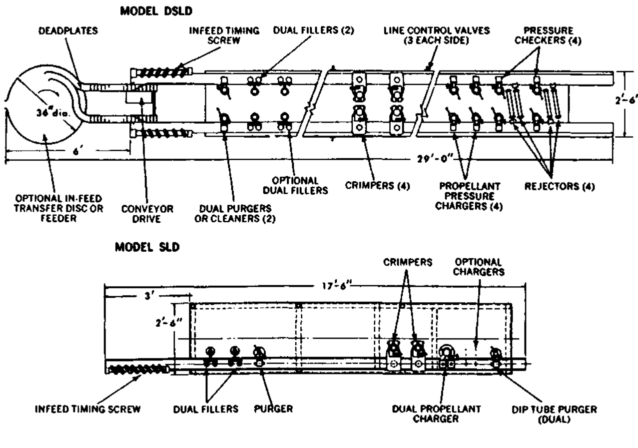


Figure 5. Nalbach Design of Single and Double Row, Double-Indexing Lines

Figure 6. Rotary Line Including Filler/Crimper/Gasser
With single-indexing, this line achieves speeds of 35 to 40cpm; with double-indexing, speeds move up to about 70 cpm. Design by John R. Nalbach Engineering Co.

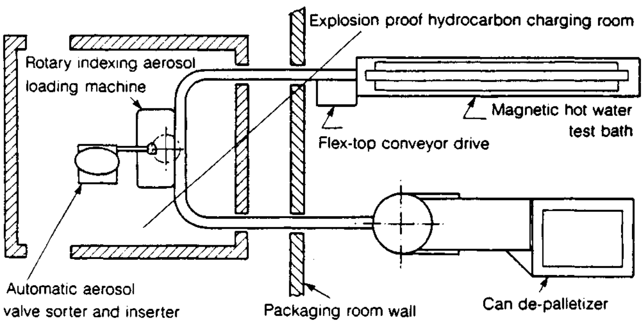
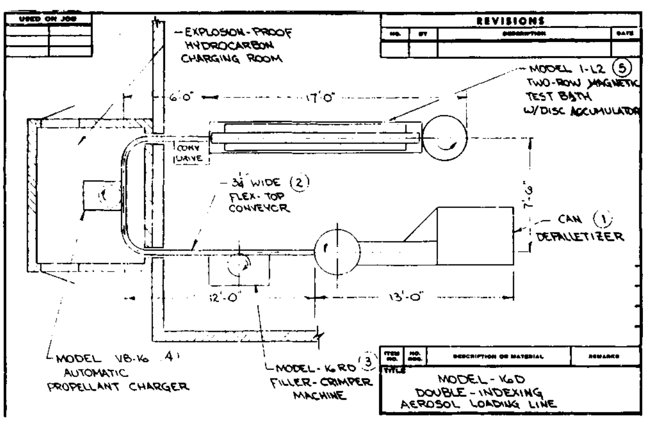


Figure 7. Double-Indexing Loading Line



Courtesy: John L. Nalbach Engineering Company, Inc.

basis. Examples of single-row and double-row double-indexing lines are illustrated in Figure 5.

Perhaps the simplest rotary line is one where the filling, crimping and gassing operations are all consolidated into one machine. In U.S.A. operations the machine is normally placed in an explosion-proof hydrocarbon charging room, or gas house, preferably outside the main production building. These lines normally operate at from 35 to 70 units per minute and are readily available to containers of different sizes and constructions, as well as to the requirements of a wide variety of different products. A schematic of such a line is shown in Figure 6. The higher speeds require double-indexing at the rotary filler/crimper/gasser.

As an alternate, the key steps can be handled by a combined filler/crimper rotary, followed by a rotary propellent charger. Again, both single and double-indexing variables can be obtained from several suppliers. A double-indexing line of this kind is illustrated in Figure 7.

This line has a rating of 40 to 50 units per minute. A similar, single-indexing line is rated at 25 to 30 units per minute. It has only a single-track hot tank, no disc accumulator and a simple 36" (914 mm) disc-type container feeder.

The largest aerosol lines are almost always rotary in design, since in-line equipment seems to have a practical limit of about 140 to 160 units per minute at best. Rotaries may go to three times that rate and are much more space efficient.

In the U.S.A. large rotary lines seem to center around high-speed rotary gassers made by The Kartridg Pak Co. (Davenport, IA). There are two types: Under-the-Cap (U-t-C) and Through-the-Valve (T-t-V), in both 9-head and larger models. They are discussed later on.

A number of machinery suppliers offer "core assemblies": an integrated single piece of equipment for doing several operations at the heart of the aerosol production operation. Figure 6 illustrates this machine in layout form, if the in-feed transfer disc is omitted. Five operations are performed by this composite unit. A similar in-line unit by the J.G. Machine Works, Inc. is shown in Figure 9.

In the case of rotary equipment an outstanding example of the "core assembly" principle is the Star Pak M-20 Filling Machine by Aerofill Ltd. (England). The base unit accommodates six metering heads and seven other heads and will produce at rates of 20 to 45 cpm, handling either cans or bottles. A twin unit has double this range. Typical of the operating heads that can be integrated with this machine are concentrate fillers, a can cleaner, ball dispenser, valve inserter, valve sensor, crimper or vacuum crimper, propellent fillers, valve rim stamp coder, checkweigher and liquid purger. With optional extras the machine fills slurries, powders or compressed gases. Odd shaped bottles can also be accomodated. The machine is illustrated in Figure 10.

In some instances the "core assembly" is extended to include machines normally before it and behind it on the production line; e.g. an "extended core assembly". All three devices are bolted directly together. In the Terco, Inc. unit shown in Figure 9 only the hot tank is conveyorized.

Individual "core assemblies" will only handle up to 45 or 60 cpm, which limits them to moderate speed operations. For faster lines the concept must be abandoned in favor of individual machines. Here again, a number of suppliers, such as Aerofill, Ltd. (England), The Kartridg Pak Co. and Coster Aerosol Filling Equipment Division (Italy) can produce high-speed machines.

Higher speed lines are often assembled by selecting the best filler, gasser, case packer and other components, setting them out in a certain arrangement,

Figure 8. Rotary Filler by Terco, Inc.
Rotary filling machine with water bath will process up to 40 cpm. It is air operated. All stations interlocked so slowest operation controls overall output speed. Machine consists of 4′×6′ table, coder, 2 product fillers, vacuum crimper and 2 propellent chargers.

Figure 9. Core-Assembly Machine
High-speed line by J.G. Machine Works, Inc. The core-assembly machine is the heart of an aerosol filling line.

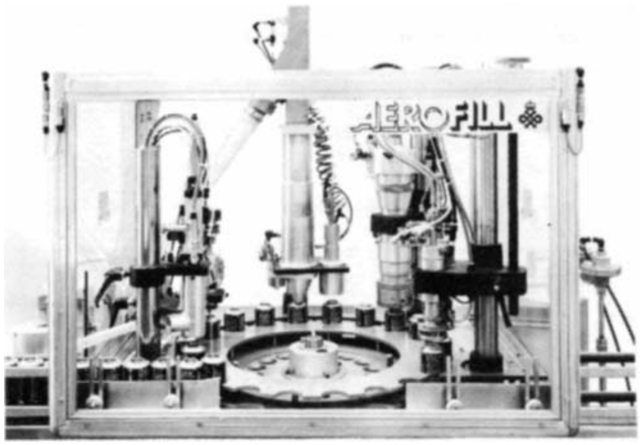
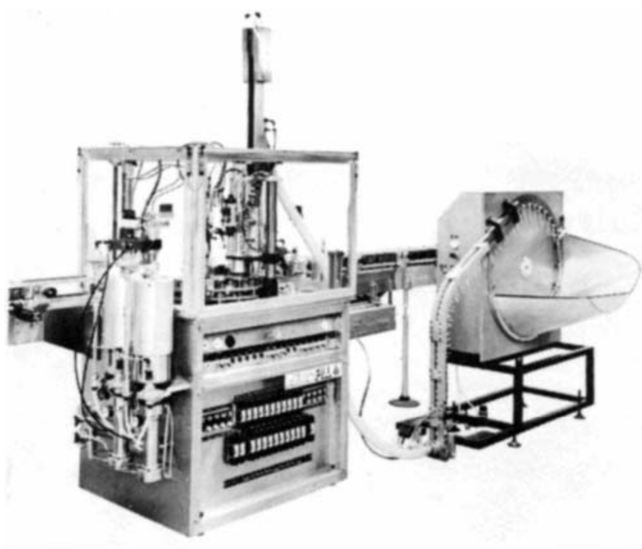
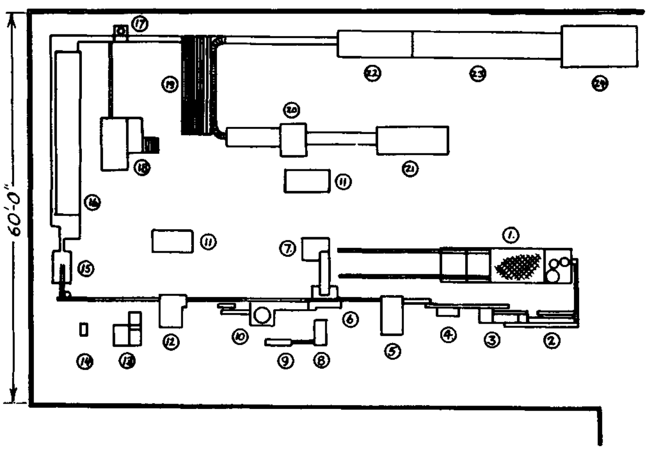


Figure 10. Star Pak M20 by Aerofill, Ltd.
Lower photo shows the Star Pak filling machine with automatic valve inserter/sorter. Photo above shows the working heads in more detail. The machine can accomodate six metering heads and seven other heads. It is the core assembly unit of any associated aerosol line.



and then linking them together with conveyers. Some lines are far more mechanized than others, and the extent to which mechanization is introduced depends largely upon the attitude of the company management and the amound of funds available. A minimally mechanized 200 cpm production line can be installed for approximately $500,000 whereas costs for the highly mechanized equivalent can total up to $850,000 or so. As more machines are added, the average production rate drops somewhat, more warehouse space is consumed and maintenance costs are increased, but the tremendous savings in labor more than justify these shortcomings. Individual machines are often purchased on the basis of pay-off time evaluations. If a rotary valve inserter costs $65,000 and saves the expense of six extra people on the production line, using a two-shift analysis, it is possible to calculate how quickly the $65,000 can be saved in labor in order to justify purchase. If the six workers were each paid $150 per week,

Figure 11. Lehn & Fink Hi-Speed Aerosol Line



List of Production Equipment

1. Depalletizer.
2. Unscrambler.
3. Can Cleaner.
4. Can Bottom Coder.
5. Concentrate Filler
6. Sorter Station of Valve Inserter.
7. Hopper of Valve Inserter.
8. Varidyne Motor.
9. Electrical Control Panel.
10. Valve Inserter.
11. Repair Benches.
12. Undercap Filler.
13. Propellent Pump.
14. Heat Exchanger.
15. Checkweigher.
16. Water Bath.
17. Capper.
18. Cap Sorter Station.
19. Accumulator Table.
20. Case Packer.
21. Box Former.
22. Case Sealer.
23. Compression Unit and Case Coder Station.
24. Palletizer.

to which a 50% benefits and overhead figure could be added, the total cost per week for these people would be $1,350. The pay-back or Return On Investment (ROI) period would then be about 48 weeks. This is normally sufficient justification for purchase, even in times of fairly tight money. But if the same plant were only running on a one shift basis, with no outlook toward two shifts, the ROI period would become about 96 weeks, which might be considered too long. Other important factors involve the financial condition of the company and its access to the required capital.

The design features of an aerosol line can be greatly simplified if only one or two produts are to be run on it. A classic example of a captive line of this kind is the high speed facility installed by 1966 by the Lehn & Fink Products Corp. at their plant in Lincoln, IL. It runs almost exclusively, even today, on a single hydroalcoholic product that is marketed in three can sizes. The line is rated at about 160 to 210 cpm, depending upon package size. Changeovers are in the area of thirty per year and require about 70 operator-hours each. The line is located in an area of about 60 × 90 ft (18 × 27 m). The original design, illustrated in *Package Engineering* many years ago, was so well conceived that relatively few changes have been necessary. One involved a necessary propellent change. Another was to add some sophisticated new equipment, such as a Currie Machinery Co. pallet loader. The basic "U"-shaped layout provides the best communications and control capability of any design, and this general shape was used by Lehn & Fink engineers, as shown in Figure 11.

Because of its limited product range, the Lehn & Fink line does not include such items as a paper labeler, auxiliary concentrate filler, hydrocarbon gassing capability (to date) and can shakers. However, the contract filler nearly always has to build these extra facilities into his aerosol lines to gain added flexibility. In many instances, a new line may be installed with spaces left for future additions of packaging machinery. In a typical example, room was left near the end of one aerosol line for a future box former, case packer and palletizer.

It is important to consider space requirements for accumulating tables, mechanized, manual or automatic weigh stations, record desks, repair benches, heat exchangers, vacuum pumps, control panels and one or two satellite production control stations when laying out a new line. Ample room should be provided for special packaging operations, such as unit boxing, addition of folders, hand cleaning, hand application of special actuators, domes or stickers, and unique display case packaging programs. These "extra allowances" may add significantly to the total space requirement, but they nearly always pay off handsomely in the long run.

Aerosol lines are frequently tailored or modified to perform specific operations. A line used only for aluminum or glass containers will have no provision for a depalletizer, since a puck-type carrier is normally used. Lines used for the production of whipped creams will not have a gasser in the usual sense, but either a rotary gasser-shaker for moderate or slow speed operations, or a U-t-C gasser with either an "instantaneous impact gassing" modification or "saturation" accessory for higher-speed productions. A can cleaner would have no real value on a tube and bottle line unless it is designed specifically for these containers. A U.S. Bottler's cleaner is available which grips these particular units, inverts, blows and then vacuum cleans each one individually. This is now done in place of the integrity check for glass, where the bottles were pressurized to 120 to 150 psig (827 to 1034 kPa) with compressed air or nitrogen, and it was assumed that any lint, corrugate dust or other light materials would be blown out when the pressure was suddenly released.

Special requirements are often handled by the addition of mobile equipment to the production line. The line is modified to readily accept insertion of such items as a paper labeler, auxiliary concentrate filler, ball dropper and accumulator. If the equipment is not needed elsewhere in the plant, the mobile units may be left in the line as non-functional fillers. An individual line may be required to handle concentrate fills of from about 6 to 600 g, as well as propellent fills over a similar range. This is usually accomplished by the use of special orifices and different sized charging cylinders, so that greater absolute fill weight accuracies can be obtained for the smaller fill requirements. Very small aerosols are sometimes filled to tolerances of as little as ± 0.05 g for both concentrate and propellent portions. In a marginal situation a 2 Av. oz, (56.7 g) shave cream had a two-sigma propellent fill weight specification of 1.93 ± 0.6 g. The contract filler could not meet this requirement with high speed T-t-V equipment. The best that could be managed was a two-sigma tolerance of ± 0.85 g. Figure 12 shows that too little propellent would result in an overly dense or soupy foam, while too much would cause the foam to be dry and hard to apply to the face or body. Rather than have the product filled with extreme accuracy, but on a slower line and therefore at an increased cost, the marketer decided to move the target fill upwards by 0.20 g. The histogram for a specification of 2.13 ± 0.85 g is not shown but is still almost entirely within the "relative acceptability" curve.

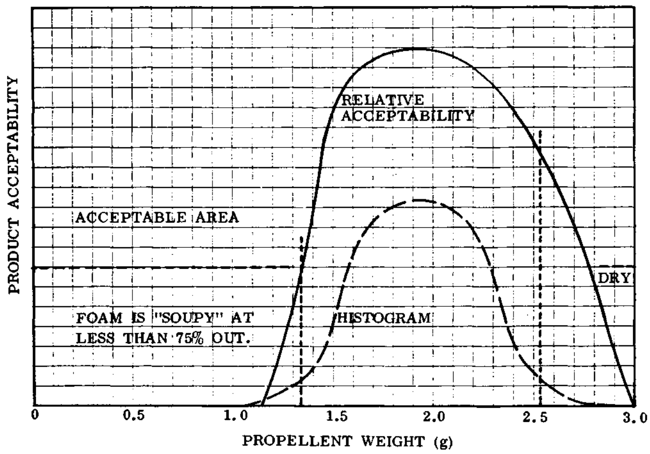


Figure 12. Product Acceptability vs. Weight of Propellent A-46 for a 2 Av. oz. Shave Cream

This situation would be totally unacceptable for aerosols with ± 0.05 g tolerances. In such cases fillers and gassers with unusual accuracy are needed. Pamasol and a few other firms supply this equipment, often for Class 100 clean room pharmaceutical productions and less frequently for meter-spray perfumes and a few other products.

The larger equipment suppliers will often provide prospective customers with a lay-out of a proposed aerosol line as part of their bidding and business solicitation programs. Figure 13 (Page 386) illustrates a production line designed by Aerofill Ltd. (England) for a marketer who wished to make only one aerosol product at rates of 120 cpm minimum. Rotary equipment is used for filling, crimping and gassing.

In contrast, a highly versatile high speed line consists of a relatively large number of individual items of production equipment. Auxiliary equipment, such as pumps, filters, electrical control boards and hot tank heat exchangers are often located nearby. Figure 14 shows such a line. A summary of the production equipment is given in the accompanying list (Page 387).

A fully versatile aerosol can production line should include the following machines or operations:

a. Semi-automatic depalletizer.

b. Can cleaner.

c. Can coder.
d. Empty can counter.
e. Ball dropper — Optional.
f. Powder filler. — Optional.
g. First concentrate filler - volume to 250 ml.
h. Second concentrate filler - volume to 750 ml.
i. Line speed indicator. — Optional.
j. Automatic concentrate checkweigher. — Optional.
k. Valve inserter.
l. Valve cup depresser - or cup seater.
m. Accumulating table.
n. Under-the-cap (U-t-C) 9 or 18 head gasser.
o. Through-the-valve (T-t-V) 12 head gasser.
p. Rotary 12 or 18 head gasser-shaker. — Optional.
q. Automatic product checkweigher.
r. Valve button tipper.
s. Can washer. — Optional.
t. Hot tank and blow drier - 4 to 6 lane.
u. Accumulating table.
v. Wrap-around paper labeler, on conveyor shunt.
w. Capper.
x. Overhead compression unit - to seat caps.
y. Assembly, cleaning, inspection and packing table.
z. Cartoner - 2, 3, 4, 6 and 8 pack. — Optional
aa. Case packer.
bb. Case sealer and compression unit.
cc. Case coder.
dd. Case counter.
ee. Case shaker. — Optional.
ff. Case palletizer frame - manual packing.

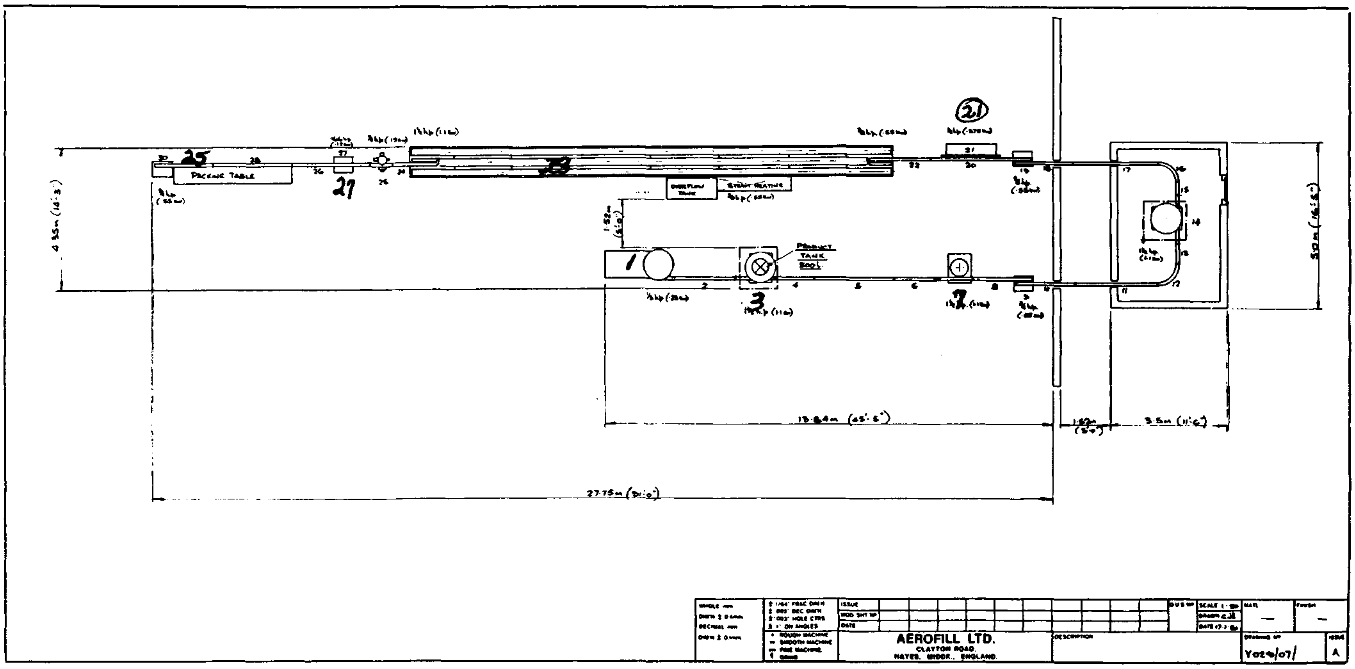
Notes:

i. Additional accumulators may be added if desired, such as just before the can washer.
ii. Box formers, sorter stations and other units not in the main sequence have been omitted.
iii. Conveyors and smaller quality assurance devices have been omitted, such as a no-button reject station prior to the capper.
iv. Items designated as "optional" are often omitted, depending on product mix or preference.

Figure 13. Lay-out of an Aerosol Production Line

Description:
1 - Rotary Unscrambler-Extended loading
3 - 6/12 Head Rotary Product Filler with Guard
7 - 6/12 Head Rotary Vacuum Crimper
14 - 6/12 Head Rotary Propellent Filler with Guard
21 - Checkweigher
23 - Six Lane Test Bath
25 - Rim Coder
27 - Tamperproof Seal Applicator

Aerosol line by Aerofill, Ltd. of England is designed to run one product at 100 cpm.



A smaller size rotary line, with far fewer stations, is shown in Figure 15. It has a working capacity of about 120 cpm, with six filling heads mounted on a nine-station U-t-C.

The line is designed for straightforward, easy-to-handle aerosol products. It has almost no accumulating (surge table) space. There is no provision for manual operations except for on-loading empty cans, packing, sealing and pallet-building. About seven people are needed to operate this line, as a minimum.

Aluminum cans with one-inch (25.4 mm) openings can be produced on versatile can lines of the types shown, such as the one in Figure 14, using puck containers, but for 13 mm, 20 mm and similar small size tubes and bottles a special line is required. The Schering-Plough Corp. (Pharmaceutical Division) tube line in St. Louis, MO is an outstanding example of what is required. The product run on this line is

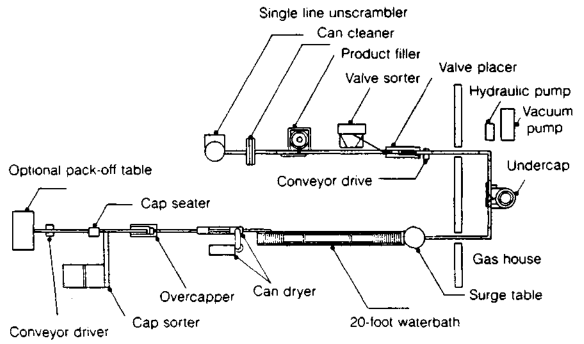
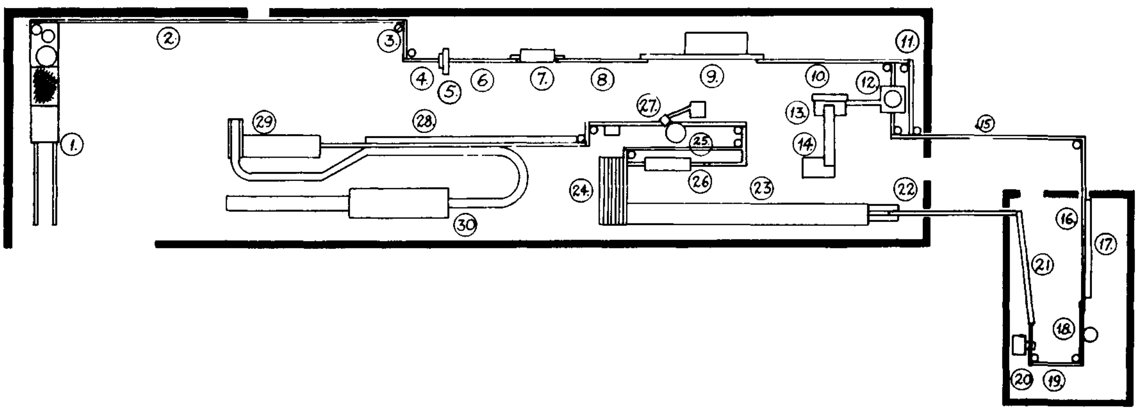


Figure 15. Simple Rotary Line, Rated 120 CPM
The Kartridg Pak U-t-C gasser in this line is outfitted with six filling heads in the 1, 2, 4, 5, 7 and 8 positions on a standard nine-head frame.

Figure 14. High Flexibility Production Line



List of Production Equipment

1. Busse Depalletizer
2. Overhead Conveyor.
3. Unibelt Conveyor
4. Unibelt Conveyor
5. Fleetwood Can Cleaner and Blower Unit
6. Conveyor and Worktable
7. Kiwi Coder
8. Conveyor and Worktable
9. Cozzoli 16-Head Concentrate Filler
10. Conveyor and Six-Foot Manual Weigh-Table
11. By-Pass Conveyor
12. PMC Valve Inserter—Rotary Applicator Head
13. PMC Valve Inserter—Disc Sorter
14. PMC Valve Inserter—Valve Supply Bin
15. Outside Conveyor—Covered
16. Outside Conveyor—Covered. Inside Worktable
17. Double-Width Conveyor
18. KP "Undercap" Gasser and Propellent Reclaim
19. Conveyor
20. "Metramatic" Checkweigher
21. Conveyor and Worktable; Two Track Split at End
22. Double-width Outside Conveyor—Covered
23. Four Track Splitter, Terco Hot Tank and Blowers
24. Can Accumulator—Six Tracks, Eight Feet Long
25. By-Pass Conveyor and Blowers. Labeler Insertion.
26. Conveyor, Blowers, Electric-Eye Button Detector and Discard Table
27. "Pneumacap" Capper
28. Conveyor With Compression Wheel and Worktable
29. Box Former
30. SKC Automatic Gluer, Compression Unit and Case Coder

NOTE: Work Tables Are Not Shown on Drawing

"Vanceril", a ½ Av.oz. cannister of inhalant, where the drug is suspended in a mixture of P-11 and P-12 and dispensed via a metering valve. The line components are listed as follows:

a. Unscrambler.	Rondo
b. Accumulating turntable.	
c. Tube cleaner.	U.S. Bottlers
d. Filler.	Pamasol
i. Product filler turret.	
ii. Valve seating transfer disc.	
iii. Crimping turret.	
iv. Gassing turret.	
e. Checkweighers - two required.	Anritsu
f. Printer.	A.B. Dick
g. Heat tunnel leak detector.	Standco
h. Bulk packaging station.	

The line normally runs at 110 to 120 tubes per minute and is crewed by five people. The bulk containers of finished aerosols are transported to another area of the plant for final pressure checking, assembly to the inhaler nozzle and final packaging. The Pamasol filler operates within an enclosed area that is the practical equivalent of a Class 100 clean room. In addition, it has its own enclosure and a laminar flow of air under positive pressure. D.H. Industries Ltd. (England) was the primary contractor for the equipment.

Individual Production Equipment Items

General descriptions and sources of the more important pieces of production equipment are of interest to persons wishing to purchase or improve aerosol installations. Although a number of suppliers are cited, listing such names should not be construed as any particular recommendation by the author, expressed or implied.

Can Depalletizers and Other In-Feed Equipment

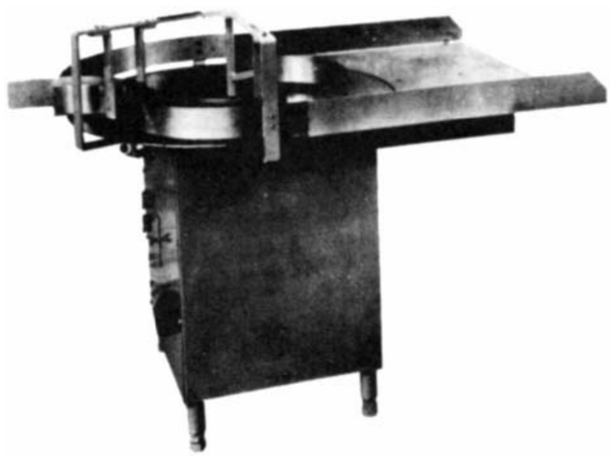
Most tinplate cans are now shipped to fillers in palletized form. In large-scale operations these standard units are mounted on the in-feed conveyor of an automatic depalletizer and then hand stripped of their bandings, polyethylene wraps and top sheet of chipboard. The hoist unit then moves the palletload upward until the top layer of empty cans is level with an accumulating table about 48" (1.22 m) wide. By pushing a button on the control board an operator causes a rake to move over the cans and draw them forward, onto the metal belt conveyor that feeds a rotary disc which then supplies cans to a single track conveyor leading to the production line. After the layer of cans has been transferred, the second layer of chipboard is removed from the palletload, it is raised another tier, and the rake again sweeps them onto the broad metal mesh belt. In some installations mirror imaged units are placed about three feet (0.92 m) apart so that one operator can handle both machines at once. In one case such a duplex installation handled over 400,000 cans in a 21 hour period.

A popular automatic depalletizer is one made by Busse Bros., Inc. and known as the Busse Hydraulic Empty Can Depalletizer, Model WD-300. Another is made by Coster Aerosols Ltd. (England), known as their FIMS 1200, rated at 400 cpm.

Container in-feeding on a less costly scale is done by rotary discs, multiple conveyors, conveyorized rotary discs, unscramblers and semi-automatic depalletizers. The rotary discs consist of ¼" (6.4 mm) thick sawed circles of steel or stainless steel from 36" to 48" (0.92 to 1.22 m) in diameter, let into the countertop of a stationary tray, as shown in Figure 16. Cans are unloaded onto the tray by hand and pushed onto the disc, which then feeds either one or two single lane conveyors. The smaller disc will handle at least 40 cpm and the larger one will do about 60 cpm. These can feeders are the least expensive ones available.

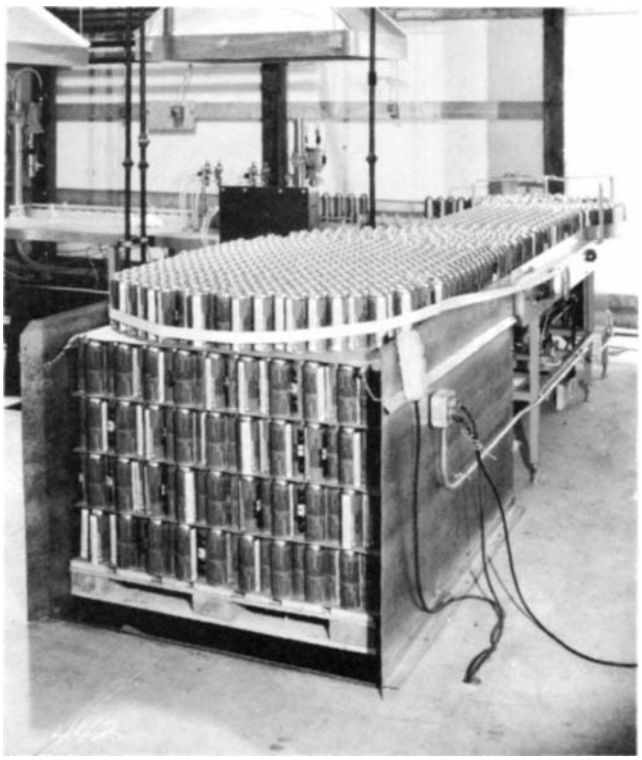
The next more sophisticated can feeder is a device like the above, but where the short stationary tray is replaced by a wire mesh belt that can hold 500 to 1000

Figure 16. Economical Tray-and-Disc Can In-Feeder Unit



cans and feed them onto the disc as they are needed. A step beyond this involves the integration of the belt-fed disc unit with a three-sided pallet guide fitted with a hydraulic scissor-lift, thus creating the semi-automatic depalletizer unit. Cans are unloaded against either the side or the end of the wire mesh conveyor belt, from which they enter the disc and then the conveyor system. Since full palletloads are about 54" (1.37 m), which is obviously higher than standard conveyor heights for production lines, two designs for semi-automatic conveyors have been developed. In what is often called the Terco design the wire mesh belt and disc are elevated to about 48" (1.22 m) to accomodate the top layer of cans on a palletload. The disc then unloads onto a magnetic lowering conveyor section to reduce the height to the 34" to 38" (864 to 965 mm) range used for the production line. In the so-called Nalbach design the pallet guide is positioned at the edge of an 18" (457 mm) deep hole. The palletload is moved across the hydraulic jack, which is then lowered into the pocket or hole until the top row of cans is even with the wire mesh conveyor belt and ready to be unloaded. Air powered clutches and sensing valves are used to integrate the operations. An illustration of the Nalbach semi-automatic depalletizer is provided in Figure 17.

Figure 17. Semi-Automatic Depalletizer
Unit by John R. Nalbach, Inc.



Can Cleaners

These devices were unknown on aerosol lines of the 1950s, became optional in the 1960s and were standard in the 1970s, at least for lines producing foods, drugs and cosmetics. They generally function by inverting the can over a blast of dry, filtered air, so that not only are dust, lint, cardboard fibers and other lightweight trash removed from empty cans, but heavier items as well. Things like solder pellets, a magnesium rod from a can-packing rake and even a pencil stub have fallen out of inverted cans during cleaning.

Tinplate cans or pucked aluminum cans can be inverted using magnetic wheels. Non-magnetic containers can be inverted by squeezing them between two long "inner tube" sections as a carrier mechanism. Smaller units are often cleaned without inversion. A magnetic wheel unit is sold by Fleetwood Systems, Inc. (Countryside, IL) and several other suppliers.

Can cleaners have been identified as a major potential source of tramp moisture in aerosol cans. Air compressor tanks always have some condensed water in the bottom. Unless it is effectively filtered out using baffles and desiccants, water can be blown into cans from the air nozzles, causing contamination, can rusting and even perforations. In one instance a stuck indicator dial on a desiccating unit eventually permitted water to travel through the air line undetected. It entered aerosol cans in amounts from about 0.01 to 0.80 ml and ultimately caused the rejection of almost 200,000 units due to internal rusting and product discoloration.

Can Coders

A very large number of can coders, sometimes called code daters or bottom coders, are supplied for aerosol filling operations. Perhaps the most widely used are machines made by the Kiwi Coder Corp. (Chicago, IL). With a few exceptions they all do a good job, requiring very little maintenance. Typical pieces of equipment are:

a. Model 631-A Production Flow Bottom Coder — Control Print Corp. (Cedar Grove, NJ) Speed to 550 cpm.

b. Model AO Date Coder — John R. Nalbach Engineering Co., Inc. (Chicago, IL) Speed to 60 cpm.

c. Kiwi Model 15-36-B Automatic Hi-Speed Coder — Kiwi Coders Corp. (Wheeling, IL) Speed to 120 cpm.

d. Kiwi Model 15-72-B Automatic Hi-Speed Coder — Kiwi Coders Corp. (Wheeling, IL) Speed to 400 cpm.
e. Ertel Bottom Coder — Ertel Bottom Coder — Ertel Engineering Co. (Kingston, NY) Speed to 120 cpm.
f. Markocoder Model BD-1 Bottom Coder — Adolph Gottscho, Inc. (Union, NJ) Speed to 250 cpm.
g. Markocoder Model SWB Bottom Coder — Adolph Gottscho, Inc. (Union, NJ) Speed to 550 cpm.
h. Code-A-Top — M.E. Cunningham Company (Ingomar, PA) Speed over 100 cpm.
i. Code-A-Can; Mark II — M.E. Cunningham Company (Ingomar, PA) Speed to 136 cpm.
j. Code-A-Can; Model 66 — M.E. Cunningham Company (Ingomar, PA) Speed to 500 cpm. on single line of cans.
k. Top Bead Code-A-Can — M.E. Cunningham Company (Ingomar, PA) Speed over 100 cpm.

Machines "a" through "g" function by rotating sets of pre-inked rubber type against the bottom of aerosol cans. Either Baselock or Kiwi channel type is used in various heights. The machine in "h" cuts the code into the side wall of ferrule-type valves and thus provides a way for indelibly coding glass bottles. The Cunningham machines, "i" and "j" operate by forcing a marking head hard against the vertical wall of the bottom double seam, so that a series of letters and numerals are impressed horizontally into the can metal. The machine in "k" is similar, but inscribes the top head.

In the U.S.A. there has been a strong preference for inked-on codes. At first there were some groundless concerns about the continuing hermetic integrity of coded bottom seams, but now the greatest fear is that a customer will reject aerosols with an indelible and incorrect punched-in code. With open code dating and rigorous government requirements the need for correct coding is now more critical than ever before. At least with inked-in codes any incorrectly marked containers can be corrected in the rework area, with solvent and hand restamping.

Recent developments in this area include the so-called microscopic coding, using extremely small numbers and letters, and also laser beam coding. Compact laser coding systems are available from Laser Applications Ltd. and Laserprint Hull Ltd. in England, as well as "Laser Mark" equipment from Lumonics, Inc. (Ottowa, Canada)

Codes with smudged or missing numbers or letters usually constitute a major defect and sometimes a critical defect, depending upon product category and marketer attitude. For this reason the operation of a coder should be checked frequently. If a problem is encountered all cans produced with a defective code will probably have to be segregated for rework. All coders have practical limits in terms of the number of lines (usually two) and characters per line. The limits must be considered during product development or in the quoting process.

Can Counters

Starwheel actuated devices are available at very low prices for counting cans passing any point on the aerosol line. Differences between two or more of these counters provide information relating to can losses during production.

Powder Filler

This type of filler is needed for the addition of talc, silicas, bentonite clays, dry starch derivatives and other finely divided solid materials to aerosol cans. In some instances limited amounts of these materials may be added alternately as a slurry, provided sufficient carrier is used that the slurry is not too stiff. Up to 16% aluminum chlorhydrate is added to antiperspirant cans in the form of a slurry, but in most cases the amount of powder that can be added is less than 6%. Direct addition of powders provides an alternate approach, and is frequently the only way to add relatively large amounts of powder, particularly if the amount of solvent carrier is very limited. Thus the addition of individual or blended powders to aerosol cans provides better formulation flexibility and may solve other handling and mixing problems as well.

The Diehl-Mateer line of powder fillers by the Mateer-Burt Co. are quite popular, especially for lower speed lines. They are available in both in-line and rotary models. Up to four in-line units have been mounted on aerosol lines, depending upon indexing and trackage. The Model 10A powder filler design is of interest in that it incorporates an electronic volume control feature. A solid state digital counter scans the auger shaft revolutions to provide improved accuracy. The system is available as a kit to improve fillers made before about 1968.

A second line of powder fillers is the CMR series: a series of higher speed rotary machines capable of virtually dust-free operation at up to 450 cpm. Most of these fillers incorporate the Perry Accofil system for greater filling accuracy. The machines are produced by Perry Industries, Inc.

In a few instances powders must be filled into non-metallic containers, and here static charges can be a serious impediment to obtaining a clean, accurate fill. Herbert Products, Inc., the 3M Company and other firms have deionizing equipment that can effectively eliminate this difficulty.

Liquid Concentrate Fillers

The selection of the concentrate filler may involve one of the most difficult and cost-intensive decisions a packager must make during equipment selection. A series of compromises must be made in relation to price, job requirements, maintenance and other factors. Some of the general types are:

a. Vacuum or vacuum-gravity — constant level — liquid.
b. Piston — volumetric — liquid, semi-viscous.
c. Pressure-time — liquid, semi-viscous.
d. Pocket filler — volumetric gravity — liquid.
e. Time-gravity — liquid.

The first consideration is the type of concentrates which must be handled. For the contract filler this will normally mean a wide variety of liquids, ranging from low viscosity to barely pourable types. Filling weights may vary between 6 and 600 grams, and this particular variation is generally best handled by the use of change-parts; e.g. different orifices or different cylinder sizes. The captive filler may use his machine for the filling of only one or two products, in which case the buying decision is much easier.

Other considerations may be summarized as follows:

a. Time required for mechanical changeover from one can diameter to another or from one height to another.
b. Cleanability of the machine. Time required to break down and thoroughly clean all contact parts such as filler bowl, filling nozzles, pistons, cylinders, valves and so forth.
c. Maintenance accessibility. Access to the motor, gear reducer and drive train is very important in case of breakdown as well as for regular maintenance.
d. Maintenance level. Consider the degree of protection given to the motor, power train and other moving parts so that concentrate spills and flush liquids will not come into contact with them and reduce their operational life. Maintenance often increases as the number of elastomeric seals increases. The seals must be made of materials compatible with the concentrates.
e. Ability of the machine to function reliably without the need for a machine operator. This saves on labor but may increase maintenance requirements.
f. Cost. A good high speed filler will cost from $20,000 to $80,000 if purchased new. A used filler has a much lower initial cost, but maintenance costs will be much higher, and production losses due to breakdowns more frequent. Older machines tend to leak and have less accuracy.

A very large number of equipment manufacturers offer concentrate fillers. Each has unique advantages and disadvantages. It has been said that the experienced maintenance man or filler operator can detect a "personality" in every filler, and that even supposedly identical fillers will respond quite differently to various production situations. By developing a rapport with filler idiosyncrasies the maintenance man can predict problems, lay in stores of change parts known to have short service lives, and make adjustments that will enable the machine to give maximum performance.

Typical fillers are listed as follows:

a. The "JG Volumetric Product Filler" (also designated as the "Model VOF-A Automatic Volumetric Filler" when mounted with conveyor system) is available from the JG Machine Works, Inc. (Patterson, NJ) The Model VOF-A has a reported accuracy of $\pm 0.25\%$ which makes it very interesting. Interchangeable product fill cylinders are available in 30 to 550 cc. capacities. The Model VOF-A provides speeds up to 65 cpm. depending on fill and viscosity.
b. "Cozzoli Filler", by the Cozzoli Machine Company (Plainfield, NJ) The 8-head model does about 50,000 units per shift under average fill conditions and the 16-head can do almost 100,000 units per shift on a similar basis. Highly versatile,

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