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UNDERSTANDING SMALL-SCALE
PAINT PRODUCTION

By
Philip Heiberger

Technical Reviewer
Patrick Raney

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VITA
1600 Wilson Boulevard, Suite 500
Arlington, Virginia 22209 USA
Tel: 703/276-1800 * Fax: 703/243-1865
Internet: pr-info@vita.org

Understanding Small-Scale Paint Production
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[C] 1989, Volunteers in Technical Assistance**PREFACE**

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries.

The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Patrice Matthews handling production, and Margaret Crouch as project manager.

The author of this paper Dr. Philip Heiberger spent most of his working years with Dupont developing and utilizing resins, paints, adhesives, and allied chemicals. On retirement, he became active in on-site assistance of companies in developing countries.

The reviewer Patrick Raney is the President of Federal Testing

Laboratories in Seattle, Washington. He has been at Federal Testing Laboratories for over 20 years. His experience ranges from electroplating processes to paints and coatings. He is involved in experimental hydroponic operations and aided VITA with the technical paper on hydroponics.

VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and published a variety of technical manuals and papers.

UNDERSTANDING SMALL-SCALE PAINT PRODUCTION

by VITA Volunteer Philip Heiberger

BACKGROUND

Since the dawn of civilization, all societies have used color to enhance the appearance of their buildings, sculptures, vehicles, interiors, pottery, weapons, and clothing. Decorative paints have always been costly luxuries; until the twentieth century they were laboriously produced by craftsmen in small quantities. Recent recognition of paint's important protective properties spurred the development of an almost infinite variety of paints

now available for nearly every decorative, manufacturing, and maintenance use.

As paint usage and development accelerated, paint making became more complex. Knowledge of chemistry, process, engineering, and quality control are now essential. In addition, good business skills are required to operate and manage a paint manufacturing enterprise.

This paper describes how to start or expand a paint manufacturing facility in a nonindustrial country. The business information can also apply to the manufacture of number of other products, printing inks, cosmetics, glues and adhesives, textile treatments, carpet backing, paper modifications, detergents, and insecticides. All require similar startup considerations and technical skills.

PAINT

End Uses

What is paint? Simply stated, paint is a fluid suspension of finely divided pigments in a resinous solution. Although it is applied in a thin liquid film, it soon solidifies. Paint has many purposes: to protect against weathering, corrosion, and biological attack; to insulate against heat; to retard fires; to maintain hygienic conditions; to control illumination; and, of course, to beautify. Because there are so many end uses, there is neither a standard paint nor a standard paint plant. Each location

has unique sets of customers, purposes, and conditions for paint use that must be considered in plans for small-scale paint production.

According to their end use, paints can be classified into three groups, as follows:

Trade-sales or decorator paints are usually packaged in small containers. These paints, which air dry, are characterized by excellent storage stability (shelf life) and are sold in a wide variety of colors. Normally applied by brushing or rolling, paints in this category include house, interior wall, trim, floor, furniture, barn and roof, and metal-decorative paints.

Maintenance and marine paints or finishes protect commercial and public property against corrosion, weathering, chemical, or biological deterioration. They are brushing or spray paints made with air-drying or chemically catalyzed resins to provide maximum resistance to sunlight, high humidities, extreme temperatures, and/or harmful industrial atmospheres. Antifouling paints for ship bottoms contain leachable toxic compounds to inhibit marine growth. Special formulations are required to protect and decorate a huge variety of structures, including office buildings, schools, chain stores, government buildings, military installations, bakeries, dairies, breweries, industrial plants, utilities, railway cars, surface or air transportation fleets, ships, shipyards, barges, warehouses, and highway pavements.

Industrial finishes are ordinarily used in large-scale applications

where speed of handling is important and special protective properties are required. Industrial finishes include coatings for automobiles, refrigerators, washing machines, machinery, prefabricated houses, office and home equipment, venetian blinds, weapons, military vehicles, furniture, cabinets, wire and cable, textile printing, and rug backings. Drying is usually carried out in heated tunnels or ovens with well-designed ventilation systems.

The world-wide paint business is estimated to be a US\$20 billion industry (estimated 1989 prices), growing at the rate of approximately 3 percent per year with an approximate mix of

Trade-Sales Paints - 40%

Maintenance and Marine Paints - 20%

Industrial Paints - 40%

Composition

What is paint made of? Paints generally consist of pigments and vehicles (binders) dissolved or dispersed in suitable solvents. Color and opacity are provided by the pigments. Many formulations also require non-opaque pigments, often called inerts or fillers. Since raw materials are invariably imported, as much as 90 percent of the costs in making paint are the delivered costs of the raw materials.

Large companies can make varnishes, alkyds, and polyvinyl acetate emulsions. Usually, the large, multinational chemical producers or their licensees sell pigments, solvents, and vehicles to paint

manufacturers.

Here are the main classes of raw materials used in paint production:

Solution Vehicles

In solution paints, the vehicle is dissolved in a solvent to form a clear, viscous solution. The pigment is then dispersed directly into the solution. As the paint dries, the solidified vehicle binds the pigment. Vehicles of this category include drying oils, varnishes, synthetic resins, shellacs, cellulose, and vinyl polymers. Such natural products as the vegetable and marine oils obtained from the seeds or nuts of certain plants and trees or from a few species of fish usually have weaknesses, including relatively slow drying rates, production of soft films, and lack of uniformity.

To overcome these deficiencies, modifications with hard resins have been made. Oleoresinous varnishes are combinations of drying oils and hard resins that are "cooked" under specified conditions. A most important category of oil-modified synthetic resin is the alkyd, a chemical blend of polyhydric alcohols, phthalic anhydride, and one or more oils. Alkyds are used today in nearly all solvent-based paints. Such lacquer resins as nitrocellulose or shellac are solvent-soluble materials capable of drying rapidly to hard films upon evaporation of the solvent.

In all paints, various reagents are used in small amounts for special effects. Catalysts (driers) accelerate the rate of conversion

from the liquid to the solid state. Surface-active agents may assist pigment dispersion, improve brushing, or maintain color uniformity. Fungicides, defoamers, waxes, buffers, or antiskinning agents are often required.

Dispersion Vehicles

In another type of vehicle, the resins are dispersed in a liquid as tiny, spherical, insoluble particles. Aqueous dispersions known as latexes (or polymer emulsions) are in widespread use. Since the pigment and vehicle of the latex paint cannot be mixed with water, each component must be separately dispersed before combining with the other.

When the water evaporates, discrete particles of pigment and resin remain behind. Film formation occurs by fusion of the plastic particles surrounding the pigment particles.

The pigments for latex paints are the same as those used in conventional solution paints. The desirable features of latex paints--rapid drying, ease of application, resistance to alkalinity, good durability, nontoxicity, absence of fume hazard, applicability to damp surfaces, and low odor--are characteristics of the latex vehicle. Because of low costs and a widespread but incorrect belief that polyvinyl acetate (PVA) emulsions are easy to make and use, PVA is often used for making trade-sales paints.

Latexes are sensitive to extremes in temperature, to the influence of electrolytes (distilled or deionized water must be

used), to changes in acidity or alkalinity, and to solvent additions. These can cause serious manufacturing problems. Customers are often disappointed with paints that have not been subjected to strict laboratory testing. With careful controls and faithful adherence to recipes, the problems can be managed.

Solvents

Solvents are volatile liquids capable of dissolving or dispersing the film-forming components (vehicle, pigment, additives) of paint to application consistency. Solvents are usually blends. The solvents in general use include terpenes, hydrocarbons (aromatic and aliphatic), oxygenated solvents, and water.

Solvents are usually quite flammable; the vapors are also explosive, toxic, and air polluting. Local laws frequently limit the use of certain solvents. Because of this, water-based paints are often favored.

Pigments

Pigments are finely divided and insoluble; they are white, colored, or metallic powders obtained from naturally occurring minerals. Their chemical nature may vary from simple inorganic oxides to complex organic molecules.

Although pigments are used primarily to provide color and opacity, they influence many other paint properties. Different pigments may affect chemical reactivity, drying rate, ultraviolet

absorption, and ease of application.

The ratio of pigment to vehicle depends on the types of both that are used, as well as on the desired end use for the paint. Gloss paints and enamels contain relatively low concentrations of pigment; flat or matte finish paints and primers are highly loaded with pigments. In general, pigments enhance the hardness and firmness of coatings. Some pigments are easily wetted by the vehicle, while others are not. A poorly wetted pigment will produce paints that are less compact and more permeable to water. The protective and anticorrosive properties of paint are affected by the pigment and the vehicle.

Pigments are often classified by color, for example:

Whites - titanium dioxides and the zinc oxides.

Extenders - barytes, talcs, clays, chalks, and silicas.

Yellows - chromes, ferrites, ochres, siennas, and organics.

Blues - ultramarines, irons, phthalocyanines, and organics.

Greens - chromes, chromiums, phthalocyanines, and organics.

Reds - iron oxides, red leads, and organics.

Browns - umbers, siennas, and iron oxides.

Black - carbon, lampblack, graphite, iron black, and organics.

Metallics - aluminum, copper, zinc, and alloys.

A typical paint plant uses many pigments, often several from each category. Pigments are usually supplied in paper bags, which upon emptying, cause excessive dusting. The dust is hazardous to health and explosive. Methods of handling are often regulated by local laws. Pigments often become moist and their characteristics are changed. Dry storage is a necessity.

HOW PAINT IS MADE

Paint manufacture is a sequence of separate operations: raw-materials storage, mixing, dispersing, color matching, testing, packaging, and shipment. The technologies involved are the same for both large and small companies; batch size and total volume determine the specific equipment needed.

First, pigments are usually added to the vehicle by blending the ingredients in a paste mixer. The paste that is formed consists of poorly mixed aggregates of pigment and vehicle; this paste is brought to a specified fineness and uniformity by using an appropriate mill. "Grinding" or shearing wets the individual pigment particles with the liquid vehicle and further reduces the size of the pigment aggregates. For emulsion paints, such as the PVAs, the pigments must be dispersed separately in a mixture of surface-active agents and hydrophilic gums.

The paste is usually further blended with vehicle, driers, fungicides,

and other additives. It is then tinted with colored dispersions to match a desired color standard, tested, adjusted for quality, and, when satisfactory, packaged and shipped.

All paints must be screened to remove lumps. Often the bulk paint is screened when the sales packages are filled. In a small plant, filling is likely to be a labor-intensive process performed by hand.

MANUFACTURE PAINT, OR MERELY SELL IT?

A company can be a successful marketer of paints without having manufacturing facilities. The critical factors are good technical service and timely distribution. The company must provide a unique product, teach the customer how to use the product, and guarantee uniformity and performance. Success requires high competence in general management, technical service, warehouse management, distribution, and packaging.

Until all of the technical skills needed for manufacture are available, a paint business should evolve and grow, rather than start as a turnkey plant. Deliberate growth is especially recommended because the product mix, the raw material base, the trading partners, and the skilled labor pool are different in each location and must be thoroughly understood before complete manufacture is attempted.

FIRST STEPS

Initially, one enters the paint business as a distributor or as a holder of a license from a foreign company. Later, when the cost of importing finished products has grown, it may be prudent to consider local manufacture. The change is often encouraged by government through its tax policies, and usually occurs when the costs of finished goods approximates the higher costs of imported raw materials and the lower local labor costs. To determine the best time for this change, estimate that 50 percent of the costs of imported material is due to the high labor costs in the industrial countries.

At this point, it is advisable that all concerned persons, the local entrepreneurs, consultant (see below), and appropriate government authorities, together develop a business plan. They should determine the level and timing for evolving a robust paint manufacturing operation.

Even a small operation will easily require an initial investment well over \$100,000:

Plant equipment	\$30,000
Shop equipment	10,000
Fire and safety equipment	5,000
Laboratory supplies	10,000
Land	?
Buildings	?
office furnishings and supplies.....	?
Miscellaneous	?

Local governments often assist by providing free land, temporary tax relief, venture capital, guaranteed purchase commitments, etc. Licensors may provide technical assistance and some international agencies may give monetary and technical assistance. All these aids must be considered in the business plan.

CRITICAL STARTUP PERSONNEL

The next step is to recruit critical personnel. At this stage, these persons are the entrepreneur, the business manager, and the technical manager. Because success strongly depends on technical experience that even the technical manager may lack, a new business needs the services of an experienced consultant.

The first person to be recruited or identified is the entrepreneur. Because the paint business is not a capital intensive industry, it is easily entered with limited facilities and with limited resources. As a result, many naive or undercapitalized entrepreneurs, who failed to accept or recognize the complexity of the business or underestimated the difficulties of production, have lost their investment.

The entrepreneur usually has access to capital, knows the local business environment, and is influential in government circles. Selection of the paint business implies particular awareness of the paint needs of the country. The entrepreneur is probably on intimate terms with many of those involved in the building, manufacturing, construction, and transportation industries; and

with many of the officials involved in the military and services sectors of the government.

The business manager manages the cost accounting, marketing, and distribution functions, and the technical manager, an experienced and scientifically trained individual, manages the laboratory, purchasing, and manufacturing operations.

No matter how competent the business management may be, it is necessary, from the very beginning, to have a technical manager with strong expertise. The business manager should be a senior person capable of maintaining full control of the technical functions even when there is pressure from higher authority to alter a product. In areas where raw materials are expensive or hard to come by, there is often pressure to make substitutions that could prove disastrous. Substitutions may be made, if technically reasonable and laboratory tested. As the business grows, these responsibilities are shared and delegated.

In the paint industry, the purchasing function requires technical decisions. Because raw materials must be imported, the cost of these materials influences the cost of the paint. Labor, warehousing, distribution, packaging, selling expenses, and related costs may account for less than 10 percent of the final product. Therefore, the purchasing function is critical to success. It is a technical function because substitutions are frequently made, standards must be set and maintained, schedules must be coordinated with manufacturing, and formulas must be adjusted to utilize available raw materials. For these reasons, purchasing is

among the responsibilities of the technical manager.

PLANT REQUIREMENTS

Site

In anticipation of later growth, a larger land tract should be obtained than is needed immediately. The site should be in a manufacturing zone with good access to transportation facilities, water, and utilities. It should be distant from any residential area. All structures on the site should be isolated and expandable. Needed will be a manufacturing area, an enclosed warehouse, an office and laboratory building, and a solvent storage area. Hazardous materials should be stored underground and the water supply should be adequate for extinguishing fires.

Initial power requirements should be capable of at least a ten-fold expansion. Water requirements should also include an emergency supply for fire control.

Equipment

There is no performance difference between a large company's expensive, high-capacity, high-speed mixer and a small company's 200-liter (L) steel drum equipped with a portable mixer. Dedicated, expensive equipment is usually justified only when labor costs are high and production schedules are heavy and inflexible. A company should buy the equipment that is most readily available and affordable. It then becomes crucial to operate it as skillfully

as possible. Equipment is readily available through the new or used machinery markets.

Rarely will a new company require tanks larger than 1,200 L. Several 200-L steel drums, one or two 400-L tanks, and perhaps a 1,200-L tank will be adequate for a startup. Two or three portable propeller mixers and one heavy-duty paddle mixer should suffice. For trade sales, a pebble mill and a vertical hybrid ball mill should be adequate. If industrial gloss finishes are to be made, a small 3-roll mill might be included. High-viscosity paints may require pressure or centrifugal filtration devices.

QUALITY-CONTROL LABORATORY

A fallacy that pervades the paint industry is that one can buy technology or transplant a recipe from one country to another. This may work if the raw materials never vary, if the equipment is identical, and if the customer's application equipment is identical to that of the original user. Since raw materials do vary, processes are modified, and users take liberties with the application procedures, the paint manufacturer must be able to modify each product and adapt it for local use.

Standards with tolerances are specified for all categories of paint. In trade-sales products, the tolerances are broader than for industrial and maintenance products. For example, a slightly off-colored white house paint may be acceptable, but a slightly off-colored automotive paint is not. A slightly more or less viscous wall paint can be managed at the time of application, but

even a slight departure from the required viscosity of a spray enamel can close down an assembly plant.

Standardization is the key to business survival; every paint must be tested and warranted by the paint manufacturer to meet the specifications established by the supplier and the customer. But raw materials are never uniform; the dispersion process is variable, often unreliable; and color matching is erratic. This means that every batch of paint, whether imported or manufactured locally, has to be tested and approved or modified to meet established standards. Standards may include such variables as color, viscosity, solids, gloss, opacity, drying time, adhesion, and corrosion resistance.

To control product quality, a laboratory is needed, appropriately equipped, and run by trained people. No paint manufacturer, no matter how small, can function without a laboratory. It is equipped with adequate instruments and adequate application facilities, (e.g., spray guns, spray booths, dip tanks, brushes, etc.), to test both incoming raw materials and outgoing finished products. Required equipment may include viscometers, balances and scales, colorimeters, glossmeters, spray equipment, ovens, laboratory glassware, office equipment, and calculators. There must be employees capable of using these tools and interpreting the results, as well as someone (initially, the technical manager) capable of hiring, training, and managing them.

The reports of the laboratory must be objective and accurate. If specifications of a product are not met, the batch must be withheld

from the market until the marketing staff determines an appropriate disposition. For example, a slightly too-fluid product might be utilized by adjusting the spray pressure; or a too-slow baking enamel could be adapted by using a higher stove temperature. Since these changes must be made by the customer, the circumstances causing the deviation are discussed and an acceptance negotiated.

SKILLED AND NONSKILLED PERSONNEL

One of the most important duties of the technical manager is to recruit, train, and develop technical specialists. Even small-scale paint production eventually requires people with the following technical skills:

Formulators - one or more for each industry served. Formulators should be personally acceptable to the customer's technical staff. Formulators must work closely with customer's staff and equipment in order to develop and adapt products needed by them. In the industrial sector, in particular, the relationship must be close and comfortable. Often the formulator develops into a technical service representative, industry trouble shooter, or new-product innovator.

Laboratory analysts - for raw materials, in-process, and quality control. About 90 percent of the control problems can be resolved by thoroughly knowing the raw material literature. Laboratory personnel should be able to read with comfort English, German, French, or Spanish.

Dispersion specialists - to develop pastes and supervise dispersion operations. Dispersion is the least reproducible process in the paint industry. Batch to batch variations in dispersion can affect viscosity, opacity, gloss, color, color strength, and porosity. Variations cannot be eliminated, but they can be minimized by attention to detail, by adherence to rigid manufacturing standards, and by appropriate adjustments.

Color shader - to supervise all color matching operations

Purchasing specialist - to maintain inventory, schedule production, assist formulators

Librarian - to maintain records, manage literature files. A major source of technical information is the supplier's literature. Raw-material suppliers provide brochures, handbooks, catalogues, suggested starting recipes, problem resolution hints, and the like. These should be read and understood, and filed for frequent and easy reference.

Plant engineer - to design, specify, and maintain equipment and manage fire control and accident prevention programs.

In addition to managers and professionals, the following skilled employees are needed: warehouse supervisor, paint manufacturing foremen, filling-line foremen, chief mechanic, chief electrician, fire chief, and first-aid technician. Semiskilled personnel include dispersion operators, assistant shift foremen, and (if

required) cook. Other employees include mixers, fillers, warehousemen, janitorial staff, loaders, housekeepers, and kitchen help if required.

PLANT SAFETY

Because paint manufacturing is a hazardous undertaking, all concerned must be aware of the fire, safety, and health hazards involved in paint making. Solvent and resin solutions are toxic as well as flammable. Mixing and dispersion processes generate static electricity, which often causes fires and/or explosions.

Appropriate fire-fighting equipment must be made available, strategically placed, maintained, with employees trained in its use. Pigment handling is dangerous, pigments are dusty, and dusts are often explosive. Employees must be trained to carry out all tasks safely without jeopardizing themselves or others.

MARKET ASPECTS

Users

Paint is a luxury item that has critical users with requirements that differ from place to place. In countries where labor costs are high, trade-sales products must have the properties of easy brushing, high hiding, and extreme durability. Elsewhere, color and appearance are the main criteria. It would be too costly to duplicate the first-named properties where labor cost is not a critical factor. In addition, paints must be formulated for local

conditions: climate, color preferences, materials and labor availability.

Maintenance and marine finishes must meet international standards. A few multinational firms distribute them throughout the world. Industrial finishes are designed for specific end uses. The users have modern application equipment and painting is an integral part of the manufacturing process. Most industrial finishes are imported, but a local paint company that has acquired market and technical experience can consider making industrial finishes to given specifications.

Suppliers

Raw materials are rarely manufactured in nonindustrial countries because the manufacture of pigments, solvents, and resins requires complex, capital-intensive operations. Thus, it is most often the large, multinational chemical producers that sell these materials to paint manufacturers. Some intermediates (vegetable oils, varnishes, alkyds, polyvinylacetate (PVA) emulsions) can be made in smaller plants. Additives are used in small amounts, but they are proprietary and are bought from the manufacturers.

Raw-material suppliers are an important source of information. They provide formulas and technical assistance on the use of their products. Even so, products claimed to be "easy to use" (e.g., PVA emulsions) can be misused.

Multinational companies distribute their products widely and have

agents in many countries. It is always best to work with the local agents. Because packaging and transportation are major cost factors, it is advisable to buy from companies located so that they can ship over short distances.

Sales Channels and Methods

Trade-sales paint outlets may be independent merchants or company-controlled shops. Sales channels thus must be selected with adequate market knowledge. New products can be promoted through radio, TV, newspaper advertisements, special offers, or locally appropriate means. Painting contractors should be directly approached. It is necessary to be part of the local business network to get the best results.

Maintenance-paint sales usually begin with social contacts. When accord has been reached, the technical people of both the supplier and the customer together sort out details and initiate a development and testing program. The paint company may need to import or license the product until a volume or skill level is reached to justify local manufacture.

In the industrial market, one deals directly with key executives of the manufacturing facility. Informal contacts often help key persons of the country or region to gain confidence in the entrepreneurs' manufacturing efforts, thus increasing sales.

Geographic Extent of Market

Sales may be limited to one country, a region or a large city that is both a population and an industrial center. If there is more than one city, each may require different marketing approaches. For example, paints for coastal areas differ from paints used at high altitudes. Satellite plants or local warehouses may be advisable, depending on labor conditions.

Competition

Imported trade-sales paints or locally repackaged, imported, bulk paints may compete with locally manufactured products. Multinational firms may establish local subsidiaries, offering them a guaranteed source of raw materials and competent technical backup. Their strengths are uniformity and reliability, but not versatility. Local entrepreneurs have the advantages of local contacts, lower labor costs, and a more intimate understanding of local needs. It is in the trade-sales area that local manufacturers have the best chance to meet foreign competition.

Market Capacity

In many countries only a few people can afford paintable homes and purchase manufactured goods. However, because nearly all governments seek to improve general living standards, paint manufacture is a potential growth industry. As an example, the factory's business plan may assume (from the best available data) that two percent of the population are paint consumers and that in five years another two percent will become users; thus usage will double in five years.

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