PDR #9

TO: W. F. H. MATTLAGE

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# FLUOROPOLYMERS
# FOR
# DURABLE FINISHES



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## INTRODUCTION

For a number of years the Organic Chemicals, Electrochemicals, Film, Plastics, Fabrics and Finishes and Central Research Departments have had active research programs in the field of fluoropolymers and finishes based on such polymers. Additionally, Film has expended substantial effort on "Tedlar®" polyvinylfluoride film.

As a result of Orchem's research efforts, Fluoropolymer B (vinylidene fluoride/tetrafluoroethylene/vinyl butyrate terpolymer, $VF_2$/TFE/VBu, 68/22/10) was developed in 1965. This fluoropolymer was visualized as being suitable for very durable, air-dry (or low baking) solution finishes for wood, such as factory-finished residential siding. F. & F. has confirmed that Fluoropolymer B has properties that might be suitable as the topcoat vehicle in a primer/enamel system for cellulosic siding and that exterior durability would probably be superior to the best commercially available vinyl or acrylic topcoats.

If such a finishing system were offered to the wood siding industry, however, even for preliminary field tests, it could have an adverse effect on Film Department's "Tedlar" film program. Customers who are currently in the decision-making stage of committing investment for the use of "Tedlar" film might delay in response to the premature news that fluoropolymer finishes were available. Because of this potential conflict, Orchem requested Development Department to undertake a study which would define the Company's broad commercial position regarding fluoropolymer finishes versus film.

In response to Development Department's recommendation (report D-1438, Fluoropolymers for Durable Finishes, dated 8/12/65) F. & F. assumed a coordinating responsibility for the determination of the market for and selection of fluoropolymer vehicles for possible Company sale to the durable finishes market. The coordinating activities had the following objectives:

1. To determine whether there are one or more markets for fluoropolymer vehicles for durable finishes.

2. To determine whether one or more vehicles would be required.

3. To determine whether Du Pont has candidate vehicles to meet the market requirements.

4. To develop a program for the commercial sale of Du Pont fluoropolymer vehicles with minimum adverse impact on "Tedlar" film and F. & F.'s "Du-Lite®" fluoropolymer finishes.

F. & F. did not assume a responsibility for determining who should sell such vehicles.

The Development Department report recommended that no outside activities should be undertaken by Du Pont to develop sales of fluoropolymer vehicles for durable finishes until F. & F.'s study was completed.

For purposes of this study, a durable fluoropolymer finish is defined as "one that is two or three times as resistant to exterior weathering (i.e.; chalk/fading and gloss retention) as the best currently available vinyl and acrylic finishes". In terms of exterior exposure time, a durable finish might be expected to have at least as good appearance after 15-20 years as the best acrylic finish would have after 5-10 years.

## SUMMARY AND CONCLUSIONS

Based on accelerated weathering data, it is logical to predict that durable fluoropolymer finishes will have exterior weathering characteristics, as described in the introduction. Since long term exposure data are unavailable, we do not know whether fluoropolymer finishes will be more or less resistant to dirt pickup than vinyl or acrylic finishes; dirt pickup has not been a problem with "Tedlar" polyvinylfluoride film and it seems reasonable to believe that finishes applied from solution, emulsion or organosol will perform similarly. Properties, such as hardness, adhesion and corrosion resistance of fluoropolymer finishes appear to be comparable to the best vinyl finishes. Flexibility and resistance to heat, chemicals and solvents are better than vinyls, but we do not know whether these property improvements are sufficient to command premium prices over vinyls.

A review of the major potential markets for durable finishes (excluding film), with emphasis on factory-applied finishes for cellulosic substrates, has indicated that the total industry requirements for durable vehicles will be relatively small, even by 1975. Our projections are as follows:

| Durable Finishes Market | Durable Vehicle Requirements (MM Lbs.) 1970 | 1975 |
|---|---|---|
| 1. Factory-applied on cellulosic substrates (low bake) | 0.1-0.3 | 0.3-0.5 |
| 2. Factory-applied on metal substrates (high bake) (Chemwk 8-9 1.5MM 1971) | 0.3-0.5 | 0.6-1.0 |
| 3. Factory-applied on plastic substrates (low bake) | 0.2-0.3 | 0.4-0.5 |
| 4. Field-applied, industrial maintenance (air dry) | 0.2-0.4 | 0.8-1.2 |
| 5. Field and factory-applied, clears for metal (air dry and low bake) | 1-1.5 ? | 2-2 ? |
| Tot (Chemwk 8-9 4MM lbs 1970) | 0.8-1.5 1.8-3.0 | 2.1-3.2 4.1-5.2 |

Tot industry 1-3 mm 1-3 mm 2-6 1-3 mil 50%

If Du Pont were to capture 50% of the total industry requirements, the Company would need facilities to produce approximately 400,000 (.9) to 800,000 (1.5) pounds of fluoropolymer vehicles in 1970; and 1,100,000 (2.0) to 1,600,000 (2.8) pounds in 1975.

It appears that two families of fluoropolymer vehicles will be required to supply the durable finishes market; (1) air dry solution (or emulsion) vehicles and (2) organosol vehicles that require baking. The air dry vehicles could also be used to formulate baking finishes. It is doubtful, however, that organosol baking vehicles can be developed for air dry finishes, but some exploratory research is directed toward this objective.

Du Pont has candidate fluoropolymer vehicles that will probably meet the market requirements, although it may take several years of research, product development and field testing to determine whether Du Pont's candidates are technically adequate and economically competitive. The currently identified Du Pont candidates are:

1. Polyvinylfluoride (PVF) vehicle for organosol baking finishes. PVF can be produced in Film Department



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facilities in quantities sufficient to supply the vehicle requirements for "Tedlar" film and fluoropolymer finishes during the next 5 to 10 years. (Film's plant could produce 7MM - 8MM pounds/year annually.) F. & F. has a program aimed at replacing Pennsalt's "Kynar" polyvinylidene fluoride ($PVF_2$) with PVF in "Du-Lite" fluoropolymer enamel by 1967. Preliminary cost estimates indicate that PVF could be sold at $1.90 to $2.10 at 2MM - 3MM lbs./year production; or $1.20 to $1.40 at plant capacity (i.e. 7MM - 8MM lbs./yr.)

2. Fluoropolymer B vehicle for air dry finishes. There are no commercial facilities for producing this terpolymer, but Orchem can supply from semi-works equipment (1000 lbs./month). This will permit development and field testing of finishes by F. & F. until the markets are better defined and the properties of finishes based on lower cost fluoropolymer vehicles have been determined. Substantial new investment would be required to produce Fluoropolymer B in commercial quantities. Preliminary cost estimates have indicated that Fluoropolymer B might be sold at $2.80 to $3.20/lb. at 3MM lbs./year plant capacity; or $1.40 to $1.80 at 10MM lbs./year plant capacity. At these fluoropolymer prices, our studies indicate that vehicle demand would be inadequate to justify commercial facilities.

3. Vinyl fluoride/vinyl acetate/methacrylic acid terpolymers (VF/VAc/MAA) for air dry finishes. Both Elchem and F. & F. have exploratory research programs directed toward the development of a family of VF/VAc/MAA terpolymers which are expected to have durability properties between the best acrylic vehicles and PVF. These polymers might ultimately be suitable for formulating solution, organosol and emulsion finishes. F. & F. plans to assist Elchem

in the characterization of their terpolymers and will conduct field tests on prototype finishes as soon as adequate quantities of terpolymer are [illegible] available. New investment would probably be required to produce VF/VAc/MAA terpolymers in commercial quantities. Preliminary cost estimates indicate that VF/VAc/MAA terpolymers could be sold in the range of $0.75 to $1.00/lb. at 3MM lbs./year plant capacity or $0.50 to $0.75 at 10MM lbs./year plant capacity.

Because of the relatively small projected requirements for durable fluoropolymer vehicles for the next ten years, it appears that new facilities for fluoropolymer manufacture would be very difficult to justify in the foreseeable future. Existing semi-works and plant capacity (Film, Orchem and Plastics) can be utilized to obtain whatever supplies of fluoropolymers are needed for field testing and trial marketing of durable finishes by F. & F.

It is premature to make a decision regarding outside sale of fluoropolymer vehicles until we know, with reasonable certainty, that our candidates are suitable for the trade. This decision can probably be made within one or two years. In the meantime, it is recommended that no outside activities be undertaken by Du Pont to develop sales of fluoropolymer vehicles for durable finishes. This program will result in the minimum adverse effect on Film's "Tedlar" sales and will provide time for additional research, development, field testing and trial marketing of durable finishes.

## DISCUSSION

This study consisted of three parts:

1. Estimation of the economics associated with each fluoropolymer candidate, or family of candidates.
2. Determination of the size and character of the major potential markets for durable finishes. Emphasis was placed on the factory-finished cellulosic residential siding market because there has been some

feeling that this market represents a large opportunity for sale of fluoropolymer vehicles.

3. Description of candidate fluoropolymers and the likely balance between functional properties and application characteristics of the finishes.

Technical and marketing representatives from Orchem, Elchem, Plastics and Film Departments were designated as contacts for F. & F. These representatives have assisted in making the study by supplying both technical and marketing information and by reviewing preliminary data developed by F. & F. The representatives were as follows:

| | | |
|---|---|---|
| C. B. Shepherd | - Elchem - Wilmington | Marketing |
| J. F. Castle | - Elchem - Exper. Sta. | Technical |
| L. F. Dumont | - Orchem - Jackson Lab. | Marketing |
| W. W. Ranson/F. J. Gradishar* | - Orchem - Jackson Lab. | Technical |
| T. C. Gibson | - Film - Wilmington | Marketing |
| C. E. Dengler | - Film - Yerkes Lab. | Technical |
| M. I. Bro | - Plastics - Wilmington | Marketing |
| G. F. Curtin | - Plastics - Wilmington | Technical |

* Gradishar - replaced Ranson in January 1966.

## FLUOROPOLYMER ECONOMICS

Fluoropolymers are inherently expensive materials, primarily because of high monomer costs, but also because of the high investment required. Radical changes in technology, plus high volume production would be required to alter this picture. Basic economics associated with manufacture of the fluoropolymers in which we are interested are not expected to change significantly during the next 5 to 10 years.

Preliminary cost estimates for Du Pont's fluoropolymer candidates indicate that selling prices might be as follows:

| Fluoropolymer | Selling Price ($/lb.) | Plant Capacity (MM lbs./yr.) |
|---|---|---|
| PVF homopolymer | 1.90-2.10 | 2-3* |
| | 1.50-1.70 | 5-6 |
| | 1.20-1.40 | 7-8 |
| Fluoropolymer B | 2.80-3.20 | 3 |
| | 1.40-1.80 | 10 |
| VF/VAc/MAA terpolymers | 0.75-1.00 | 3 |
| | 0.50-0.75 | 10 |

* Film Department has existing plant capacity to produce 7MM to 8MM lbs./year of PVF for liquid finishes and "Tedlar".

Using ~~these fluoropolymer~~ FPB & PVF vehicle selling prices and assuming 1.5 to 2.5 pounds of fluoropolymer per gallon, the selling price for durable finishes would range from $10.00/gal. to $20.00/gal. On a coverage basis, this translates to an approximate selling price of 2.0 to 4.0 cents/square foot at 1.0 mil.

By comparison, vinyl and acrylic vehicles generally sell in the range of $0.25/lb. to $0.50/lb.; price per gallon ranges from $3.75 to $4.75. On a coverage basis, this translates to an approximate selling price of 0.75 to 1.25 cents/square foot at 1.0 mil.

In summary, durable fluoropolymer finishes are two to three times as expensive as the best currently available acrylic and vinyl finishes. If durable finishes based on lower cost VF/VAc terpolymer can be developed & sold in volume, however, these finishes might approach the price of vinyls.

?? I calculated that VF/VAc would be in same range as acrylics at high prod. rates. (40 vs 55¢) [illegible]

## MARKETS FOR DURABLE FINISHES

### I. Factory-Finished Cellulosic Residential Siding

Based on information from many sources, the total surface area of residential (low rise) exterior siding, soffit and gable was estimated for 1960, 1965, 1970, and 1975, (see Table I). All types of siding are included and a breakdown between new and replacement siding is shown. The surface area for cellulosic material (lumber, shingles, plywood and composition board) represents approximately 25% of the total for each year.

Table I does not include the surface area for residential exterior mill work (i.e. windows and doors) and flat trim (i.e. miscellaneous facia). It is estimated that the surface area of millwork was 120MM sq. ft. and flat trim was 180MM sq. ft. in 1965. Wood is used almost exclusively for both items. We have not studied these markets in great detail, but it seems reasonable that the growth of factory-finished millwork and trim might parallel cellulosic siding. If this occurs, the total industry durable vehicle requirements would be on the high side of the range shown in the summary and conclusions.



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During the summer of 1965, Orchem and F. & F. made a joint market survey of the major wood manufacturers to determine whether they were interested in premium-priced durable low bake fluoropolymer coatings for factory-finished cellulosic residential siding. On this initial survey contacts were made primarily with research personnel. Late in 1965, F. & F. made a market survey in which 14 builders (including large and small builders and prefabricators), 4 architects, and 3 trade associations were contacted. Early in 1966, F. & F. and Film Departments made a resurvey of the major wood manufacturers, including Georgia-Pacific, U. S. Plywood, Simpson Timber, Weyerhaeuser, Boise-Cascade, Masonite and Andersen (windows). During this resurvey contacts were made primarily with marketing and sales personnel.

Information that was developed during the three surveys reflected the subjective attitudes and opinions of the various groups with regard to (1) the future growth of prefinished cellulosic siding (with various organic coatings), and (2) the percentage of the market that might use premium-priced, durable finishing systems, such as low bake fluoropolymer finishes or "Tedlar" film laminates.

It was the consensus of all groups that factory-finished cellulosic siding will eventually be extensively used in residential building, but growth will be slow. Three basic reasons were given in support of this:

(a) Better quality and control can be obtained by factory finishing than by on-site finishing.

(b) On-site finishing costs (primarily labor) are rising faster than factory-finishing costs.

(c) With education and experience, the public will demand better exterior finishes.

Except for Georgia-Pacific, all the manufacturers contacted are conducting, or planning to conduct, trial marketing programs with prefinished cellulosic siding. It was generally agreed, however, that the acceptance of prefinished cellulosic siding will proceed at a relatively slow rate during the next 10 years for several reasons:

(a) To date, prefinished cellulosic siding has been priced so high that it is cheaper in many parts of the country for builders to rely on on-site finishing. Because of rapidly rising labor costs, however, there will probably be substantial financial incentive for the builder to use prefinished cellulosic siding by 1970 or 1975.

(b) Prefinished aluminum siding is cheaper than prefinished cellulosic siding now and will be in the foreseeable future. The cellulosic siding industry cannot apply finishes (or film laminates) as economically as can be done by high speed roller coating on metal. In addition, if a liquid system is used, the cellulosic siding will require several coating operations and greater film thicknesses (i.e., 3.0 mils for wood versus 1.0 mil for aluminum).

(c) The wood industry is fragmented and it is very unlikely that manufacturers will pool monies for massive advertising at the consumer level. To date, the wood industry has directed its advertising and promotional efforts toward the distributors and builders. With this kind of effort, it is going to take many years to educate the public regarding the value of prefinished cellulosic siding.

(d) All exterior parts of the house (particularly windows) need to be factory-finished, if on-site labor is to be effectively eliminated. This will require considerable coordination among the manufacturers, since no one manufacturer is currently in a position to finish all exterior components. Prefinishing of wood windows is just now beginning and it may take 5 to 10 years before a high percentage of windows are prefinished.

(e) The wood industry is still commodity oriented and they have much to learn about distribution and marketing of specialty products, such as prefinished siding.

Attempts are being made to find answers by trial marketing programs (i.e., Should they bypass the distributor and sell direct to the builder or siding applicator? How can advertising money be spent more effectively for siding which loses its identity on the total house? How important is the warranty, since less than 5% of home owners send in cards to validate the warranty?).

(f) Builders are going to resist the use of prefinished cellulosic siding unless they can foresee economic advantages through reduced cost or more saleable houses. At present the builders are concerned about increased costs resulting from handling, application problems (i.e., fastening, end sealing, touch-up) and inventories of siding in different colors. It is recognized that many of these problems confronted the prefinished aluminum siding industry a few years ago, but they were overcome or minimized. The builders also feel that more tangible features, such as modern appliances, additional floor space, air conditioning, etc. are the items that really count in making a house sale. It was the consensus of builders that a durable coating on prefinished cellulosic siding would not be a strong house selling feature for the mass market; people move frequently (20% move every year and the average life of a mortgage is around 6 years), and many people repaint their houses for psychological reasons (i.e., the neighbors painted their house, or the wife wants a new color, etc.). It was conceded, however, that with proper education and experience, the public will eventually demand more maintenance-free residential siding, particularly for higher priced homes.

During the resurvey of wood manufacturers, we discussed the analogy between the growth of prefinished interior panels and prefinished exterior siding. In 1946, development work on prefinished interior panels was begun and trial marketing was underway by 1950. Sales of interior prefinished panels were modest by 1955, but had increased ten-fold (over 1955) by 1965. It was estimated that sales of prefinished interior panels will amount to $250MM in 1966. Vehicle requirements for finishes on these panels are approximately 12MM pounds. Several reasons were given for the rapid growth of the interior panel market since 1955. These were:

(a) Lower cost panels were developed.

(b) There has been an increase in the "do-it-yourself" home improvement market.

(c) Interior panels represent a complete system (i.e. panels, molding, etc.)

(d) The product filled a need and sold itself without massive advertising.

There was general agreement that the prefinished interior panel market has grown faster than the factory-finished cellulosic siding market would be expected to grow. A U.S. plywood representative told us that "it is 1946 as far as their "Tedlar"/plywood siding program was concerned".

All of the wood manufacturers expressed interest in our proposal to develop durable low bake fluoropolymer finishing systems for residential cellulosic siding. When we have a feasible system developed, they will be happy to test it and assist in evaluations on test houses. Whether or not they will buy our system will depend on the outcome of tests and economics.

We explained that the proposed fluoropolymer finishing system would consist of a good conventional primer (2 mils) and a fluoropolymer topcoat (1 mil). It was anticipated that such a system could be developed for application on existing equipment and that durability (resistance to chalk/fading and gloss loss) might be two or three times as good as the best currently available finishing system. It was estimated that material cost of the liquid fluoropolymer system would be somewhat higher than the cost of the best currently available systems (i.e. 5-6¢/sq. ft. versus 3-4¢/sq. ft.), but slightly less than the current material cost for "Tedlar" film plus adhesive (7-8¢/sq. ft. at 2 mils). Film Department may be successful in their program to reduce the "Tedlar" film thickness to 1.5 or 1.0 for cellulosic substrates, such as hardboard, however, and this would result in "Tedlar" being less expensive than a liquid fluoropolymer system, (assuming application costs are equal for film and liquid).

With the economics, as described above for "Tedlar" film and low bake fluoropolymer finishing systems, we asked for comments from the manufacturers regarding the percentage of the prefinished siding market that might use durable coatings in 1970 and 1975. The most optimistic response to this question came from U. S. Plywood; they felt that 35% of all cellulosic siding might be prefinished by 1970, and most of the coatings (film and/or liquid materials) will be durable. The other manufacturers were much more pessimistic than U. S. Plywood. Masonite, who sell polyurethane finished hardboard siding (Color-Lok) and Mando Division of Boise-Cascade, who sell vinyl coated particle board siding (vinyl-bond Insulite) stated that an increase in finishing material cost could not be justified to gain durability beyond 10 years. (Both Color-Lok and Vinyl-bond Insulite carry 10 year guarantees against cracking, chipping and peeling, but not color retention). Weyerhaeuser took the position that a premium-priced durable coating (film or liquid finish) might be justified, if 25 year durability claims could be made.

By taking into account all opinions and attitudes expressed during the market surveys, as well as opinions expressed by F. & F. Research and Marketing managements, a <u>total industry</u> potential market projection for durable vehicles for factory-finished cellulosic siding was prepared (See Table II). In arriving at these projections, many factors were taken into account, some were well established and others were reasonable estimates. The most important data presented in Table II are as follows:

(a) The percentage of surface area that is factory-coated will grow from 4% in 1965 to 32% in 1970, and 57% in 1975. Most of the factory-finished substrates will be plywood and composition board (i.e., hardboard, particle board, etc.), rather than lumber or shingles.

Plywood and composition board are more uniform, dimensionally stable, and easier to handle on production lines than lumber or shingles. Further, the supply of uniform natural lumber is limited.

(b) The market will include film laminates (14% in 1970 and 24% in 1975) and liquid finishing systems (18% in 1970 and 33% in 1975). The percentages are based on the total surface area of cellulosic siding.

(c) Of the laminates, durable films, such as "Tedlar", will be primarily used (80%), with the balance (20%) being less durable films, such as vinyl.

(d) Of the liquid coatings, low bake durable systems are expected to obtain 25% of the market, with the remaining 75% being less durable systems, such as urethane, vinyl, or acrylic.

(e) It is estimated that durable laminates will obtain a larger share of the market (11% in 1970 and 19% in 1975) than durable liquid finishes (4% in 1970 and 8% in 1975), because films are commercially available now and economics will likely favor the film approach, particularly if 1.5 or 1.0 mil films prove to be satisfactory. In addition, there is evidence to indicate that films will be inherently superior to liquid coatings because of better cohesive strength, toughness, resistance to dimensional instability and ability to obscure surface imperfections.

In summary, projections shown in Table II indicate that the total industry requirements for durable vehicles will be 1.2MM pounds in 1970, of which 1.0MM pounds will be films (such as "Tedlar") and 0.2MM pounds will be low bake liquid finishing systems; the 1975 total industry requirements are projected to be 2.0MM pounds for films and 0.4MM pounds for liquid systems. These projections represent mean or average durable vehicle requirements; in the summary and conclusions section a range is shown with the mid-point taken from Table II. Film Department has plant facilities to produce

PVF for "Tedlar", but it does not appear that the potential market for liquid durable finishes is adequate to justify construction of new manufacturing facilities to produce Fluoropolymer B, or other fluoropolymer vehicles with a similar cost/property balance.

The liquid finishing system was defined as 1 mil of fluoropolymer topcoat and 2 mils of conventional primer. The fluoropolymer topcoat has a coverage of 400 sq. ft. at 1 mil and requires 1.5 to 2.0 pounds per gallon of durable vehicle. Application would be by curtain coating or airless spray, thereby providing high (80-90%) application efficiencies.

II. Factory-Finished Aluminum and Galvanized Steel Exterior Building Panels and Residential Siding

Finishes for this market are generally applied by roller on high speed continuous coil or strip coating production lines, and baked at 400°F. to 450°F. for 30 to 60 seconds. Organosol baking finishes can be applied satisfactorily with such equipment and are ideally suited for the coil coating industry. The prefinished metal is formed into building panels or siding; galvanized steel is used primarily for building panels and aluminum for residential siding. F. & F. has been manufacturing coil coating finishes for more than 15 years.

In 1963, F. & F. conducted a market research study to determine the market potential and opportunity for premium-priced fluoropolymer finishes for exterior building components. This study was updated late in 1965. Interviews were held with primary metal producers who have coil coating lines, independent coil coaters, manufacturers who use precoated metal to fabricate building components and residential builders.

Trial marketing of 815-Line "Du-Lite" fluoropolymer coil coating enamel was begun in 1965. Sales during 1965 amounted to $15,600 (626 gallons) and sales through April 1966 amounted to $45,000 (1,800 gallons). To date, all "Du-Lite" has been used on galvanized steel and aluminum for fabrication of building panels.

Based on information developed by (1) market research, (2) field contacts, (3) preliminary trial marketing experience and (4) opinions of F. & F. research and marketing managements, the potential market requirements for durable vehicles for metal residential siding and building panels was projected for 1970 and 1975 (See Tables III and IV).

In Table III, data are presented on the current and projected market for factory-applied finishes for non-residential (and high rise residential) aluminum and galvanized steel exterior building panels. Reliable estimates of the total surface area of all exterior building materials were obtained, but data could not be found to construct a profile of the market as was done for residential siding (Table I). The most important data presented in Table III are as follows:

(a) In 1970, 23% of the total surface area of non-residential buildings and high rise residential buildings will be factory-finished (with organic coatings); 27% will be factory finished in 1975.

(b) The market for organic coatings will include film laminates (11% in 1970 and 16% in 1975) and liquid finishes (89% in 1970 and 84% in 1975).

(c) Of the laminates, durable films, such as "Tedlar", will be primarily used (80%), with the balance being less durable films, such as vinyl.

(d) Of the liquid systems, durable finishes, such as PVF finish, will obtain 10% of the market in 1970 and 16% in 1975, the balance of the market being less durable finishes, such as alkyd, acrylic, vinyl, or silicone-alkyd (and silicone-acrylic). Note that vinyls were used for more than half the market (58%) in 1965; the projections indicate that vinyls will be less widely used by 1975 (i.e. 22%) and silicone-alkyds will capture the largest market share (i.e., 41%). Silicone-alkyds are currently being sold with a five-year guarantee against color change, versus "Du-Lite" with an eight-year guarantee against color change. It it were not for the silicone-alkyds, fluoropolymer finishes might obtain more than 16% of the market by 1975.

In Table IV, data are presented on the current and projected market for factory-applied finishes for residential aluminum and galvanized steel siding, soffit and gable. All metal for this market is factory-finished. Data for the total surface area of aluminum and steel substrates are the same as shown in Table I. The most important data presented in Table IV are as follows:

(a) The market for organic coatings will include film laminates (9% in 1970 and 14% in 1975), and liquid finishes (91% in 1970 and 86% in 1975).

(b) Of the laminates, durable films, such as "Tedlar" will be largely used (90%), with the balance being less durable films, such as vinyl.

(c) Of the liquid systems, durable finishes, such as the PVF system, will obtain 5% of the market in 1970 and 8% in 1975. The balance of the market will consist of less durable finishes, such as alkyd, acrylic, vinyl and silicone-alkyd (or silicone-acrylic). We believe that acrylics will continue to dominate this market in 1970 and 1975 and that silicone-type finishes will take second place by 1975.

It is difficult to see how durable finishes (or films) can obtain high penetration into the residential siding market in the foreseeable future, because the predominant exterior color is white (70-80%). There is growing reason to believe that coil coating acrylic finishes (white) will maintain satisfactory appearance for upwards to 15 years, and there is little incentive to switch to premium-priced durable coatings when good performance can be obtained with low cost materials. In the case of building panels (Table III), however, white is not so widely used and the incentive to use durable coatings is greater.

In summary, the projections shown in Tables III and IV indicate that the total industry requirements for durable vehicles for metal residential siding and building panels will be 1.3MM pounds in 1970, of which 0.9MM pounds will be films (such as "Tedlar") and 0.4MM pounds will be liquid finishing systems (such as PVF organosol); the 1975 total industry requirements are projected to be 2.6MM pounds;

with 1.8MM pounds for films and 0.8MM pounds for liquid systems. These projections represent mean or average vehicle requirements; in the summary and conclusions section a range is shown with the mid-point obtained by adding the durable vehicle requirements shown in Table III and Table IV.

III. Factory-Finished Plastic Substrates

The Development Department is projecting sales of plastic ("Darvyl®" polycaprolactam and Polymer W) exterior building components, including shutters, roofing, siding and trim, amounting to between 100MM and 150MM square feet by 1971. Development Department plans to use the most durable coating materials available on these building components. If satisfactory fluoropolymer finishes (low bake solution or emulsion types) were developed, it is conceivable that half of the exterior surface area might be coated with such materials. "Tedlar" film is currently being considered for these applications, but the overall economics might favor liquid finishing systems over film laminates.

In view of the above, it is estimated that 200,000 to 300,000 pounds of fluoropolymer vehicle might be required by Development Department for liquid finishes by 1970; 400,000 to 500,000 pounds by 1975.

IV. Field-Applied Industrial Maintenance Finishes

F. & F. has been selling industrial maintenance finishes for many years and marketing background has been developed for all types of products. For purposes of this study, the industrial maintenance market includes air dry finishes for the following: buildings, bridges, ships, utilities, aircraft, railway, manufacturing plants and equipment. Finishes for existing structures as well as new structures are included; the volume of finishes used for existing and new structures is split approximately 50/50. The ratio of top-coat to primer consumption is roughly 60/40. If highway traffic marking paints are eliminated, the ratio of finishes for interior use to exterior use is approximately 55/45. (Highway traffic marking paints were not included because there is no reason to believe that premium-priced fluoropolymer traffic marking finishes would ever replace currently available finishes.)

In Table V a profile is shown of the types of industrial maintenance finishes that are used now and projections are made regarding the profile in 1970 and 1975. Alkyd finishes dominate the market now (47%) and it is expected that alkyds will be the most important type of finish in 1975. Latex paints are predicted to show fairly rapid growth during the next 10 years. Moderate growth in the use of medium-priced finishes, such as vinyl, chlorinated rubber and epoxy is expected in the future, particularly where improved chemical resistance is desired.

Assuming that an Industrial Maintenance system, comprising a durable fluoropolymer topcoat (at 1.0-1.5 mils) and a good conventional primer (at 2.0-3.0 mils) is developed, which has satisfactory application characteristics and properties (particularly high gloss), it is projected that durable vehicle requirements will be 300,000 pounds in 1970 (0.2% penetration of the market); requirements will be 1,000,000 pounds in 1975 (0.7% penetration of the market). As was done with the other markets, these projections represent average durable vehicle requirements and a range of vehicle requirements is shown in the summary and conclusions section. Pigmented topcoats would be expected to constitute most of the volume, but it is conceivable that clear finishes might be applied over conventional primer/enamel systems.

These projections seem reasonable because:

(a) This market is notoriously slow in accepting new finishing systems until they have been proven in the field. This prove-out time requires 5 to 10 years for most customers, although a few might be willing to reach a decision to buy durable systems based on short term accelerated weathering and exterior exposure data.

(b) The best currently available vinyl systems have been slow in replacing low cost alkyds and it is illogical to assume that high-priced durable finishes will rapidly replace vinyls. Experience has shown that the average customer will have difficulty perceiving that economic advantages can be realized by using a high-priced durable system rather than a medium-priced vinyl system or low-priced alkyd system.

(c) The historical analogy presented by premium-priced inorganic zinc primers seems appropriate to compare with durable fluoropolymer finishing systems. Back in the early 1950's, development work and field testing was begun on these primers. By 1960, the vehicle requirements for inorganic zinc primers were approximately 450,000 pounds (0.5% penetration of the market) and their durability characteristics had been proven. By 1970, it is estimated that vehicle requirements for these primers will be 2,500,000 pounds (2% penetration of the market). It seems unlikely that Du Pont or others will, in fact, be ready to begin extensive field testing of fluoropolymer systems before 1967 or 1968. By analogy, the total industry requirements for durable vehicles in 1970 and 1975 will certainly be relatively small.

## V. Field and Factory-Applied Clears for Metal and Plastic Substrates

The potential markets for fluoropolymer clears, for use over bright metal and plastics, are not well defined. There is a recognized need for durable, tough, hard, clear finishes for a variety of end uses, such as automotive trim parts, plastic building components, aluminum trucks and trailers, architectural aluminum extrusions, aluminum windows, doors and screens. We do not know, however, whether fluoropolymer clears could be developed with suitable functional properties (hardness, abrasion and chip resistance) and satisfactory application characteristics for use on automotive trim, trucks and trailers. To date, the evidence strongly indicates that functional properties will not be adequate. Further, we do not know whether fluoropolymer clears will show exterior durability improvements over existing clears that are great enough to justify premium-prices (i.e., 2.0-4.0¢/sq. ft. at 1 mil versus 1.3-1.5¢/sq. ft. at 1 mil for the best acrylic clears) in the other possible end uses.

who say?

who say?

Because of the uncertainties relative to the potential markets for durable clears, we are not projecting total industry requirements for fluoropolymer vehicles at this time. Additional studies are planned which will better define this potential market with respect to size and characteristics.

## VI. Other Major Markets

There is no evidence to indicate that the automotive industry will pay premium prices for better topcoat durability (i.e. improved chalk/fade resistance and gloss retention) than can be obtained with currently available lacquers and enamels. The durability of today's automobile finish is considered satisfactory for 5 years or longer; the average life of an automobile is 8 years, and the great majority of automobiles are refinished because of physical damage. Currently available automotive finishes are deficient in some properties, such as chip, water spot and chemical resistance. Fluoropolymer finishes are superior to acrylics in chemical and water spot resistance, but the industry will not pay high prices to gain such improvements. To date, there is no laboratory evidence to indicate that fluoropolymer vehicles, when used as additives for conventional finishes, will eliminate or lessen these deficiencies, but Research is planning limited work in this area.

With consumer house paints, experience has indicated that customer resistance is very great when price is high, regardless of performance claims. There appears to be an upper limit on the price per gallon of about $10.00 for the mass market. Everything possible has already been claimed for the best currently available house paints and meaningful guarantees cannot be used to promote the sale of premium-priced products because of uncontrolled substrate and application variables. In addition, the ultimate exterior durability characteristics of the best acrylic emulsion house paints is not precisely known, but exposure data indicates that under optimum conditions a 10 to 15 year service life for white paints may be attainable.

Although analogies are never perfect, we fear that the market for durable fluoropolymer clears for natural wood might be similar to that represented by "Super-Shield" Exterior Clear. This product is considerably more durable than existing competitive exterior clears, as measured by accelerated weathering tests and two year old exterior exposure panels. The product fails by gradual erosion to an easily repaintable surface. It was recognized at the outset that the chief value of the product lies in its long term durability and that we had to convince home owners to pay a premium price now for benefits that could be perceived after several years.

Studies have indicated that there is a potential U. S. market for exterior clears which amounts to approximately 2,000,000 gallons annually (not including stains). Exterior clears are used more widely in the West Coast Region (estimated annual consumption is 700,000 gallons) than other areas. For this reason, the West Coast was chosen for trial marketing of "Super-Shield".

In the spring of 1965 all of our consumer paint outlets in the West Coast Region were solicited for sale of "Super-Shield". The product was priced by F. & F. to yield an approximate retail price of $12.00 per gallon. Promotion of the product was via newspaper advertising and "point of sale" merchandising material. The following information on the 1965 trial marketing program is of interest:

| | |
|---|---|
| Number of retail outlets that stocked "Super-Shield" | 175 |
| *Advertising and promotional expenditures | $10,000 |
| Gallons sold | 2,000 |

* Translated to a national basis, advertising and promotion expenditures would be approximately $2MM during the introductory year.

The conclusions reached were as follows:

(a) The $12.00/gallon price is too high for "Super-Shield" to reach the mass market. Market Research studies have indicated that the average retail price of exterior clears is approximately $6.50/gallon, with prices ranging from $3.00 or less/gallon to $9.00 and over/gallon (20% of consumers are willing to pay $9.00 or more/gallon).

(b) Our advertising claims that "Super-Shield" had outstanding durability, apparently had little effect on the average consumer's willingness to buy the product. Without a meaningful guarantee on durability, it is difficult to see how premium-priced clears, such as "Super-Shield", could be sold in large volume.

(c) There was dealer resistance to stocking the product because of the high retail price required to obtain an adequate margin over cost.

(d) The market for "Super-Shield" is too small to justify mass advertising and promotion.

(e) The trial marketing effort on the West Coast will be continued during 1966, but our dealer price is being substantially reduced (resulting in a financial loss for F. & F. and an estimated $8.00/gallon retail price). Even with a reduced price, we are less than boldly optimistic about the sale of current stocks and the future of "Super-Shield"; current plans call for discontinuing the program next year.

DESCRIPTION OF CANDIDATE FLUOROPOLYMERS AND FINISHES

Since 1962 over 100 fluoropolymer vehicle candidates have been synthesized and evaluated as film formers for durable liquid finishes by Orchem, Elchem, F. & F., Plastics, Film and Central Research. F. & F. has characterized many of these vehicles as well as competitive fluoropolymers, prepared prototype finishes for both screening and evaluation for specific end uses, conducted field tests with baking finishes and begun trial marketing of "Du-Lite" coil coating enamels.

The most promising fluoropolymer vehicle candidates for organosol baking finishes are $PVF_2$ and PVF homopolymers. Both can be dispersed in organic liquids to form 40% solids organosols and both can be formulated to produce pigmented finishes (semi-gloss and flat) that are two to three times as resistant to chalk/fading and gloss loss as the best vinyl and acrylic finishes, when exposed in various weatherometers. Although correlation of accelerated weatherometer data and actual exterior exposure performance is never perfect, the likelihood is good that $PVF_2$ and PVF finishes will, in fact, be two or three times as resistant to chalk/fading and gloss loss as the best currently available finishes. Since long term exposure data is unavailable, we do not know whether these finishes will be more or less resistant to dirt pickup than the best vinyl and acrylic finishes; obviously, resistance to dirt pickup can be equally as important as resistance to chalk/fading and gloss loss on long term exposure. Many factors contribute to dirt pickup, such as surface roughness, gloss level, chalking rate, inherent surface chemistry, binder thermoplasticity, and environmental conditions. Data has indicated that fluoropolymer finishes will not support the growth of mildew, but under some environmental conditions mildew can grow on surface dirt. It is encouraging to know that dirt pickup problems have not been serious with "Tedlar" film, and hopefully liquid finishes will perform similarly.

Preliminary tests show that $PVF_2$ and PVF finishes are equal to the best vinyl finishes in initial appearance, abrasion resistance, corrosion resistance, hardness and adhesion. Flexibility and resistance to chemicals, stains, solvents and heat of the fluoropolymer finishes are better than vinyls, but we do not know whether these property improvements are sufficient to justify premium prices over vinyls. Additional testing by ourselves and prospective customers is needed to more precisely define the properties of fluoropolymer finishes.

Since $PVF_2$ and PVF organosol finishes require fairly high baking schedules to obtain proper coalescence of the dispersed vehicle, their use has been limited to metals. With current formulations, good durability is obtained when metal temperature in the range of 300°F. to 350°F. is reached for a few seconds; higher temperature, in the range of 400 to 450°F., is needed to obtain the maximum formability. The technical chances of developing $PVF_2$ and PVF air dry and/or low bake organosol finishes are poor, although it may be possible to formulate medium bake (200°F. to 300°F.) finishes which could be used for coating reconstituted cellulosic substrates, such as hardboard.

In 1964, F. & F. selected "Kynar" $PVF_2$ (manufactured by Pennsalt) for use in "Du-Lite" coil coating enamel. The decision was made to use $PVF_2$ because the polymer supply was assured, exploratory studies had demonstrated that finishes could be formulated with a minimum of technical effort, initial film properties were superior to those obtained with other fluoropolymer candidates and the prototype finishes had good application characteristics on existing coil coating lines. Both Film and F. & F. have research and development activities which are directed toward the replacement of $PVF_2$ with PVF in "Du-Lite". Good progress was made in this joint endeavor during the past 12 months and if application problems can be resolved, "Du-Lite" will be based on Film's PVF by late 1967. Orchem did exploratory research in 1964 and 1965 on a $PVF_2$ candidate that might replace Pennsalt's "Kynar", but work was discontinued because of the likelihood that a lower cost PVF finish could be developed.

The most promising fluoropolymer vehicle candidates for air dry or low bake finishes are Fluoropolymer B and VF/VAc/MAA terpolymers.

Orchem's Fluoropolymer B can be dissolved in organic solvents to obtain a 40% solids solution, and pigmented topcoats can be formulated for possible use over a variety of primed substrates, including cellulosic, plastic and metals. Flexibility, hardness, abrasion resistance, adhesion to primers, block resistance and moisture blistering resistance of the finish appear to be equal or superior to the best air dry house paints. Both high gloss and flat finishes can be formulated. Based on accelerated weatherometer tests, the Fluoropolymer B finish is comparable to "Du-Lite" in chalk/fade and gloss retention characteristics; exterior exposure studies are in progress. Preliminary data indicates that Fluoropolymer B finishes can be applied by airless spray, conventional spray or curtain coating.

F. & F. is currently developing a high quality primer for use with Fluoropolymer B topcoat on factory-finished cellulosic siding. We plan to field test this system at Weyerhaeuser and construct several test houses during 1966.

Development Department is currently field testing Polymer W roofs which have been coated with a primer/Fluoropolymer B system. If initial tests are encouraging, further studies will be made by

Development to determine the relative economics of durable liquid finishing systems versus "Tedlar" film laminates for various plastic building components.

Elchem's and F. & F.'s VF/VAc/MAA terpolymer studies are in an exploratory stage of development. Elchem has been working to develop vehicles that would be suitable for formulating both solution and emulsion air dry finishes. F. & F. has been scouting possible routes to produce vehicles that would be suitable for formulating both air dry and baking organosol finishes. Terpolymers with high and low VF content are being studied; theoretically, high VF content will result in the best durability. As a family, these terpolymers are expected to have durability characteristics between the best acrylics and PVF. It is possible that some limited field testing of finishes, based on VF/VAc/MAA terpolymers, can be undertaken during 1966. It will not be known, with reasonable certainty, however, whether these vehicle candidates are suitable for the trade until we have one or two years of field test experience.

TABLE I

TOTAL SURFACE AREA OF LOW RISE RESIDENTIAL EXTERIOR HOUSE SIDING, SOFFIT AND GABLE MARKET
(MM Sq. Ft.)

| | 1960 | | | 1965 | | | 1970 | | | 1975 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | New | Replace & Repair | Total | New | Replace & Repair | Total | New | Replace & Repair | Total | New | Replace & Repair | Total |
| Brick, Stone & Cement Block | 690 | 10 | 700 | 740 | 10 | 750 | 785 | 15 | 800 | 885 | 15 | 900 |
| Stucco | 290 | 10 | 300 | 365 | 10 | 375 | 440 | 10 | 450 | 490 | 10 | 500 |
| Lumber - Lap Siding | 375 | 25 | 400 | 280 | 20 | 300 | 230 | 20 | 250 | 185 | 15 | 200 |
| Wood - Shingles | 100 | 10 | 110 | 90 | 10 | 100 | 80 | 10 | 90 | 70 | 10 | 80 |
| Plywood | 45 | 5 | 50 | 100 | 10 | 110 | 190 | 25 | 215 | 250 | 50 | 300 |
| Composition Board | 100 | 30 | 130 | 165 | 50 | 215 | 240 | 85 | 325 | 280 | 120 | 400 |
| Aluminum & Galv. Steel | 50 | 300 | 350 | 180 | 600 | 780 | 245 | 750 | 995 | 320 | 950 | 1,270 |
| Cement/Asbestos | 100 | 280 | 380 | 120 | 200 | 320 | 60 | 180 | 240 | 50 | 150 | 200 |
| Asphalt | - | 200 | 200 | - | 125 | 125 | - | 100 | 100 | - | 75 | 75 |
| Other | 5 | 5 | 10 | 10 | 40 | 50 | 40 | 35 | 75 | 40 | 60 | 100 |
| | 1,755 | 875 | 2,630 | 2,050 | 1,075 | 3,125 | 2,310 | 1,230 | 3,540 | 2,570 | 1,455 | 4,025 |
| Total Cellulosic | 620 | 70 | 690 | 635 | 90 | 725 | 740 | 140 | 880 | 785 | 195 | 980 |

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(3) Construction Industry Data, Roofing and Siding Estimates, Nov. 1962, by J. D. DeLaughter, Elaschem Dept.

(4) The Sales Potential for V-T Fluorocarbon Finish in Exterior Applications, Feb. 1964, by H. Calvin Place, F. & F. Dept.

(5) "Tedlar®" Polyvinylfluoride Film Market Study, Oct. 1960, by Alderson Associates, Inc.

(6) A Market Potential Study for a New Pre-Finished "Low Maintenance" Residential Siding, Oct. 1961, by Stevenson, Jordan & Harrison, Inc., Management Engineers & Consultants.

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(8) Residential Siding Candidates, Aug. 1965, by A. R. Blakey, Jr., Development Department.

(9) Mill Finishing of Wood Siding Products for Use in Building Construction - A Market Survey, Dec. 1962, (R-62-88), by D. R. Strehlau, F. & F. Department.

TABLE II

POTENTIAL MARKET FOR DURABLE VEHICLES

Market: Factory-applied finishes for low rise residential cellulosic siding, soffit and gable.

| | 1965 | | | 1970 | | | 1975 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sq. Ft. (MM) | % | Lbs. Durable Vehicle (MM) | Sq. Ft. (MM) | % | Lbs. Durable Vehicle (MM) | Sq. Ft. (MM) | % | Lbs. Durable Vehicle (MM) |
| Total Surface Area-Cellulosic Substrates | 725 | 100 | | 880 | 100 | | 980 | 100 | |
| Factory-finished - liquid | | | | | | | | | |
| Durable | - | - | - | 40 | 4 | 0.2 | 80 | 8 | 0.4 |
| Less Durable | 16 | 2 | - | 120 | 14 | - | 240 | 25 | - |
| Factory-finished - other* | | | | | | | | | |
| Durable | 14 | 2 | 0.15 | 95 | 11 | 1.0 | 190 | 19 | 2.0 |
| Less Durable | - | - | - | 25 | 3 | - | 50 | 5 | - |
| Uncoated or semi-finished (i.e. primed, paper overlay, etc.) | 695 | 96 | - | 600 | 68 | - | 420 | 43 | - |
| | | | 0.15 | | | 1.2 | | | 2.4 |

Factory-finished - liquid

| Life** Expectancy (Years) | Type Finish | Material Cost (¢/ft² at 3 mil) | *** Total Cost (¢/ft²) | 1965 Sq. Ft. | 1965 % | 1965 Lbs. | 1970 Sq. Ft. | 1970 % | 1970 Lbs. | 1975 Sq. Ft. | 1975 % | 1975 Lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 - 6 | Urethane | 3 - 4 | 6 - 7 | 8 | 50 | - | 24 | 15 | - | 48 | 15 | - |
| 2 - 6 | Acrylic | 3 - 4 | 6 - 7 | - | - | - | 48 | 30 | - | 96 | 30 | - |
| 3 - 9 | Vinyl | 3 - 4 | 6 - 7 | 8 | 50 | - | 48 | 30 | - | 96 | 30 | - |
| 8 - 24 | Fluoropolymer (or equiv.) | 5 - 6 | 8 - 10 | - | - | - | 40 | 25 | 0.2 | 80 | 25 | 0.4 |
| | | | | 16 | 100% | - | 160 | 100% | 0.2 | 320 | 100% | 0.4 |

* Films and 100% solids materials (i.e. plastisols, polyesters, etc.)

** Years of exterior exposure with acceptable chalk/fading of colors.

*** Total cost to large builder includes material (1 mil topcoat and 2 mil primer) + application cost + coater's profit.

## TABLE III

### POTENTIAL MARKET FOR DURABLE VEHICLES

Market: Factory-applied finishes for non-residential (and high rise residential) aluminum and galvanized steel exterior Building Panels.

| | 1960 Sq.Ft. (MM) | 1960 % | 1960 Lbs. Durable Vehicle (MM) | 1965 Sq.Ft. (MM) | 1965 % | 1965 Lbs. Durable Vehicle (MM) | 1970 Sq.Ft. (MM) | 1970 % | 1970 Lbs. Durable Vehicle (MM) | 1975 Sq.Ft. (MM) | 1975 % | 1975 Lbs. Durable Vehicle (MM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Surface Area - All Materials* | 1,500 | 100 | | 1,800 | 100 | | 2,000 | 100 | | 2,200 | 100 | |
| Surface area - metal substrates with factory-finished-organic coatings | 180 | 12 | - | 325 | 18 | 0.1 | 460 | 23 | 0.5 | 600 | 27 | 1.0 |
| Surface area - all other substrates- (i.e. brick, stone, ceramic, steel, aluminum, wood, etc.) | 1,320 | 88 | - | 1,475 | 82 | - | 1,540 | 77 | - | 1,600 | 73 | - |
| | | | | | | 0.1 | | | 0.5 | | | 1.0 |

| | 1960 Sq.Ft. (MM) | 1960 % | 1960 Lbs. Durable Vehicle (MM) | 1965 Sq.Ft. (MM) | 1965 % | 1965 Lbs. Durable Vehicle (MM) | 1970 Sq.Ft. (MM) | 1970 % | 1970 Lbs. Durable Vehicle (MM) | 1975 Sq.Ft. (MM) | 1975 % | 1975 Lbs. Durable Vehicle (MM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Factory-finished-metal substrates-liquid | | | | | | | | | | | | |
| Durable | - | - | - | - | - | - | 40 | 9 | 0.2 | 80 | 13 | 0.4 |
| Less Durable | 180 | 100 | - | 310 | 95 | - | 370 | 80 | - | 420 | 71 | - |
| Factory-finished-metal substrates-other** | | | | | | | | | | | | |
| Durable | - | - | - | 10 | 3 | 0.1 | 40 | 9 | 0.3 | 80 | 13 | 0.6 |
| Less Durable | - | - | - | 5 | 2 | - | 10 | 2 | - | 20 | 3 | - |
| | 180 | 100 | - | 325 | 100 | 0.1 | 460 | 100 | 0.5 | 600 | 100 | 1.0 |

Factory-finished-metal substrates-liquid

| Life*** Expectancy (Years) | Finish Type | Material Cost (¢/ft² at 1 mil) | **** Total Cost (¢/ft²) | 1960 Sq.Ft. | 1960 % | 1960 Lbs. | 1965 Sq.Ft. | 1965 % | 1965 Lbs. | 1970 Sq.Ft. | 1970 % | 1970 Lbs. | 1975 Sq.Ft. | 1975 % | 1975 Lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-3 | Alkyd | 0.5-0.6 | 2.5-3.0 | 80 | 44 | - | 60 | 19 | - | 50 | 12 | - | 40 | 8 | - |
| 2-6 | Acrylic | 0.7-0.8 | 2.7-3.2 | - | - | - | 40 | 13 | - | 60 | 14 | - | 70 | 13 | - |
| 3-9 | Vinyl | 0.8-1.0 | 3.0-3.5 | 100 | 56 | - | 180 | 58 | - | 140 | 34 | - | 110 | 22 | - |
| 5-15 | Silicone-Alkyd | 1.0-1.2 | 3.5-4.0 | - | - | - | 30 | 10 | - | 120 | 30 | - | 200 | 41 | - |
| 8-24 | Fluoropolymer (or Equiv.) | 2.0-4.0 | 6.0-8.0 | - | - | - | - | - | - | 40 | 10 | 0.2 | 80 | 16 | 0.4 |
| | | | | 180 | 100 | | 310 | 100 | | 410 | 100 | 0.2 | 500 | 100 | 0.4 |

* Reference: Construction Review, U. S. Department of Commerce and "Tedlar®" Market Study by Alderson Associates, Inc., 1960.

** Organic films and 100% solids materials (i.e. plastisols, polyesters, etc.)

TABLE IV

POTENTIAL MARKET FOR DURABLE FINISHES

Market: Factory-applied finishes for low rise residential aluminum and galvanized steel siding, soffit and gable.

| | 1960 | | | 1965 | | | 1970 | | | 1975 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sq.Ft. (MM) | % | Lbs. Durable Vehicle (MM) | Sq.Ft. (MM) | % | Lbs. Durable Vehicle (MM) | Sq.Ft. (MM) | % | Lbs. Durable Vehicle (MM) | Sq.Ft. (MM) | % | Lbs. Durable Vehicle (MM) |
| Total Surface Area - Aluminum galvanized steel substrates | 350 | 100 | | 780 | 100 | | 995 | 100 | | 1,270 | 100 | |
| Factory-finished - liquid | | | | | | | | | | | | |
| Durable | - | - | - | - | - | - | 40 | 4 | 0.2 | 80 | 6 | 0.4 |
| Less Durable | 347 | 99 | - | 760 | 97 | - | 870 | 87 | - | 1,020 | 80 | - |
| Factory-finished - other* | | | | | | | | | | | | |
| Durable | - | - | - | 15 | 2 | 0.1 | 75 | 8 | 0.6 | 150 | 12 | 1.2 |
| Less Durable | 3 | 1 | - | 5 | 1 | - | 10 | 1 | - | 20 | 2 | - |
| | | | - | | | 0.1 | | | 0.8 | | | 1.6 |

Factory-Finished - Liquid

| Life** Expectancy (Years) | Finish Type | Material Cost (¢/ft2 at 1 mil) | *** Total Cost (¢/ft2) | 1960 Sq.Ft. | 1960 % | 1960 Lbs. | 1965 Sq.Ft. | 1965 % | 1965 Lbs. | 1970 Sq.Ft. | 1970 % | 1970 Lbs. | 1975 Sq.Ft. | 1975 % | 1975 Lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-3 | Alkyd | 0.5-0.6 | 2.0-2.5 | 245 | 71 | - | 190 | 25 | - | 137 | 15 | - | 110 | 10 | - |
| 2-6 | Acrylic | 0.7-0.8 | 2.2-2.7 | - | - | - | 494 | 65 | - | 548 | 60 | - | 550 | 50 | - |
| 3-9 | Vinyl | 0.8-1.0 | 2.5-3.0 | 102 | 29 | - | 76 | 10 | - | 91 | 10 | - | 110 | 10 | - |
| 5-15 | Silicone-Alkyd | 1.0-1.2 | 3.0-3.5 | - | - | - | - | - | - | 91 | 10 | - | 244 | 22 | - |
| 8-24 | Fluoropolymer (or Equiv.) | 2.0-4.0 | 5.0-7.0 | - | - | - | - | - | - | 43 | 5 | 0.2 | 86 | 8 | 0.4 |
| | | | | 347 | 100 | - | 760 | 100 | - | 910 | 100 | 0.2 | 1,100 | 100 | 0.4 |

* Films and 100% solids materials (i.e. plastisols, polyesters, etc.)

** Years of exterior exposure with acceptable chalk/fading of colors.

*** Total cost to large builder includes material + application cost + coater's profit.

TABLE V

POTENTIAL MARKET FOR DURABLE VEHICLES

Market: Industrial Maintenance - Exterior Finishes for existing and new buildings, bridges, ships, aircraft, railway, manufacturing plants, equipment and utilities (excluding traffic marking paint).

| | 1960 | | 1965 | | 1970 | | 1975 | |
|---|---|---|---|---|---|---|---|---|
| | Gallons (MM) | % | Gallons (MM) | % | Gallons (MM) | % | Gallons (MM) | % |
| Total Gallons | 100 | 100 | 120 | 100 | 140 | 100 | 160 | 100 |
| Exterior Finishes | 45 | 45 | 54 | 45 | 63 | 45 | 72 | 45 |
| Interior Finishes | 55 | 55 | 66 | 55 | 77 | 55 | 88 | 55 |

Exterior Finishes (Primers and Topcoats)

| Life(1) Expectancy (Years) | (2) Repaint Cycle (Years) | Type Finish | Finish Cost (¢/sq.ft. at 1 mil) | 1960 (3) % of Market | 1960 Lbs. Durable Vehicle (MM) | 1965 % of Market | 1965 Lbs. Durable Vehicle (MM) | 1970 % of Market | 1970 Lbs. Durable Vehicle (MM) | 1975 % of Market | 1975 Lbs. Durable Vehicle (MM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-3 | 3-10 | Miscellaneous (4) | 0.2-0.4 | 3.0 | | 3.0 | | 2.0 | | 2.0 | |
| 1-3 | 3-12 | Alkyd | 0.4-0.5 | 51.5 | | 47.0 | | 43.8 | | 40.3 | |
| 1-3 | 3-12 | Oil-base | 0.4-0.5 | 22.0 | | 19.0 | | 15.0 | | 9.0 | |
| 1-3 | 3-12 | Enamel (5) | 0.5-0.6 | 9.0 | | 9.0 | | 10.0 | | 10.0 | |
| 2-6 | 3-15 | Latex (6) | 0.6-0.7 | 5.0 | | 10.0 | | 12.0 | | 16.0 | |
| 3-9 | 3-20 | Vinyl (7) | 0.8-1.0 | 2.0 | | 3.0 | | 5.0 | | 7.0 | |
| 1-3 | 3-12 | Epoxy (8) | 0.8-1.2 | 4.0 | | 5.0 | | 6.0 | | 7.0 | |
| 2-6 | 3-15 | Miscellaneous (9) | 0.8-1.0 | 3.0 | | 3.0 | | 4.0 | | 5.0 | |
| - | 10-20 | Inorganic Zinc (Primer) | 2.3-2.7 | 0.5 | | 1.0 | | 2.0 | | 3.0 | |
| 8-24 | 10-20 | Fluoropolymer (or equivalent) | 2.0-4.0 | - | | - | | 0.2 | 0.3 | 0.7 | 1.0 |
| | | | | 100.0 | 0 | 100.0 | 0 | 100.0 | 0.3 | 100.0 | 1.0 |

Notes:
(1) Years of exterior exposure with acceptable chalk/fading of colors.
(2) Years of exterior exposure with acceptable substrate protection.
(3) % of market based on gallons.
(4) Includes low-priced finishes based on bitumin, asphalt, rosin, etc.
(5) Primarily higher cost alkyds, with improved appearance (i.e. higher gloss and properties.
(6) Includes emulsion finishes based on vinyl acetate, styrene/butadiene, and acrylic.
(7) Finishes based on vinyl chloride-acetate copolymers (primarily PVCl).
(8) Includes modified and unmodified epoxy coatings.
(9) Includes medium priced finishes based on chlorinated rubber, polyurethane, polyester, chlorosulphonated polyethylene, acrylic, etc.