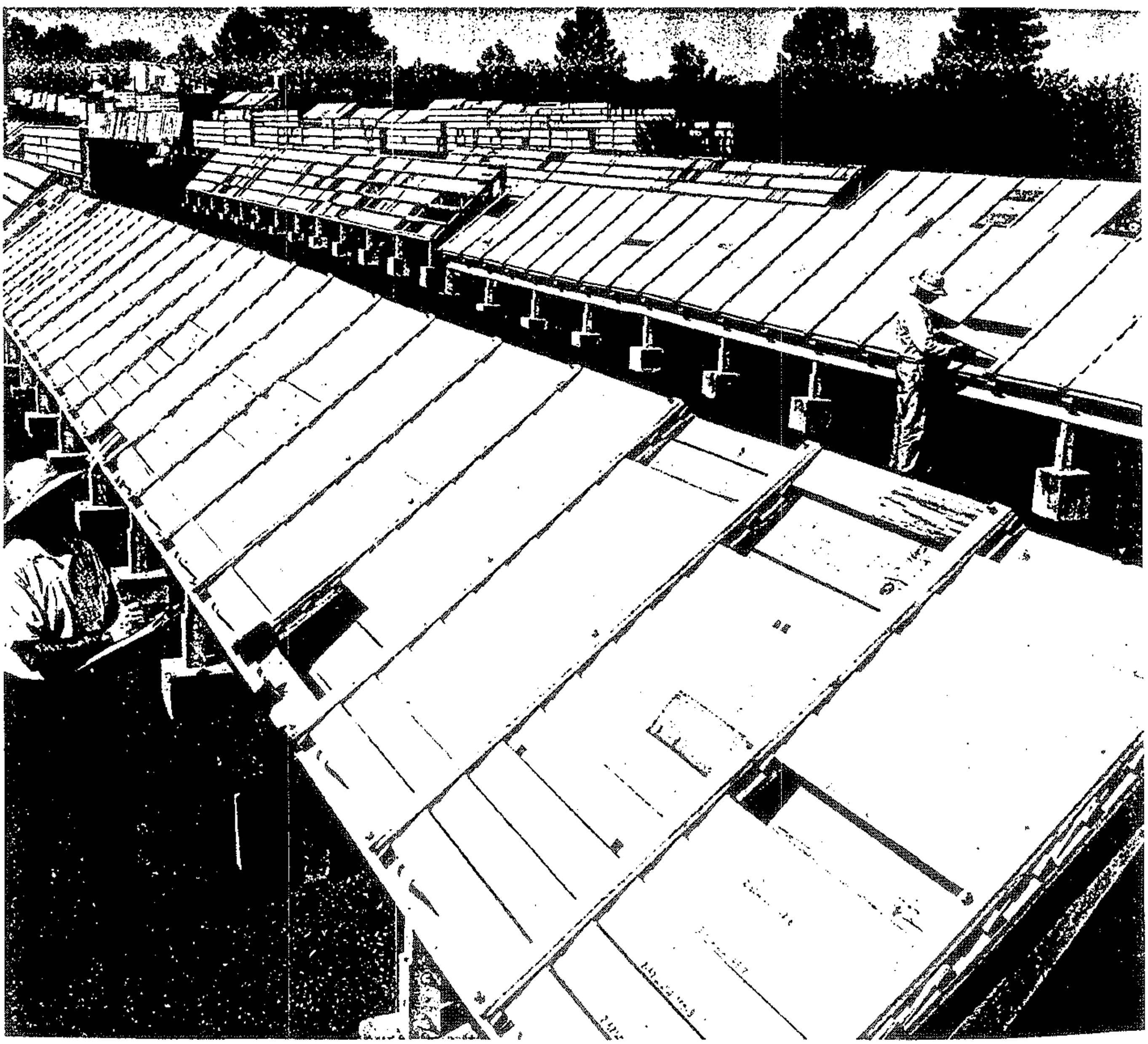

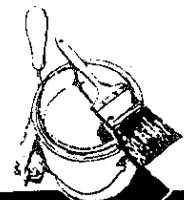

FOREWORD TO 11th ANNUAL PROGRESS REPORT

Eleven years have now elapsed since the first 100-percent acrylic emulsion vehicle, Rhoplex AC-33, was introduced to the paint industry. This emulsion polymer provided a tough, flexible, color-retentive film and was designed primarily for masonry surfaces. Rhoplex AC-33 was followed in 1961 by Rhoplex AC-34, specifically designed for paints to be used on wood surfaces. Use of these emulsion polymers has continued to expand.

Progress Report No. 11 is devoted to summaries and conclusions from our large-scale panel and house test program on acrylic emulsion paints and from commercial experience in the field. Tabular data on the many exposure series included in earlier issues of the Progress Report are not given this year because of the mass of the data.

Paint manufacturers are invited to examine in detail the many panel and house exposures in the Philadelphia area which comprise the basis for the conclusions and formulations given in this report.

General view of the Newtown Test Farm showing exposure of paints made with the Rhoplex emulsions. Paint manufacturers are invited to inspect these panels.

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Characteristics and Treatment of Surfaces Commonly Painted

Acrylic emulsion house paints are being successfully applied to an ever-increasing variety of substrates. These surfaces differ greatly in their condition and have different performance requirements. Therefore, the number of suggested formulae has been increased to cover the wide range of surfaces involved. Earlier systems were designed for good general overall service and were too limited in number to give an optimum cost-performance balance for all substrates. In this section the more common of these painting surfaces will be discussed with recommendations for surface preparation and suggested starting formulations.

Repaint Substrates

Previously Painted Wood

Sound Non-Chalking and Glossy Surfaces

The main problem in repainting gloss paints and aged but unweathered surfaces found under eaves and in other protected areas has been that of obtaining satisfactory adhesion. This is particularly true under wet conditions. Rhoplex AC-34 is renowned for its excellent adhesion to oil paints and primers under either wet or dry conditions and has eliminated such surfaces as a serious problem, as may be seen in Figure 1. However, proper surface preparation is essential to attain maximum adhesion and durability. Surfaces should be cleaned of all dirt and mildew, and surface gloss or oily deposits should be removed by either chemical or physical means, using sandpaper or solvent-type cleaners. Iron nailheads should be countersunk and puttied or primed with an oil paint before the Rhoplex AC-34 paint system is applied; otherwise, rust will bleed through the topcoats. Any of the suggested topcoat formulations can be used successfully, and will give satisfactory performance over a properly prepared surface. Selection of the particular formula will depend on the desired cost-performance relationship.

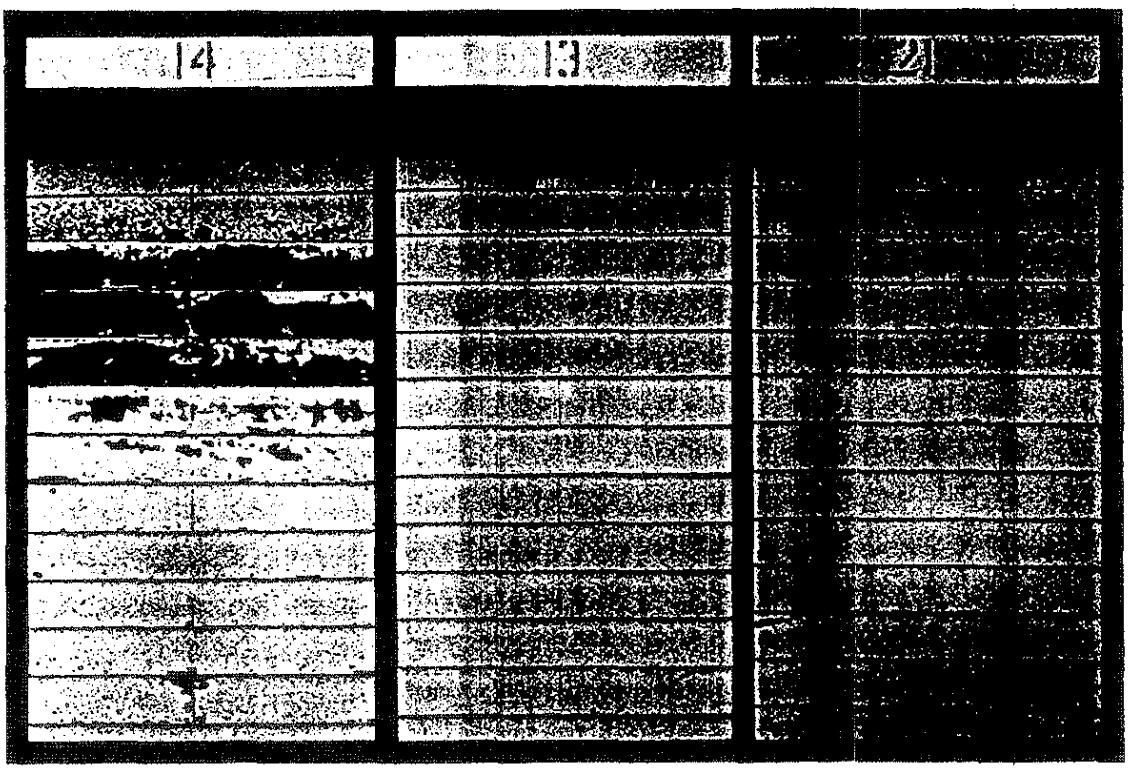

FIGURE 1. Test fence (facing north) consisting of white pine clapboards topped by eave with an 18-inch overhang. Clapboards were first painted with an oil primer, then given two coats of dark green oil-type gloss (non-chalking) trim paint. The finish was weathered one year and then given two coats of an emulsion paint (35 PVC tint base) without surface preparation. Emulsion paint on left has polyvinyl acetate copolymer vehicle; in center, Rhoplex AC-34; on right, vinyl acetate copolymer. Photo shows condition after three years' exposure.

Sound Chalky Surfaces

How well a paint performs over chalk is a function of the type of chalk, degree of chalk, weather conditions at time of application and the formulation involved. Experience with Rhoplex AC-34 paints over standard self-cleaning oil and emulsion house paints on test panels, test houses and in actual commercial applications has been very satisfactory. Although many of these tests have been conducted on undisturbed chalky surfaces, for optimum performance under all application conditions preliminary surface preparation is recommended. Surface preparation not only insures maximum performance, but also guards against failures due to unusual or problem substrates or weather conditions, and permits successful application of a wider variety of lower cost, high pigment volume content formulations.

As a further safeguard against loss of adhesion on chalky surfaces, some paint manufacturers modify the first coat of an emulsion paint with oil or alkyd. This is done either through modification of the prepared paint, or through an oil or alkyd addition at time of application. Formulation 204, given in the formulation section of this report, is an example of a product that can be used for this purpose. Such materials give some improvement in adhesion over chalky surfaces, but with some reduction in the wet-adhesion characteristics of Rhoplex AC-34. They should not be used in topcoats, where they may cause early color fading and increase dirt collection and mildew.

There are various types of chalks, not normally found on wood, which are difficult for emulsion paints to penetrate and bind properly, and these are discussed in a later section.

The degree or rate of chalking is important because it is an indication of the sponginess or porosity of the old paint film. Chalk has a definite water demand. This results in a strong wicking force which rapidly extracts the water from new paint, causing the film to form on the surface rather than penetrating to the substrate. This is true of all porous surfaces, and they should be prewetted with water and the Rhoplex paints applied to the damp surface.

Weather conditions can also have a pronounced effect on the drying speed of the paint. If the paint dries too fast, penetration is reduced. The influence of low humidity, dry breezes and direct sunlight in causing premature film formation will be minimized by proper surface preparation.

Formulation is a major factor in the exterior performance of a paint. Thickener level, solids content and pigment volume content can all affect the wicking and drying rates of a system, as well as its water sensitivity. Paints with low pigment volume content, high solids and low thickener content insure maximum performance. With proper surface preparation, however, all of the appropriate suggested starting formulations will provide a high degree of satisfactory performance.

The best procedure for preparing the surface consists of a thorough washing with plain water, rinsing and applying the emulsion paint while the surface is still damp. Any exposed nailheads should be treated before painting as described earlier.

Unsound Surfaces

In this category are those previously painted surfaces which show signs of inadequate adhesion such as cracking, flaking, peeling, lifting or blistering. The only method of preventing a continuation of these failures is the removal of the poorly adhering coating to obtain a sound surface.

Photo A in Figure 2 shows a weathered oil-painted surface with some cracking and peeling. However, considerably more of the paint is already loose and, when scraped, can readily be removed from the surface. The condition after dry scraping is shown in photo B. These photographs illustrate the need for careful surface preparation to avoid subsequent adhesion failures after the surfaces have been repainted.

Reoccurrence of failure due to a poorly adhering paint film can be minimized through application of the more highly pigmented emulsion paint systems. These coatings relieve localized stresses because of their reduced film continuity and flexibility, since less binder is present. Oil-based paint films which are readily oxidized and become brittle are subject to fine cracking and checking. With oil paints the poorly adhering layer will continue to loosen, crack and flake, and re-establishment of a good sound surface will be a difficult and tedious job.

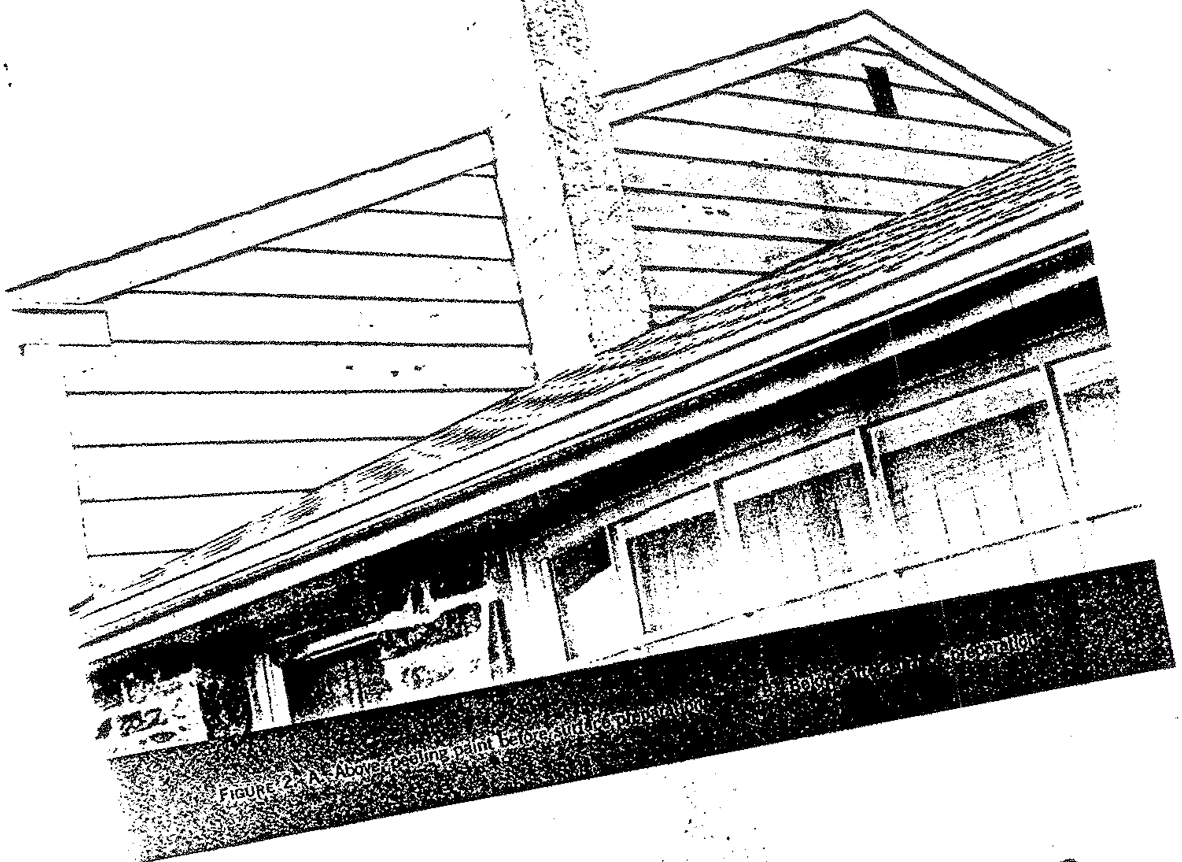

FIGURE 2. A. Above: peeling paint before surface preparation. B. Below: [illegible] preparation.

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Although scraping is recommended, it is realized that complete removal by this method is not always easily accomplished. Quite possibly the old paint not removed may continue to show a loss of adhesion, regardless of the paint used for recoating. The time involved for the appearance of this additional failure is usually several years, and spot patching of these areas, should they appear, is commonly employed.

As sound a surface as possible should be reestablished, including the puttying or priming of exposed nailheads as described previously. If the surface is bare wood, one of the suggested Rhoplex AC-34 bare-wood primers should be used, followed by a suitable topcoat system.

Mildew

Surfaces with mildew growth should first be washed thoroughly with Clorox or an equivalent product at a concentration of one pint per gallon of water, then rinsed by hosing with clear water. The substrate is then considered a sound repaint surface and is treated as described earlier.

Knots

Knots in a substrate are a problem for two reasons: (1) they may become loose and cause paint film rupture, and (2) they contain high concentrations of tannins which stain the paint. Nothing short of removal of the knot can guarantee no loosening. Shellacking tends to contain the tannins and prevent staining if the knot does not move and break the shellac film.

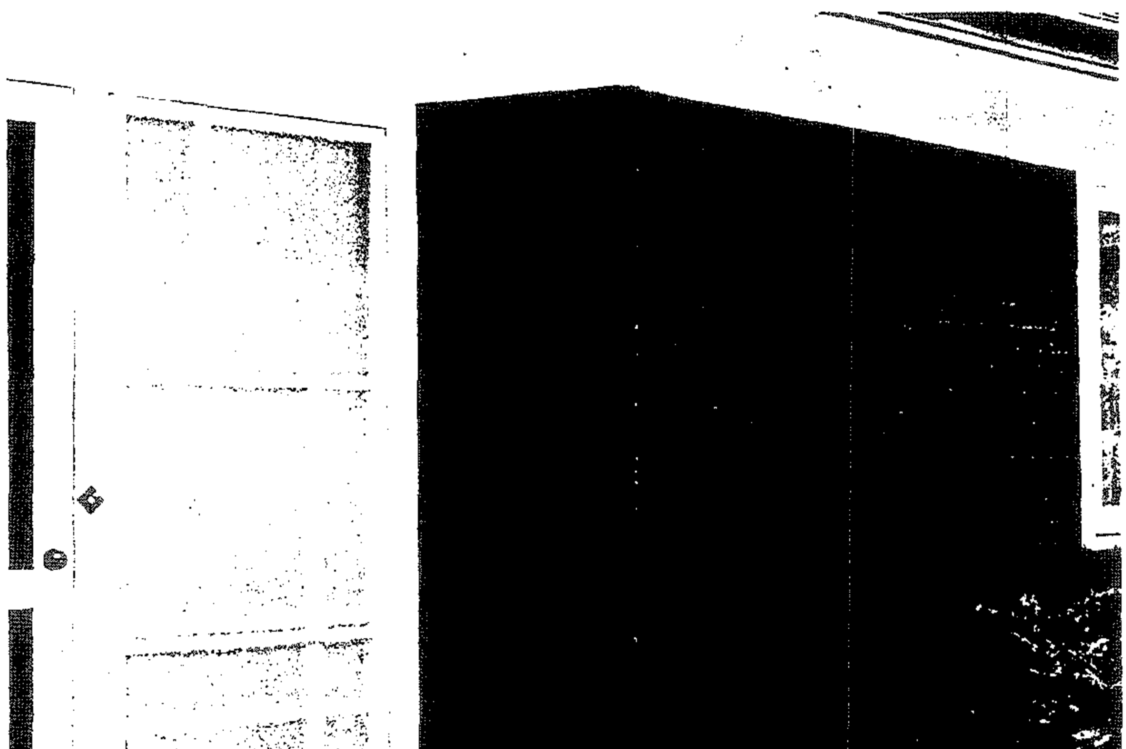
Previously Painted Masonry and Cement Asbestos Shingles

Sound Repaint Masonry Surfaces

These substrates should be treated in the same manner as sound surfaces on previously painted wood. In addition, the lower cost, 55-percent pigment volume content Formulation 309 may be used over these dimensionally stable surfaces.

The excellent results possible when sound masonry surfaces are repainted with Rhoplex-based paints are illustrated by the house front pictured in Figure 3.

FIGURE 3. Excellent adhesion and color retention are shown on sound repaint masonry surface in this six-year exposure.



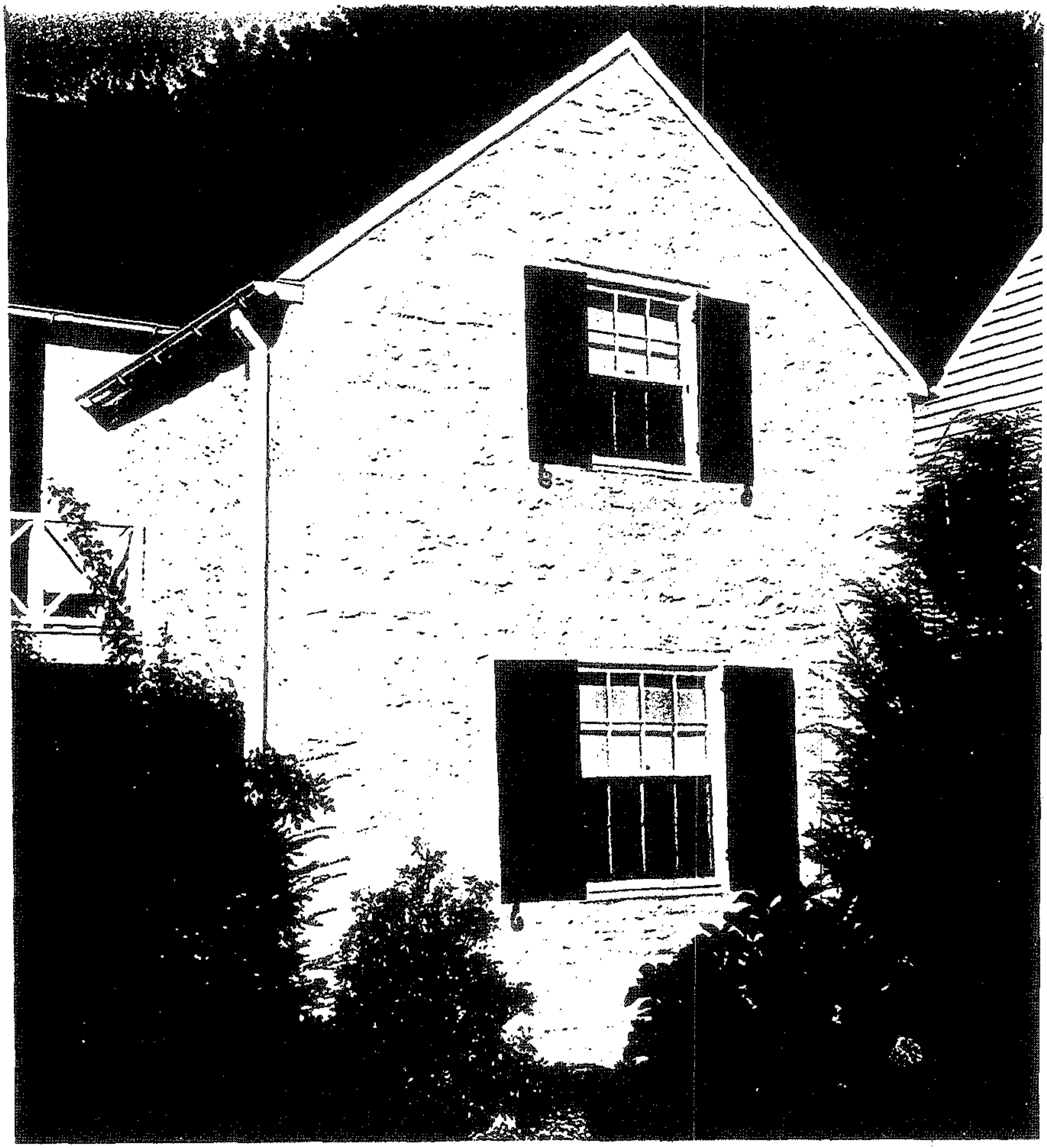


FIGURE 4. Rhoplex paint over cement paint which had been surface-conditioned by a coat of clear Rhoplex emulsion. This photo was made eight years after painting. However, sandblasting would have been a safer method of preparation.

Cementitious Coatings

This group includes the lime, whitewash and so-called artificial or synthetic chalks. In general, these surfaces are dangerous to repaint since they continue to disintegrate or deteriorate under the new paint. This results in poor adhesion with the passing of time even if apparently good adhesion is obtained initially. Satisfactory service with Rhoplex AC-34 systems is often obtained over these surfaces, as may be seen in Figure 4. However, the incidence of problems and paint failures associated with these chalks is high.

These chalks sometimes contain materials which are not efficiently wetted by water, leading to loosely bound aggregates which crumble or lose adhesion readily. The water demands of such porous surfaces are very high and lead to excessive wicking and premature drying of the paint film on the surface. Predampening the surface and/or diluting the first coat of paint often helps penetration and performance. There is no foolproof method of repainting heavily chalking cement surfaces, and they must be removed by sandblasting to obtain a nondisintegrating substrate.

Aged Cement Asbestos Surfaces

If the original coating is intact, the cement asbestos surface may be treated as a sound repaint surface.

If the shingle or board itself has begun to disintegrate, exposing fibrous material, but is still in fair condition, a problem similar to that described under Cementitious Coatings may exist. Predampening the surface or diluting the first paint coat with water often yields satisfactory performance.

For a high degree of degradation, those problems associated with cement coatings are present, and there is no foolproof method of preventing continuing failure. Best performance under these circumstances is achieved through the penetration and binding of the substrate with a surface conditioner prior to application of the topcoat paint.

When the above substrates have been properly prepared, all of the suggested formulations will provide a high degree of good performance. Because of the relative dimensional stability of cement asbestos surfaces, the lower cost, 50- and 55-percent pigment volume content Formulations 308 and 309 may be of special interest.

Unpainted Substrates

Wood

Wood has a number of characteristics which are potentially detrimental to the performance of a paint applied to it. For example, the dimensions of wood vary with its moisture content. The degree of this fluctuation is not uniform across a board; consequently, for long-term satisfactory performance, any coating applied to wood must be sufficiently flexible to withstand dimensional fluctuation without rupturing or losing adhesion.

In addition to picking up moisture, the structure of most woods is such that moisture is readily transmitted through the panel. This property is of special significance in cold weather, when the temperature gradient from the interior of a house to the outside surfaces provides a driving force for moisture transmission. The result of this phenomenon is a tendency for blister formation, which has been a serious problem with oil paints. A desirable property in a paint, therefore, is adhesion to the substrate under wet conditions.

Many types of wood contain extractable color bodies, saps, tannins, rosin, etc., which can adversely affect their coatability and the appearance of the paint system.

Of all the vehicles used in exterior coatings, regardless of type, Rhoplex AC-34 contains the best balance of properties necessary for maximum performance in the presence of these problem conditions. Its all-acrylic backbone insures long-term durability and retention of flexibility. Its outstanding wet adhesion and blister resistance have made it the standard for the paint industry.

Exposures of up to 11 years' duration of paints based on the Rhoplex emulsions dramatically illustrate the outstanding general durability and retention of elasticity of acrylic polymers. Seven years of exposure experience with Rhoplex AC-34 have confirmed its superior durability, resistance to grain cracking, flaking and blistering and wet adhesion over oleoresinous and wood substrates.

A stain-resistant primer, Formulation 305, has been developed for cedar and redwood. These woods are relatively dimensionally stable and do not require coatings with the degree of grain-crack resistance necessary for white or yellow pine.

Although until recently acrylic primer formulations have not been purposely developed for nonstaining types of bare wood, all published Rhoplex AC-34 exterior systems have been routinely tested on such surfaces. The results have been so outstanding we do not hesitate to recommend application of Rhoplex AC-34 primers to new or bare wood. Formulation 304, with which we have considerable experience including over four years' south 45° exposure on southern yellow pine, has been adopted as a suggested starting primer for nonstaining woods. Typical test panels from this exposure series are pictured in Figures 5 and 6. Note that none of the Rhoplex AC-34 self-primed panels shows any grain cracking or flaking.

Formulation 303 has been designed specifically for bare wood surfaces. However, exterior exposure experience with this new formulation is limited.

Although primers of this type have been tested with only one topcoat, for ultimate performance two should be applied. The topcoat formulation should be selected on the basis of the nature of the wood and the desired performance. The greater the cracking forces in the wood and the longer the desired durability, the higher should be the level of free binder in the formulation. In general, two coats of any of the published suggested starting formulations (except Formulation 309, recommended for masonry only) will give excellent service.

Using Rhoplex AC-34 paints from priming the bare wood to applying topcoats takes fullest advantage of the blister resistance, grain-crack resistance and durability of this acrylic vehicle. In addition, such a system provides a sound repaint surface which will retain good adhesion and avoid the failures described under Unsound Surfaces.

The use of basic silicate of white lead, as in Formulation 305, minimizes stain-through when cedar and redwood are painted. The primer will discolor, but this is not normally transmitted to the topcoat. Occasionally, boards may be encountered which are very oily. These may require two coats of primer to completely seal off all the stain bodies.

If water flows down the unpainted back of a staining-type wood panel and then over a lead-containing coat, a relatively long-lasting discoloration may occur. Therefore, a topcoat without lead content is recommended.

It is extremely important to use the proper dispersant and to test carefully the stability of lead-containing paints.

Masonry

This category includes previously unpainted concrete, stucco, cement asbestos siding and cinderblock. The main problems encountered with these substrates are related to their alkalinity, porosity or water demand and their surface texture.

Acrylic emulsions are not subject to the hydrolysis or saponification which occurs with most other vehicles. It is essential, for the reasons previously discussed, to satisfy the water demand of these substrates. Highly porous cinderblock may often require a fill coat to seal and smooth the surface. Generally, two coats of any of the suggested topcoat formulations are sufficient for highly durable performance.

Galvanized Surfaces

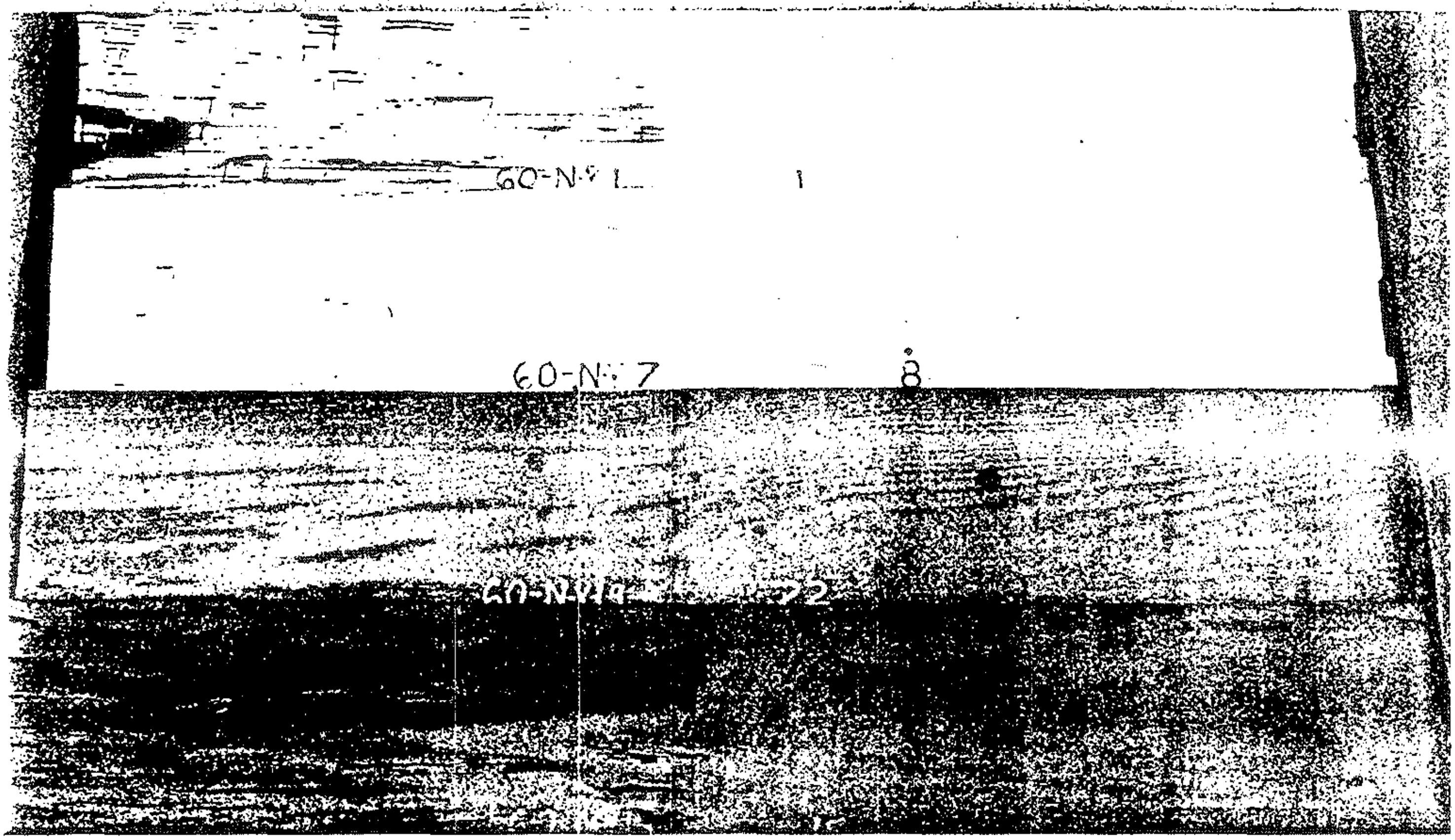
Galvanized steel is one of the increasing variety of substrates which have been coated successfully with Rhoplex AC-34 house paints.

Most new galvanized metal is given a surface treatment to prevent "white rust". Although experience indicates it is not always necessary, in order to insure maximum paint adhesion this coating should be removed before painting. Sometimes wiping with mineral spirits is helpful. An alternative is exterior aging of the galvanized metal for at least 6 months.

Acrylic emulsion paints retain a very high percentage of their original flexibility for extended periods of time. Therefore, they will expand and contract with the metal as temperature changes. Oleoresinous coatings dry by oxidation and become brittle with time; therefore, they cannot flex with the metal and experience early cracking and flaking. Application of Rhoplex AC-34 paints to the bare metal is essential for best results.

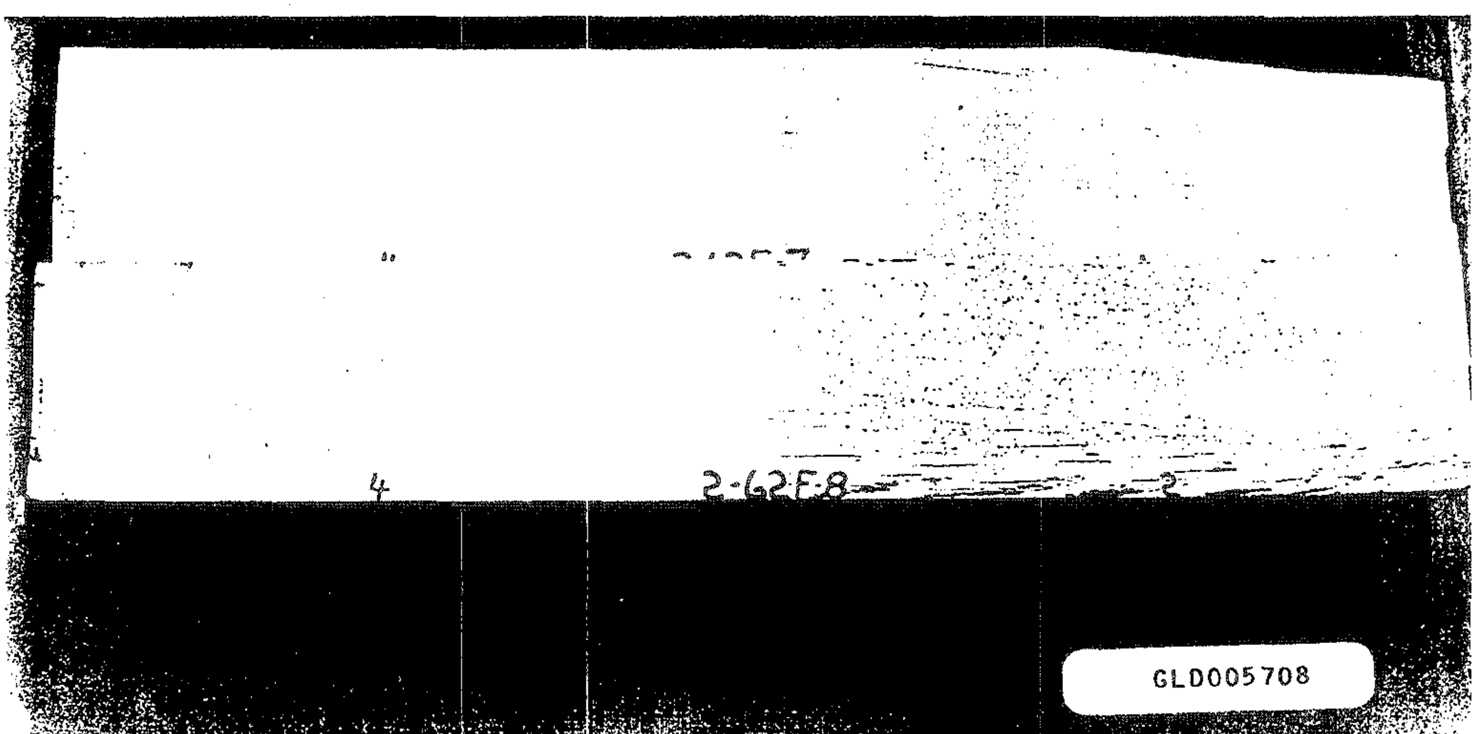
No special formulations have been developed for this surface, but 30- to 40-percent pigment volume content house paints have been utilized with very satisfactory results.

Present experience on galvanized metal with paints having a pigment volume content higher than 40 percent is limited. Although the flexibility of a paint film will be somewhat reduced as pigment volume content is increased, these systems show enough promise to encourage manufacturers to test them.



↑ FIGURE 5. Four-year south 45° exposure of Rhoplex AC-34 paint, self-primed, on yellow pine. Note the resistance to *grain cracking of Rhoplex AC-34 on right compared to paints* made with Rhoplex AC-33 on left.

↓ FIGURE 6. Rhoplex AC-34 paint on left versus solubilized linseed oil emulsion paint on right after two years' self-*primed south 45° exposure on yellow pine. Note the excel*lent whiteness and resistance to grain cracking of the Rhoplex AC-34 paint.



Dispersion, Pigmentation and Colorants

Hiding, stability, chalk resistance, tint retention, in fact all phases of performance of a paint, are dependent upon the quality of the pigment dispersion. Although pigment dispersion may be good initially, uniformity of the dispersion may decrease with age if it is not properly prepared. A high percentage of the complaints concerning poor performance of a paint can be attributed to lack of good pigment dispersion stability. For this reason, accelerated stability tests such as freeze-thaw, heat stability, color rub-ups and lap tests are of extreme importance in assessing the long-term quality of a paint.

Any ingredient used in the preparation of a paint can affect its stability and performance characteristics. It is for this reason that the effect of every ingredient substitution or addition should be assessed separately.

Concentration-Aggregation Test

Each prime pigment and extender requires a certain amount of material to disperse it properly. The amount of dispersant required for each pigment or extender varies widely depending on the grade, type and manufacturer. In addition, the presence of too much or too little dispersant will be detrimental to the stability of pigment dispersions.

Our laboratory has devised a titration method for determining the maximum dispersant requirement of any pigment or extender, or of combinations of pigments and extenders.

In this method, 50 grams of pigments or extenders is mixed with sufficient water so that a stiff, slightly moist mass forms. The dispersing agent, in water solution, is then added in small increments with thorough mixing. When the pigment mass becomes fluid enough so that surface ripples disappear on gentle shaking of the container, the pigment is deflocculated.

A small portion of the pigment system (about 1 cc.) is then removed and placed in a watch glass. To this small portion an ionic thickener is added. A suitable thickener is Acrysol GS. The quantity added is not critical, but in our work from 2 to 3 drops of Acrysol GS reduced with water to 6-percent solids was used. This quantity of ionic additive is sufficient to cause severe flocculation or even gelation of the pigmented system if the amount of dispersant used was insufficient.

Additional dispersant should then be added to the main dispersion and another small portion tested in the same fashion. Test results using a variety of pigments in this method are shown in Table I.

The dispersant demand percentages in Table I constitute a change from values listed in previous Progress Reports. This is due to the adoption of an improved method of translating the results of the concentration-aggregation test to use in practice.

The titrating solution was at 10-percent solids and contains Tamol 731 and Triton CF-10 at a solids weight ratio of 1:1. In the past, the published percent dispersant solids value reflected the total solids used (i.e., Tamol 731 and Triton CF-10). Now, in order to simplify the use of the method, the assumption is made that Triton CF-10 has no activity as a pigment dispersant. The values in Table I reflect only the percent of Tamol 731 solids required by each pigment.

As previously noted, the values in Table I constitute maximum dispersant requirements. In practice, it has been found that good dispersion may be achieved with lower quantities. In white paints, about 62 to 70 percent of the theoretical total dispersant requirement is needed. In tint bases, the percentage is often higher (up to about 80 percent) to promote better acceptance and development of colorants.

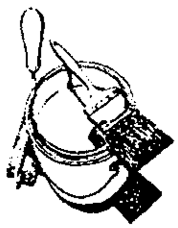


TABLE 1

Dispersant Demands of a Number of Pigments and Extenders for Tamol 731 (25%)

Pigment (50 gm.)	Amount of Water Added (cc.)	Dispersant Solution[1] Required for Dispersion in the Presence of Acrysol GS (cc.)	Percent of Tamol 731 Solids Based on Dry Pigment
Barytes #1	8	2.4	0.24
Calcium Carbonate			
Atomite	18	3.0	0.30
Duramite	18	0.2	0.02
Purecal O	38	3.0	0.30
Snowflake	14	2.0	0.20
Suspenso Whiting	17	1.8	0.18
Clay (ASP-400)	26	10.0	1.00
325 Mica	32	9.0	0.90
Silica			
Silver Bond B	15	4.5	0.45
1160	17.5	2.8	0.28
Talc			
Asbestine 3X	27	5.5	0.55
Nytal 300	30	6.5	0.65
Rutile Titanium Dioxide			
Ti-Pure® R-610	24	12.0	1.20
Titanox RANC	23	15.0	1.50
Ti-Pure® R-901	21	24.2	2.42
Ti-Pure® R-902	20	25.7	2.57
Anatase Titanium Dioxide			
Ti-Pure® FF	32	24.0	2.40
Titanox A-168LO	35	18.5	1.85
Zinc Oxide			
Kadox 515	45	12.5	1.25
AZO-ZZZ-11	40	15.8	1.58
Iron Oxide			
Kroma Red (RO-8097)	17	3.8	0.38
Red (R-2899)	30	4.1	0.41
Brown (Hoover #7565)	36	9.6	0.96
Yellow (YLO-4088)	35	10.2	1.02
Germantown Lamp Black	112	21.3	2.13
Nickel Titanate (Sun Yellow C)	24	2.2	0.22

[1] A 1:1 solids mixture of Tamol 731 (25%) and Triton CF-10 at 10% total solids in water.

For example, the pigmentation of Formulation 306 is as follows:

Material	Pounds	Unit Dispersant Demand, %	Tamol 731 Solids Required, Pounds
Ti-Pure® R-610	240	1.2	2.88
Ti-Pure® FF	10	2.4	0.24
Asbestine 3X	100	0.6	0.60
Snowflake calcium carbonate	110	0.2	0.22
Total Concentration-Aggregation level (Tamol 731 solids)			3.94 lb.
Tamol 731 (25%) required at Concentration-Aggregation level			15.76 lb.
Tamol 731 (25%) used in F-306 (68.6%)			10.7 lb.

A wetting agent is required to realize maximum dispersant efficiency. The level of Triton CF-10 used in a paint formula will be determined by consideration of the specific pigmentation, as well as the brushing and drying characteristics of the paint. In order to minimize the water sensitivity of the paint film, excessive quantities of wetting agent should be avoided. In practice, between 1 and 3 pounds of Triton CF-10 per 100 gallons of paint is sufficient, with 1.5 to 2.5 pounds per 100 gallons being the amount normally used.

Tamol 731 (25 percent) is normally the dispersant chosen because of its excellent performance and high efficiency with a wide range of pigments and extenders. Triton CF-10 exhibits efficient wetting characteristics coupled with low foaming characteristics.

Reactive Pigments

For those instances when a reactive pigment such as basic lead silicate or zinc oxide is incorporated, Tamol 850 (30 percent) has demonstrated superior performance as the dispersant, imparting improved stability to such a system. The dispersant demands of a number of pigments for Tamol 850 are listed in Table II. Because of its limited use in Rhoplex paints, no specific percentage limits of the theoretical levels have been determined. Tamol 850 (30 percent) is relatively poor for dispersion of organic pigments.

Incorporation of Colorants

Water-Dispersed Colorants

These are designed for use in emulsion paint systems and generally give no problems in color acceptance and color development.

Universal Colorants

Colorants of this type are designed to be incorporated into both water-thinned and oleoresinous coating systems. Because of this, they generally leave something to be desired in performance with either system and special formulation techniques are needed. California Ink 8800 and the Rockcote 7600 line of colorants, however, have given particularly good results with paints based on Rhoplex AC-34 and should be considered if color problems are encountered.

A combination of morpholine and soya fatty acids (MSFA) has been useful in improving the performance of most universal colorants with Rhoplex paint formulations. The levels and techniques involved in using morpholine and soya fatty acids are somewhat different from those for Tamol 731 (25 percent).

Determination of dispersant demand values with morpholine and soya fatty acids has been complicated by the inability of the ionic thickener to wet and thus flocculate the dispersion. Empirical methods for arriving at a proper dispersant content have, therefore, been employed. Early work with Formulation 247 at 35-percent pigment volume content indicated that between 12 and 22 pounds of morpholine and soya fatty acids per 100 gallons yields a universal tint base having excellent shelf, heat and freeze-thaw stabilities. The precise level of morpholine and soya fatty acids used in a specific case is normally dictated by the behavior of a given universal colorant line in color acceptance and development.

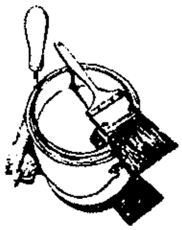


TABLE II

Dispersant Demands of a Number of Pigments and Extenders for Tamol 850 (30%)

Method: The basic method described on page 11 was employed. Best results were obtained by adding 4 drops of 5% aqueous Triton X-102 (wetting agent) just after the initial water, and titrating with 5% aqueous Tamol 850.

Pigment (50 gm.)	Amount of Water Added (cc.)	Dispersant Solution[1] Required for Dispersion in the Presence of Acrysol GS (cc.)[2]	Percent of Tamol 850 Solids Based on Dry Pigment
Basic Lead Silicate			
EP-202	26	4.1	0.41
Oncor 45X	20	0.3	0.03
Calcium Carbonate			
Atomite	17	2.6	0.26
Purecal O	36	2.9	0.29
Snowflake	15	1.0	0.10
Suspenso Whiting	17	1.5	0.15
325 Mica	64	4.4	0.44
Silica			
Silver Bond B	20	0.4	0.04
1160	25	0.3	0.03
Talc			
Nytal 300	42	2.7	0.27
Rutile Titanium Dioxide			
Ti-Pure® R-610	24	6.1	0.61
Titanox RANC	23	5.1	0.51
Ti-Pure® R-901	23	10.2	1.02
Ti-Pure® R-902	22	11.7	1.17
Anatase Titanium Dioxide			
Ti-Pure® FF	36	5.3	0.53
Titanox A-168LO	35	3.3	0.33
Zinc Oxide			
Kadox 515	45	5.9	0.59
AZO-ZZZ-11	45	1.5	0.15

[1] Tamol 850 at 5% total solids in water.
[2] This is a maximum. Lower quantities are used in practice.

During the course of our work with universal colorants, several other pertinent observations were made:

1. For complete neutralization of soya fatty acids with morpholine, a fatty acids-morpholine ratio of 70 parts to 30 parts by weight is sufficient. For best results, the temperature of this exothermic reaction should be maintained below 105°F.

2. For additional improvement of the acceptance and development of some universal colorants, the use of extra morpholine (up to 50 percent by weight of the MSFA employed) has proved helpful. This morpholine may be incorporated into the MSFA during its preparation.

3. As an aid in minimizing the viscosity drop often encountered when using high levels of certain colorants, incorporation of up to a maximum of 6 pounds of Acrysol G-110 (22 percent) per 100 gallons of paint is suggested.

4. As the pigment volume content of a universal tint base is increased, the minimum MSFA level must also be increased slightly (by about 1 to 2 pounds per 100 gallons for each 5-percent pigment volume content increase).

5. As the titanium dioxide level of the tint base is reduced, the range of MSFA used should be decreased proportionally, holding the formulation constant in all other respects.

6. Another method of obtaining a preliminary starting weight of MSFA is to determine the proper Tamol 731 solids level according to the procedures described above, then use approximately 4.25 to 5.25 times this value. The precise level should be adjusted to obtain satisfactory tint base stability and color development. It is still desirable to add the excess morpholine mentioned above.

7. Although much higher levels of predispersed colorants are often used in practice, a maximum of 4 fluid ounces per gallon is recommended for optimum performance and durability. A more desirable method of producing deeper colors is to reduce the titanium dioxide level; this both improves durability and reduces costs.

Pigment-Binder Relationships

Every pigment or combination of pigments requires a specific amount of vehicle to cement all the particles and to form a continuum of binder. This fixed value is known as the system's binder demand. The performance of a paint film (i.e., its tint retention, chalk resistance, dirt pickup and grain-crack resistance) depends on the actual level of binder used relative to the system's binder demand. This can be most accurately determined by actual service tests. Pigment volume content is not a measure of this binder to pigment relationship because it considers only total volume of pigment and does not take into account the number of pigment particles, their shape, surface characteristics or surface area.

The difference in performance between large and small particle size extenders, at constant pigment volume content, has been recognized for years. Yet, even average size can be misleading since it does not take into account the number of particles, their shape or the magnitude of the particle size distribution curve. For example, at constant pigment volume content the level of titanium dioxide, solids level, and type and size of the extenders can all significantly affect the performance characteristics of a paint.

Titanium Dioxide

Titanium dioxide has the greatest binder demand of the more commonly employed pigments. The higher the level of titanium dioxide, the more binder (via lower pigment volume content and/or higher solids) is required to maintain resistance to chalking, erosion and fading and promote general durability. The types and levels of titanium dioxide used in the published formulations are based on exposure experience with the chalk-resistant sulfate grades such as Ti-Pure R-610, Titanox RANC and Unitane OR-640, and free-chalking anatases such as Ti-Pure FF and Titanox A-MO. Substitution with other grades should be made in accordance with the recommendations of their manufacturers.

Extenders

Every extender has some characteristics, physical or chemical, which make it unique. There are chemical differences between calcium carbonates, clays, talcs and zinc oxides. Each one of these classes will impart different performance properties to a given paint. Also, the physical characteristics of the various types as well as the physical variations within a class can produce significant performance differences in a given paint.

As mentioned previously, the binder demand of an extender is related to its shape and the number of particles per unit of volume. Average particle size does not take these factors or particle size distribution into account. For this reason, extenders should be thoroughly evaluated and not substituted arbitrarily in a paint formula. This is true despite the fact that their published physical constants may be similar. In general, extenders with broad particle size distributions will have higher binder demands than those with narrow distributions, especially when their average sizes are similar. This is why narrow particle size distribution calcium carbonate is recommended for tint bases. Its low binder demand promotes maximum chalk resistance and tint retention. Talcs, with their wider size distributions, are often used in whites to obtain brighter whiteness, cleanliness and ease of chalking.

Solids Content

At constant titanium dioxide content, reducing solids involves reducing extender and binder. This significantly lowers the binder level relative to the binder demand of the pigmentation and results in less chalk resistance or ultimate durability.

The thickness of the dry paint film depends on the solids content. Film thickness is important for maximum durability, especially over dimensionally unstable substrates.

Additives

Antifoamers

These materials are necessary to minimize the formation of foam during manufacture and to prevent foaming during application. Any good commercial material can be used, but levels should be checked to determine the quantity necessary for good protection with freedom from "fish eyes". To achieve this it has been found most efficient to split the antifoamer, half in the grind, and half in the letdown. When incorporating the final aliquot, moderate agitation should be used. The formation of a vortex should be avoided. In the absence of good stirring, or sometimes even with it, "fish eyes" may be temporarily present at the necessary level of antifoamer. If present after ample time for the finished paint to have equilibrated (approximately 24 hours), "fish eyes" are indicative of excess antifoamer concentration.

Preservatives

A preservative is required in a paint to give protection from microbiological growth both in the can and on the final paint film. The level of preservative is determined by the particular vehicle, substrate, geographical location and exposure location. Phenyl mercury compounds are the most commonly used preservatives.

Acrylic emulsion house paints have been found to be inherently resistant to microbiological growth, but a film preservative is invariably used. Higher levels than those required for can stability are needed for painting over substrates which are either already innoculated with mildew or constitute a nutritional surface because of the presence of oleoresinous materials. In partially protected areas where excessive surface dirt can accumulate, the presence of a preservative in the acrylic emulsion paint film serves to retard or eliminate the growth of mildew.

The type, level and method of incorporation of the preservative are important, since these factors can influence the stability and ultimate performance of the finished product. Preservatives which are relatively water soluble are detrimental. Such materials tend to wash out of the paint film with time.

Solubilized grades of mercurial preservatives also exhibit a tendency to react with other ingredients in the paint, such as the dispersant. Reaction between these two ingredients effectively reduces both the dispersant and fungicide concentrations, causing pigment flocculation and reduced microbiological resistance. When these solubilized types are incorporated in the let-

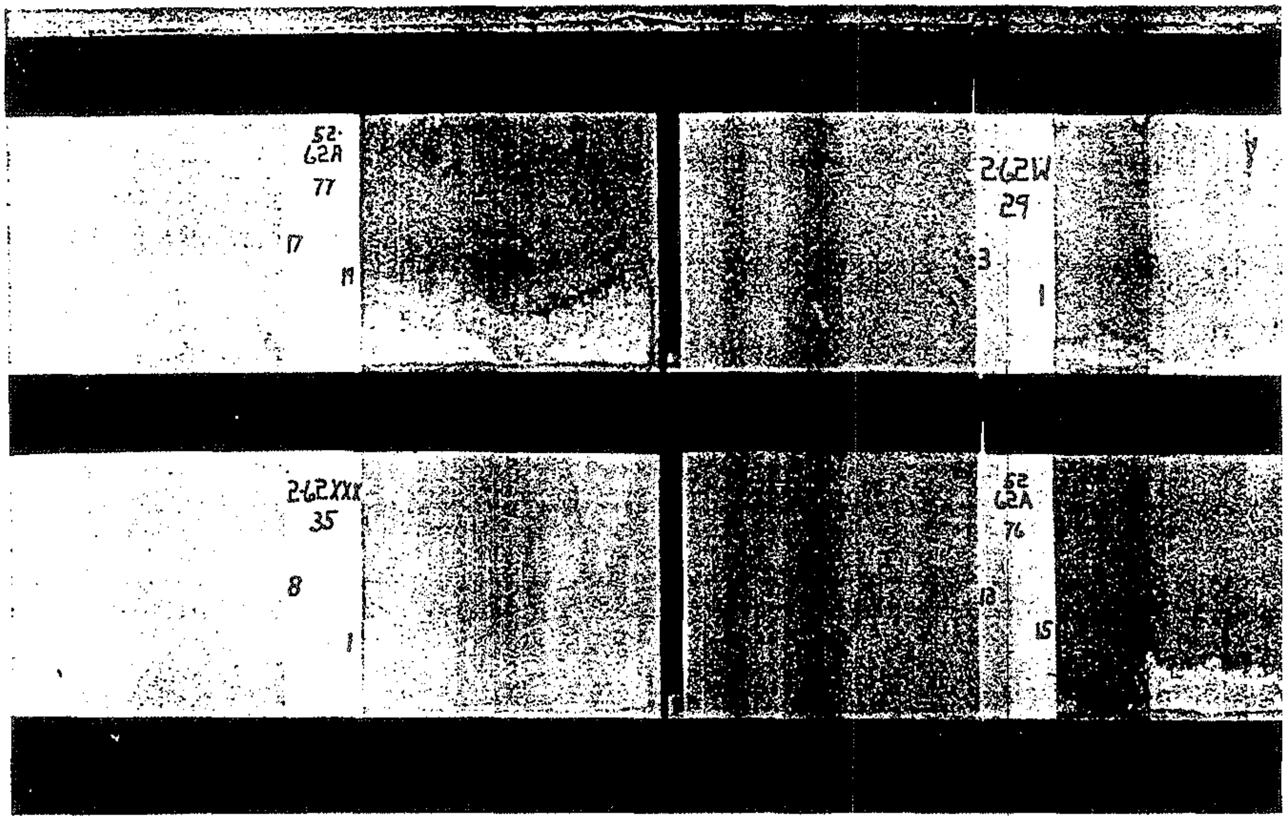


FIGURE 7. Rhoplex AC-34 paints exhibit excellent resistance to saponification by alkali in masonry surfaces and cement asbestos shingles. Rhoplex AC-34 paints on left show no change, whereas polyvinyl acetate copolymer paints saponify.

down, this reaction may be minimized; however, this method introduces the danger of local shock.

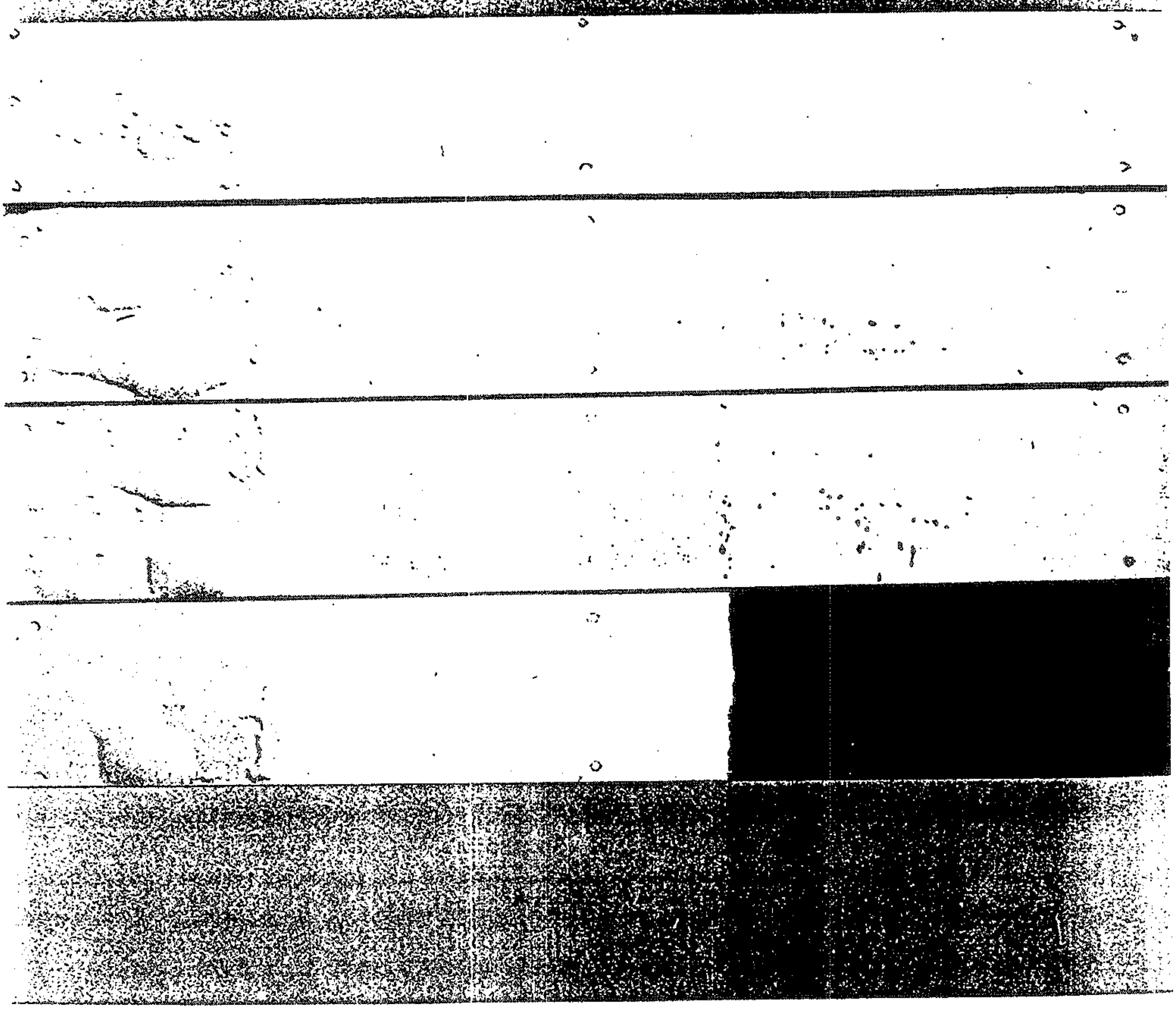
The solid grades of mercurials are preferred because they are relatively water insoluble, are easily incorporated in the grind and have little effect on paint stability. Occasionally, the rheological properties of the grinding paste will be altered by the presence of the solid preservative. If found to be undesirable this may be overcome by either cooling or diluting the paste. This does not affect the final paint constants or performance. Levels of solid grades used vary from 0.1 to 1.5 pounds of mercury metal per 100 gallons of paint, but the amount most commonly employed is 1.1 to 1.2 pounds. Both 100-percent phenyl mercuric propionate and 100-percent phenyl mercuric acetate have given good results.

Most mercury compounds are very sensitive to hydrogen sulfide originating in such sources as salt-water marshes, papermill operations and coke furnaces. Reaction of the mercury with hydrogen sulfide may produce black or brown discoloration of the paint film. The solid grades of the material seem to be significantly more resistant to discoloration than solubilized types. In locations where hydrogen sulfide concentrations are high, the only practical solution is to omit mercury from the formulation. A number of other materials have been proposed to replace mercury as a film preservative, but none of those tested to date has been effective in controlling mildew.

Thickeners

In order to achieve a desirable paint consistency which will prevent pigment settling, avoid dripping and assist in applying proper film thicknesses, it is necessary to pigment at relatively high solids, use high-water-demand extenders or incorporate thickening agents.

FIGURE 8. Paints made with Rhoplex AC-34 show excellent [illegible] blister resistance over chalky acrylic paint in blister house test. Oil paint topcoats on left third of each panel exhibit extreme blistering due to the high humidity in the blister house. Unmodified Rhoplex AC-34 paints on center third of top two panels show excellent blister resistance. Modification of the 40% PVC Rhoplex AC-34 paint on right third of the top panel gave good blister resistance, but modification gave reduced blister resistance on the right third of the second panel coated with a 45% PVC Rhoplex AC-34 paint. A polyvinyl acetate paint with and without oil modification on the third panel blistered. An alkyd-modified polyvinyl acetate paint on the center of the bottom panel cracked. A commercial acrylic colored paint on the right third of the bottom panel showed excellent blister resistance.



The most common thickeners are the cellulosics. The presence of these materials will increase the paint's water sensitivity, detract from its flow properties and will sometimes adversely affect dispersion and application properties. For this reason, the preferred method of attaining the desired consistency is through increased solids. Increasing the solids improves film build and overall durability and performance. The published topcoat formulations are of the order of 40-percent solids by volume.

The maximum level of dry cellulosic thickener which should be employed in Rhoplex AC-34 paints will vary depending on the formulation constants, but generally should not exceed about 3.5 pounds per 100 gallons of paint. For ultimate performance and wet adhesion, minimum quantities should be used.

Those interested in maximum durability and those investigating one-coat systems can and should test higher solids levels. However, very satisfactory performance, especially over dimensionally stable substrates, can be achieved at much lower volume solids content. The minimum will vary depending on such factors as pigment volume content and type of pigmentation. Formulations below 38-percent volume solids should be tested carefully for durability before manufacturing.

The thickener grades suggested for use in the published formulations are the easily wettable types such as QP grades of hydroxyethyl cellulose. Other grades or types usually give satisfactory durability if reasonable levels are used and if such factors as dispersion are not affected. It is important that these materials be used or incorporated in accordance with their manufacturer's recommendations.

Coalescents

Coalescents are helpful in obtaining good film formation under borderline application conditions. In addition to low temperatures this includes high winds or other conditions leading to premature drying. Coalescents are particularly useful at higher pigment volume contents.

To avoid local shock leading to flocculation or coagulation, the coalescent should be prediluted and added slowly with good agitation. This is particularly important when the coalescent is incorporated during the letdown operation.

Formulations 303 and 313 contain 3 pounds of pine oil per 100 gallons of paint. Test work has shown that considerable improvement in film formation without a noticeable reduction of paint stability properties is achieved by the presence of this material. Somewhat higher levels may be desirable for best results under poorer conditions of paint application. In many cases, these higher levels may reduce freeze-thaw resistance. The optimum concentration will depend on the desired minimum film-forming temperature and stability requirements.

Other materials such as tributyl phosphate and glycol ethers are often used as coalescents in Rhoplex AC-34 house paints. Hydrolyzable esters or highly soluble materials will adversely affect shelf stability, and should be avoided.

The quantity of coalescent which may be incorporated into paint without loss of stability properties can vary with the specific formulation being considered. Thus, determination of a satisfactory coalescent level becomes a matter of trial and error. To determine this level, a range of concentrations of the coalescent are post-added to samples of the paint. These paints are tested for freeze-thaw and heat stabilities until the range yielding the desired degree of performance is found. More thorough evaluation of paint containing this level of coalescent should then be conducted.

Oleoresinous Modification

Numerous house and panel exposures clearly indicate that good performance can often be attained with unmodified Rhoplex AC-34 paints over natural-chalking oil house paints. This is definitely true if a reasonable degree of surface preparation is undertaken. However, emulsions do not penetrate chalk as well as solution binders. This fact can readily be demonstrated in laboratory tests, but is not as apparent in actual practice. Many manufacturers using Rhoplex AC-34 are successfully producing complaint-free unmodified paints. Others feel it is necessary to modify with an oleoresinous material to obtain a sufficient degree of safety over chalk.

The advantages of modification include better penetration of chalk and the ability to formulate higher solids paints. The disadvantages or properties which require special attention are: increased chalking and loss of tint retention, increased susceptibility to dirt pickup and mildew, decreased stability (especially with extreme heat and cold) which results in loss of penetration and decreased blister resistance.

If modification is considered, to retain the inherently good durability and blister resistance of the Rhoplex AC-34 system no more than 25 percent of the Rhoplex AC-34 binder should be replaced. The weight per gallon of the dry polymer in Rhoplex AC-34 is 9.5 pounds. This value will be useful in calculations involving the substitution of oleoresinous binder for part of the Rhoplex AC-34 in a formulation.

Formulation 204 was originally designed as an additive for Rhoplex AC-33. This system is typical of the wide variety of materials available for use in oleoresinous modification, and constitutes a satisfactory starting point for initiating such tests. To use this formulation as a modifier, an equivalent volume of emulsion solids should be removed.

The solids of Formulation 204 are 57 percent by weight to achieve optimum penetration. Using modifiers with higher solids will tend to increase film build, but will also decrease the degree of penetration.

In many cases the oleoresinous material can readily be added in the binder letdown step without any special treatment. If pre-emulsification is desired, materials such as Triton N-101 or a mixture of equal parts of Triton X-114 and Triton X-100 can be used. It is also important to add extra preservative when using oleoresinous materials.

Other Additives

Ethylene Glycol

The primary function of ethylene glycol is to improve the freeze-thaw resistance and wet-edge characteristics of a paint. The importance of the latter is not always fully appreciated. The significance of excessive wicking and premature drying has been discussed earlier. Ethylene glycol has a moderating effect on these actions and tends to improve penetration, adhesion and film coalescence. Some caution should be exercised in using excessive levels (over 30 pounds per 100 gallons of paint) as this will introduce some early water sensitivity.

Ammonium Hydroxide

In order to obtain maximum stability with the published topcoat formulations it is usually necessary to adjust the pH to 9.4 to 9.7. Although use of a pH meter is preferred, approximate determinations may be made with pH indicator paper. These values will usually drop to about 9.2 to 9.5 with time or accelerated testing but should not, under normal circumstances, fall below these levels.

Standard Control and Laboratory Testing Procedures

In the development of new formulations it is necessary to be able to assess those properties which are essential in a satisfactory exterior emulsion paint. Many of these evaluating procedures may also be useful as production control tests. Details of the following methods used in our laboratories are available upon request:

Paint Constants

- Viscosity: modified Stormer at 200 r.p.m.
- pH
- Weight per gallon
- Luminous reflectance and contrast ratio

Performance Properties

- Color acceptance and development: rub-up and lap tests before and after artificial aging.
- Wet adhesion: adhesion to gloss enamels utilizing a Gardner scrub machine.
- Blister resistance: blister box with vapor temperature at 140° F.
- Minimum paint film formation temperature

Accelerated Stability

- Heat: ½- or 1-pint samples held at 140° F. for 100 hours to 1 week.
- Freeze-thaw: ½- or 1-pint samples held at −5° to 15° C. for 16 hours and room temperature for 6 to 8 hours per cycle. Three to five cycles are normally required.

Suggested Formulations for Exterior Testing

The following suggested formulations for Rhoplex AC-34 are not tailormade for the individual paint manufacturer. They do, however, constitute examples of Rhoplex AC-34 paints which will yield highly satisfactory performance. These formulations embody the latest formulation principles for Rhoplex AC-34 and are designed to exhibit a good general balance of cost and performance. A summary list of the formulations is provided in Table III.

The formulations and raw materials used should be checked closely during initial testing and exposure in order to furnish a sound basis for any desired modification. Comparable raw materials from other suppliers should give equally satisfactory performance in these systems; however, slightly different dispersant levels may be required when pigment grades which exhibit different dispersant requirements are used.

A list of raw materials appears at the end of this section in Table IV. Where several grades of a particular ingredient are listed, the grade listed first is the one employed in our work on the suggested formulations.

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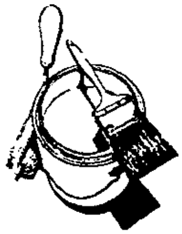

TABLE III

Summary Table of Formulations

See pages 23 to 28 for formulation details.

Formulation		Pigment Volume Content, %	Solids Volume, %	Solids Weight, %	Approximate Raw Material Cost per Gallon[1]
303	Highest Quality Primer for Bare Wood	29.8	44.7	58.2	$1.72
304	High-Quality Primer for Bare Wood	34.7	42.2	57.4	$1.68
305	High-Quality Primer for Staining Wood	34.7	38.1	56.6	$1.84
306	High-Quality White Topcoat	39.7	40.9	58.2	$1.79
307	Lower Titanium Dioxide Content White Topcoat	44.7	38.5	56.3	$1.54
308	White Topcoat for Sound Repaint Surfaces	49.8	38.5	56.9	$1.41
309	White Topcoat for Repaint of Masonry	54.8	40.0	59.3	$1.37
310	Light Tint Base	39.8	41.8	58.0	$1.58
311	Light Universal Tint Base	40.0	40.0	56.3	$1.60
312	Medium Tint Base	45.0	40.0	56.4	$1.28
313	Medium Universal Tint Base	45.0	40.0	56.6	$1.33
204	Additive and Surface Conditioner	—	51.8	56.7	—

[1] December 1964

Formulation 303 *Highest Quality Primer for Bare Wood based on Rhoplex AC-34*

Material	Pounds	Gallons
Tamol 731 (25%)	7.0	0.76
Triton X-102	2.0	0.22
Antifoamer	1.0	0.13
Ethylene glycol	25.0	2.69
Pine oil	3.0	0.33
Hydroxyethyl cellulose (2.5% solution)	77.2	9.41
Preservative	1.8	0.11
Rutile titanium dioxide	150.0	4.29
Calcium carbonate	153.2	6.79
Crystalline silica	50.0	2.27
Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)		
Letdown:		
Rhoplex AC-34 (46%)	649.8	73.01
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	2.0	0.27
	1123.0	100.41
Pigment volume content	29.8%	
Solids: Weight	58.2%	
Volume	44.7%	
pH	9.4-9.7	
Viscosity range	73-79 Krebs units	

Approximate raw material cost—$1.72/gallon

Formulation 304 *High-Quality Primer for Bare Wood based on Rhoplex AC-34*

Material	Pounds	Gallons
Water	30.0	3.60
Tamol 731 (25%)	8.6	0.93
Triton CF-10	2.5	0.28
Antifoamer	1.0	0.13
Ethylene glycol	20.0	2.15
Pine oil	3.0	0.33
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	100.0	12.19
Rutile titanium dioxide	171.0	4.89
Calcium carbonate	186.5	8.26
Water-ground mica	30.0	1.28
Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)		
Letdown:		
Rhoplex AC-34 (46%)	561.6	63.10
Water	7.2	0.87
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	1.0	0.14
	1125.2	98.39
Pigment volume content	34.7%	
Solids: Weight	57.4%	
Volume	42.2%	
pH	9.4-9.7	
Viscosity range	75-81 Krebs units	

Approximate raw material cost—$1.68/gallon

Formulation 305

High-Quality Primer for Staining Wood based on Rhoplex AC-34

Material	Pounds	Gallons
Tamol 850 (30%)	[illegible]	0.51
Triton X-102	1.0	0.11
Antifoamer	1.0	0.13
Water	[illegible]	[illegible]
Ethylene glycol	25.0	2.69
Pine oil	3.0	0.33
Preservative	1.3	0.11
Hydroxyethyl cellulose* (2% solution)	162.5	19.82
Rutile titanium dioxide	200.0	5.71
Calcium carbonate	114.6	5.08
Basic silicate of white lead	125.0	2.33
Grind the above in a high-speed mill (Cowles—3800-4500 feet per minute for 10-15 minutes).		
Letdown		
Rhoplex AC-34 (46%)	512.1	57.54
Antifoamer	1.0	0.13
	1192.6	99.34
Pigment volume content	[illegible]	
Solids: Weight	56.0%	
Volume	38.1%	
pH	9.0-9.4	
Viscosity range	79-85 Kreb units	

Approximate raw material cost—$1.83/gallon

* Cellosize WP-4400

Formulation 306

High-Quality White Topcoat based on Rhoplex AC-34

Material	Pounds	Gallons
Water	53.6	6.43
Tamol 731 (25%)	10.7	1.16
Triton CF-10	2.5	0.28
Antifoamer	1.0	0.13
Ethylene glycol	25.0	2.69
Pine oil	3.0	0.33
Preservative	1.3	0.11
Hydroxyethyl cellulose (2.5% solution)	115.0	14.02
Rutile titanium dioxide	240.0	6.86
Anatase titanium dioxide	10.0	0.31
Talc	100.0	4.21
Calcium carbonate	110.0	4.87
Grind the above in a high-speed mill (Cowles—3800-4500 feet per minute for 10-15 minutes).		
Letdown		
Rhoplex AC-34 (46%)	[illegible]	[illegible]
Water	[illegible]	0.93
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	2.0	0.2[illegible]
	[illegible]	100.2[illegible]
Pigment volume content	[illegible]	
Solids: Weight	[illegible]	
Volume	[illegible]	
pH	[illegible]	
Viscosity range	[illegible] Kreb units	

Approximate raw material cost—$[illegible]/gallon

Formulation 307

Lower Titanium Dioxide Content White Topcoat based on Rhoplex AC-34

Material	Pounds	Gallons
Water	97.2	11.67
Tamol 731 (25%)	9.6	1.04
Triton CF-10	2.0	0.23
Antifoamer	1.0	0.13
Ethylene glycol	20.0	2.15
Pine oil	3.0	0.33
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	140.0	17.07
Rutile titanium dioxide	190.0	5.43
Anatase titanium dioxide	10.0	0.31
Talc	100.0	4.21
Calcium carbonate	164.1	7.27
Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)		
Letdown:		
Rhoplex AC-34 (46%)	440.2	49.46
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	3.0	0.40
	1182.9	99.94

Pigment volume content	44.7%
Solids: Weight	56.3%
Volume	38.5%
pH	9.4-9.7
Viscosity range	80-86 Krebs units

Approximate raw material cost—$1.54/gallon

Formulation 308

White Topcoat for Sound Repaint Surfaces based on Rhoplex AC-34

Material	Pounds	Gallons
Water	135.6	16.28
Tamol 731 (25%)	8.4	0.91
Triton CF-10	2.0	0.23
Antifoamer	1.0	0.13
Ethylene glycol	25.0	2.69
Pine oil	3.0	0.33
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	120.0	14.63
Rutile titanium dioxide	175.0	5.00
Talc	65.0	2.74
Calcium carbonate	257.9	11.43
Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)		
Letdown:		
Rhoplex AC-34 (46%)	400.7	45.02
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	2.0	0.27
	1198.4	99.90

Pigment volume content	49.8%
Solids: Weight	56.9%
Volume	38.5%
pH	9.4-9.7
Viscosity range	73-79 Krebs units

Approximate raw material cost—$1.41/gallon

Formulation 309

[illegible]

Material	Pounds	Gallons
Water	138.9	16.68
Tamol 731 (25%)	8.3	0.90
Triton CF-10	2.0	0.23
Antifoamer	1.0	0.13
Ethylene glycol	25.0	2.69
Pine oil	3.0	0.33
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	120.0	14.63
Rutile titanium dioxide	175.0	5.00
Talc	25.0	1.05
Calcium carbonate	360.0	15.95
Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)		
Letdown:		
Rhoplex AC-34 (46%)	375.4	42.18
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	2.0	0.27
	1238.4	100.28
Pigment volume content	54.8%	
Solids: Weight	59.3%	
Volume	40.0%	
pH	9.4-9.7	
Viscosity range	74-80 Krebs units	

Approximate raw material cost—$1.37/gallon

Formulation 310

[illegible]

Material	Pounds	Gallons
Water	49.6	5.95
Tamol 731 (25%)	8.2	0.89
Triton CF-10	2.0	0.23
Antifoamer	1.0	0.13
Ethylene glycol	20.0	2.15
Pine oil	3.0	0.33
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	118.2	14.41
Rutile titanium dioxide	170.0	4.86
Calcium carbonate	262.0	11.61
Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)		
Letdown:		
Rhoplex AC-34 (46%)	516.0	57.98
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	2.0	0.27
	1154.8	99.05
Pigment volume content	39.8%	
Solids: Weight	58.0%	
Volume	41.8%	
pH	9.4-9.7	
Viscosity range	80-86 Krebs units	

Approximate raw material cost—$1.58/gallon

Formulation 311 *Light Tint Base for Universal Colorants based on Rhoplex AC-34*

Material	Pounds	Gallons
Water	55.0	6.60
Soya fatty acids } *Premix*	9.1	1.18
Morpholine } *Premix*	3.9	0.48
Morpholine	6.0	0.72
Antifoamer	1.0	0.13
Ethylene glycol	25.0	2.69
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	100.0	12.19
Rutile titanium dioxide	170.0	4.86
Calcium carbonate	251.4	11.14
Pine oil	3.0	0.33

Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)

Letdown:		
Rhoplex AC-34 (46%)	497.0	55.84
Antifoamer	1.0	0.13
Acrysol G-110 (22%) } *Premix*	6.0	0.68
Water } *Premix*	18.0	2.16
Water	4.1	0.49
Ammonium hydroxide (28%)	2.0	0.27
	1154.3	100.00

Pigment volume content	40.0%
Solids: Weight	56.3%
Volume	40.0%
pH	9.4-9.7
Viscosity range	85-92 Krebs units

Approximate raw material cost—$1.60/gallon

Formulation 312 *Medium Tint Base based on Rhoplex AC-34*

Material	Pounds	Gallons
Water	76.6	9.20
Tamol 731 (25%)	6.0	0.65
Triton CF-10	1.5	0.17
Antifoamer	1.0	0.13
Ethylene glycol	25.0	2.69
Pine oil	3.0	0.33
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	140.0	17.07
Rutile titanium dioxide	100.0	2.86
Calcium carbonate	342.0	15.15

Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)

Letdown:		
Rhoplex AC-34 (46%)	455.4	51.17
Antifoamer	1.0	0.13
Ammonium hydroxide (28%)	2.5	0.33
	1155.8	99.99

Pigment volume content	45.0%
Solids: Weight	56.4%
Volume	40.0%
pH	9.4-9.7
Viscosity range	78-85 Krebs units

Approximate raw material cost—$1.28/gallon

Formulation 313

Material	Pounds	Gallons
Water	40.0	4.80
Soya fatty acids (Premix)	5.8	0.75
Morpholine (Premix)	2.5	0.30
Morpholine	4.2	0.51
Antifoamer	1.0	0.14
Ethylene glycol	25.0	2.69
Preservative	1.8	0.11
Hydroxyethyl cellulose (2.5% solution)	100.0	12.19
Rutile titanium dioxide	100.0	2.86
Calcium carbonate	342.0	15.15
Pine oil	3.0	0.33

Grind the above in a high-speed mill (Cowles, 3800-4500 feet per minute for 10-15 minutes)

Material	Pounds	Gallons
Letdown:		
Rhoplex AC-34 (46%)	455.4	51.17
Antifoamer	1.0	0.14
Acrysol G-110 (22%) (Premix)	6.0	0.68
Water (Premix)	18.0	2.16
Ammonium hydroxide (28%)	2.5	0.34
Water	42.8	5.13
	1151.0	99.45

Pigment volume content	45.0%
Solids: Weight	56.6%
Volume	40.0%
pH	9.4-9.7
Viscosity range	84-92 Krebs units

Approximate raw material cost—$1.33/gallon

Formulation 204

Material	Pounds	Gallons
Duraplex DX-656 (50%)	208.0	27.0
Alkali-refined soya oil	312.0	40.3
Cobalt drier (6%)	3.3	0.4
Manganese drier (6%)	2.1	0.3
Mineral thinner	200.0	30.9
Anti-skinning agent	0.8	0.1
Preservative (Super Ad-It)	12.0	1.5
	738.2	100.5

Solids: Weight	56.7 %
Volume	51.8 %
Ratio of alkyd to oil solids	25:75
Drier calculated as metal on solids:	
Cobalt	0.05%
Manganese	0.03%

If desired, alkali-refined linseed oil may be substituted for soya oil. Lead drier (1%) should be used instead of manganese in this case.

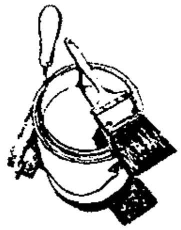

TABLE IV

Raw Materials Used for Preparation of Formulations 303 to 313

Material	Designation	Supplier
Soya fatty acids	Wecoline S	Drew Chemical Corporation
Morpholine	Morpholine, water-white	Chemicals Division of Union Carbide Corporation
Antifoamer	Nopco NXZ Balab 748	Nopco Chemical Company Balab, Incorporated
Pine oil	Yarmor 317	Hercules Powder Company
Hydroxyethyl cellulose	Cellosize QP-15000 Cellosize WP-4400	Chemicals Division of Union Carbide Corporation
Preservative	Metasol 57—100% grade	Metalsalts Corporation
Rutile titanium dioxide	Ti-Pure® R-610 Titanox RANC Unitane OR-640	E. I. du Pont de Nemours & Co., Inc. Titanium Pigment Corporation American Cyanamid Company
Anatase titanium dioxide	Ti-Pure® FF Titanox A-168LO Unitane O-220	E. I. du Pont de Nemours & Co., Inc. Titanium Pigment Corporation American Cyanamid Company
Talc	Asbestine 3X Nytal 300	International Talc Company R. T. Vanderbilt Company
Calcium carbonate	Snowflake	Thompson-Weinman & Company
Crystalline silica	Silver Bond B	Tamms, Incorporated
Basic silicate of white lead	EP-202 Oncor 45X	Eagle-Picher Company National Lead Company

Paint Manufacture with Rhoplex Emulsions

Several types of conventional paint manufacturing equipment can be used very satisfactorily for the production of Rhoplex AC-34 exterior paints. The usual procedure is to make an aqueous pigment dispersion. Part of the Rhoplex AC-34 may have to be added to furnish sufficient liquid to wet the pigment, but minimum quantities should be used.

Although the exact procedure depends on the equipment available, the following general instructions should be helpful in the preparation of paints:

1. Charge a high-speed disperser with the dispersing and wetting system, coalescent, antifoamer, water and thickener solution.

2. Add the solid preservative; then add the required pigments and the extenders together in several small portions, mixing all dry materials thoroughly before adding each portion. For deep-toned paints, the colored pigments are also added at this time.

3. Mix at high speed. In our laboratory equipment 4000 feet per minute peripheral speed was used for 12 minutes.

4. The resulting dispersion is then reduced in a mixer at low mixer speed by adding the balance of the Rhoplex AC-34. The pH should be adjusted, if necessary, to 9.4 to 9.7 with ammonium hydroxide, and additional antifoamer added.

5. The paint is then tinted and packaged.

Pebble mills can also be used for the production of these paints. Generally, it is necessary to charge more emulsion to the pebble mill then is required for other methods. The charge is ground for the required time; then the final addition of vehicle, ammonium hydroxide and antifoamer is made.

Application of Rhoplex Emulsion Paints

Paints made with Rhoplex emulsions may be applied by brush, roller or spray gun. Since the paints brush easily, brushes 4 to 6 inches wide may be used. Brushes with tapered nylon bristles are among the most satisfactory. They retain their fiber stiffness because they do not absorb water, yet permit uniform coverage and freedom from lap marks. Nylon brushes are cleaned easily since the paints do not penetrate the filaments appreciably. Brushes or rollers should be wet with water before painting. It is good practice to keep a pail of water handy and change brushes every hour or so, putting the used brushes in the pail. This will prevent drying in the brush.

Rollers can be used very satisfactorily. Dip rollers are preferable since they are lighter, easier to clean and create less foam during application than the fountain type. Long-nap rollers are used on rough cement, brick or stucco.

For spray applications, paints may be used at approximately the same viscosity as for brushing. External-mix spray guns should be used at 20 to 40 pounds line pressure. Bleeder-type guns usually clog.

In all exterior applications one should be sure enough paint is applied. Since emulsion paints spread very easily, thin coats can be applied which will give reduced hiding and durability. Spreading rate should be from 250 to 450 square feet per gallon depending upon the surface roughness, water demand, previous treatment and type of surface.

Paints based on the Rhoplex emulsions dry very quickly, so that window sash should be moved shortly after painting to avoid sticking. If a torch is used to remove old emulsion paints, it should be moved rapidly over the surface, applying just enough heat to soften the paint and permit its removal by a scraper.

TABLE V

Principal Newtown Test Farm Exposure Series used in Preparation of Progress Report No. 11[1]

Series Number	Exposure Date	Surface Painted	Principal Vehicles	Pigment Volume Content	Colors	Object of Exposure
Vehicle Studies						
60N	September 1960	White Pine Yellow Pine Cedar	Rhoplex AC-34 Rhoplex AC-33 Rhoplex B-60-A	35% 40%	White Red Blue	To illustrate performance differences with emphasis on Rhoplex AC-34 on bare wood.
63Y	March 1963	White Pine Chalky Oil Gloss Trim Spruce	Rhoplex AC-33 Formulation 204	35%	White	To determine value of oil addition.
63BJ	July 1963	White Pine Yellow Pine Chalky Oil Chalky Acrylic	Rhoplex AC-34	35%	White	To determine value of alkyd and oil additions in increasing adhesion.
Eave Exposures	Between September 1961 and June 1963	Gloss Trim Chalking Oil House Paints of Various Ages	Rhoplex AC-34 Commercial Paints	Usually 35%	White Pink	To determine adhesion and performance over gloss trim and chalking oil paints, both south vertical and under eaves.
Formulation Variables						
53B & C	August 1953	Cedar Asbestos Shingles	Rhoplex AC-33	30%-50%	White	To determine formulation variables which control performance.
60P	July 1960	White Pine Primed Cedar Asbestos Shingles	Rhoplex AC-33	30%-40%	White	To determine extender, TiO_2 ratio and thickener variables which control performance.
60Y	October 1960	White Pine Primed Cedar	Rhoplex AC-33	30%-35%	Red Blue	To determine variations in chalking rate with two commercial grades of TiO_2 and two extenders.
61O	August 1961	White Pine Primed Cedar Asbestos Shingles	Rhoplex AC-34	30%-45%	Blue	To illustrate effect of varying levels of TiO_2 on performance.
63BF	July 1963	White Pine Cedar	Rhoplex AC-34	35%-60.8%	White	To correlate pigment binding capacity with performance.
63BA	June 1963	White Pine Gloss Trim Chalking Oil Yellow Pine Chalking Acrylic	Rhoplex AC-34	40%-45%	White	To check published formulations.
Film Preservatives						
54F	January 1955	White Pine Asbestos Shingles	Rhoplex AC-33	28%	White	To determine effectiveness of various preservatives.
58PP	October 1958	White Pine Asbestos Shingles	Rhoplex AC-33	40%	White	To provide additional exposure of zinc oxide and barium metaborate preservatives.
62H	February 1962	White Pine	Rhoplex AC-34	30%	White	To provide additional preservative studies.

[1] *Many other test series were also reviewed for this Report and are available for inspection by visitors.*

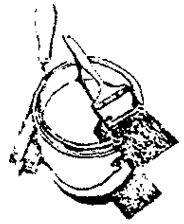

TABLE VI

Some Laboratory-Controlled House Paint Tests with the Rhople:

Structure	Major Test Substrates[1]	Previous Coating[1]	Major Formulation
Ackerman House	Composition siding *Stucco*	Oil paint, moderate chalk None	40 PVC gray-green; Rhoplex AC-34 40 PVC white; Rhoplex AC-34, $CaCO_3$ and ta extenders
Adams House	Cinderblock Wood panels	Cement-type paint Dark red stain	32 PVC dark red; Rhoplex AC-33
Balderston House	Clapboard	Heavily chalking oil paint	35 PVC white; Rhoplex AC-34, $CaCO_3$ extend
Balmer House	Clapboard	Heavily chalking oil paint	35 PVC white; Rhoplex AC-34, talc extender
Berger House	Plywood and batten	Light to moderately chalking oil paint	35 PVC medium-tone green; Rhoplex AC-34
Bogenrief House	Cedar clapboard	Moderately heavy chalking oil paint	40 PVC white; Rhoplex AC-34, $CaCO_3$ and ta extenders
Caulfield House	Clapboard	Moderately heavy chalking oil paint	35 PVC white; Rhoplex AC-34, $CaCO_3$ extend
Connor House	Stone and brick Clapboard	Cement-type paint Burned off for repainting	35 PVC white; Rhoplex AC-33, talc extender 35 PVC white; Rhoplex AC-34, $CaCO_3$ extend
Faust House	Redwood clapboard	Light to moderately chalking oil paint	40 PVC white; Rhoplex AC-34, $CaCO_3$ and ta extenders
Gusman House	Philippine mahogany clapboard	Light to moderately chalking oil paint	35 PVC white; Rhoplex AC-34, $CaCO_3$ extend
Haag House	Composition "clapboard," wood trim and galvanized iron	*New—none, except for factory* primer on composition board	*Formulation 244-A (wood primer)* Topcoat—40 PVC white; Rhoplex AC-34, CaC and talc extenders
Harmon House	Wood and composition siding	Heavily chalking Rhoplex AC-33 paint	40 PVC white; Rhoplex AC-34, $CaCO_3$ and t extenders
Hurwitz House	*Philippine mahogany clap*board	*Very dark stain, some "chalk*ing"	*41 PVC reddish-brown;* Rhoplex AC-55
McBurney House	Smooth stucco	Moderately chalking cement paint	50 PVC white; Rhoplex AC-33, extender mos $CaCO_3$
Moody House	*Cedar clapboard*	*Heavily chalking oil paint*	40 PVC white; Rhoplex AC-34, talc extender
Newtown Conference Room Building	Cinderblock	New, with cement-type filler coat	40 PVC light green; Rhoplex AC-34
Newtown Service Building	Cinderblock	Moderately chalking cement *paint*	35 PVC light green; Rhoplex AC-33 (first c *modified with oil/alkyd)*
Van Hook House	Clapboard and stucco	Heavily chalking Rhoplex AC-33 paint	40 PVC white; Rhoplex AC-34

[1] In addition, the wood trim was usually painted white at the same time. Frequently, colored Rhoplex formulations were used on some trim items, such as shutters.

Emulsions (Eastern Pennsylvania)

Method of Application	Number of Coats	Painting Date	Comments
Brush	Two	June 1963	Excellent appearance with little chalk or dirt retention.
Brush	Two	September 1958	Appearance is still very attractive. Little chalking; film failure limited to scattered grain cracking on wood.
Brush	Two	July 1961	The carbonate-extended formulation has resulted in light chalking and moderate dirt retention.
Brush	Two	June 1962	Good cleanliness and moderate chalking have resulted from the use of talc in this white formulation.
Brush	Two	August 1961	Good condition. No intercoat failure and a minimum of fine cracking of the plywood.
Brush	Two	July 1963	Very good cleanliness with light chalking.
Brush	Two	July 1961	Moderate chalking is providing improved cleanliness. There is a modest amount of lifting due to failure at the oil paint/wood interface.
Brush Brush	Two Two	August 1956 June 1961	The 1956 paint on the masonry is chalking heavily; appearance is very good although there is some lifting and peeling from the old cement paint layer. The 1961 paint is practically perfect, and is exhibiting light to moderate chalk and dirt retention.
Brush	Two	July 1963	Very good appearance, but some scattered failure at the old oil paint/wood interface required repairing.
Brush	Two	August 1960	Chalking is moderate and cleanliness is good. Adhesion has been excellent.
Brush plus probably some roller	Two (primer plus topcoat on bare wood)	Summer 1963	Excellent adhesion and freedom from cracking. Slight chalking with very good cleanliness.
Brush	Two	August 1963	Excellent performance. Slight chalking; very good cleanliness.
Brush	Two	July 1960	Excellent adhesion and freedom from cracking. No obvious color fading.
Brush	Two	April 1956	Two walls still in excellent condition. One required repainting (Rhoplex AC-34 paint) in 1962 because of failure in the cement paint layer near the ground.
Brush	Two	June 1962	Very good cleanliness. Moderate to moderately heavy chalk. Scattered blisters due to failure at old oil paint/wood interface.
Roller	One	April 1963	Very slight chalking; very good cleanliness and adhesion.
Roller	One modified, one unmodified	May 1959	Moderate chalk. Good appearance with scattered lifting or peeling, partly due to substrate failure.
Brush on wood, roller on stucco	Two	June 1963	Excellent performance; slight chalk and very good cleanliness.

[1] In general, the surfaces were prepared for painting by light sanding, spot scraping and priming problem areas. Then loose dirt and chalk were reduced with plain water.

Properties of Individual Rhoplex Emulsions for Exterior Use

Rhoplex AC-33

It has now been more than eleven years since the first 100-percent acrylic emulsion paint vehicle, Rhoplex AC-33, was introduced to the paint industry. The tough, adherent, flexible, and color-retentive acrylic polymer in Rhoplex AC-33 has provided exceptional performance in exterior emulsion paints. These paints have shown unusually good resistance over the years to climatic extremes and to the effects of sunshine, rainfall, frost, and to alkali from masonry surfaces.

Acrylic emulsion paints based on Rhoplex AC-33 have been firmly established since 1953 as the standard of durability and appearance for exterior emulsion coatings on stucco, cinderblock, concrete, cement asbestos shingles and other masonry surfaces. Such paints give unusually good alkali resistance, adhesion and color retention.

Rhoplex AC-34

Rhoplex AC-34 was introduced in 1961 as the first new 100-percent acrylic emulsion polymer specifically designed for use on exterior wood surfaces. Exposure tests show that the long, favorable exposure history of Rhoplex AC-33 also applies to paints made with Rhoplex AC-34.

However, several advantages are obtained when paints made with Rhoplex AC-34 are applied to wood surfaces:

1. Greatly improved resistance to grain cracking and flaking when applied to bare wood.
2. Much better adhesion over old oil paints and oil-based primers.
3. Excellent adhesion to glossy oil paints and oil-based primers under wet conditions.
4. Outstanding blister resistance.
5. Higher pigment binding capacity permitting use of higher pigment volume content paints.

Rhoplex AC-55

In 1957 Rhoplex AC-55 was introduced as a higher solids acrylic emulsion closely related to Rhoplex AC-33. Rhoplex AC-55 utilizes an anionic dispersing system rather than the nonionic system utilized in Rhoplex AC-33. As a result, Rhoplex AC-55 provides a wider range of compatibilities with tinting colors and difficult-to-disperse tube colorants. Emulsion paints made with Rhoplex AC-55 exhibit the film properties characteristic of acrylic polymers, particularly excellent adhesion, flexibility and color retention, and resistance to water, sunlight and alkali.

Rhoplex B-60A

Rhoplex B-60A has the same polymer composition as Rhoplex AC-33, but is lower in viscosity. In some formulations it shows better color acceptance than Rhoplex AC-33.

Physical Properties of Rhoplex Emulsions

The physical properties of these emulsions are tabulated below:

Property	Rhoplex AC-33	Rhoplex AC-34	Rhoplex AC-55	Rhoplex B-60A
Solids Content	46-47%	46-47%	49.5-50.5%	46-47%
pH (approximate)	9.0-9.5	9.2-9.8	9.0-9.5	9.0-9.5
Appearance	White Milky Liquid	White Milky Liquid	White Milky Liquid	White Milky Liquid
Weight per Gallon	8.9 lb.	8.9 lb.	9.0 lb.	8.9 lb.
Specific Gravity of Solids	1.15	1.15	1.16	1.15

All of the Rhoplex emulsions listed above show excellent storage stability. However, if Rhoplex AC-33 is to be stored in bulk, occasional mild agitation should be used to prevent creaming on standing with increase in solids at the bottom of the tank. The other three emulsions show little tendency to cream.

All four emulsions have excellent heat resistance and freeze-thaw stability. Rhoplex AC-33 is particularly outstanding in freeze-thaw stability so that containers in which it is shipped do not carry a "protect from freezing" marking. All of the emulsions have excellent pH stability.

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GL D005733

December 1984

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GLD005734