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"48 PROCESS" DEVELOPMENT

PROCESS & METHODS STUDY P-10

PHILADELPHIA PROCESS & METHODS GROUP

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INCORPORATED
FINISHES DIVISION
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ENGINEERING DEPARTMENT

Philadelphia, Pennsylvania

April, 1955

"48 PROCESS"
DEVELOPMENT

Philadelphia Process & Methods Group

Study P-10

Prepared by

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ABSTRACT

A large scale mixer-dispersion process, classified as "48 Process," has been developed for finishes manufacture. A new agitator design and formula calculation procedures are presented in this report. The basic principles and procedures utilized in "48 Process" development are applicable to other dispersion processes and to product formulation, in particular, calculation of pigment substitution.

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I - SUMMARY

A. PURPOSE OF INVESTIGATION

Dispersions of pigments in vehicles can be made in several types of commercially available heavy-duty mixers (e.g. W & P) but high investment and operating costs per unit of capacity restrict usage. Development of a large efficient mixer-dispersion unit could provide advantages of minimum operating cost and investment per unit capacity.

A 1000-gallon "CA" mixer-dispersion unit was developed during the initial Finishes Division study of large scale mixer-dispersion but application was confined to a few relatively coarse products, and controlling variables were not determined.

The present study, begun December 1950, under the designation of "48 Process" Development, carried four general objectives:

(1) Determine the factors controlling mixer-dispersion.

(2) Determine the optimum type of dispersion mixture formulation.

(3) Design a large high-efficiency mixing unit.

(4) Align adaptable major products on mixer-dispersion manufacture.

B. RESULTS

Accomplishments under the first three general objectives can be summarized as follows:

1. General mechanics of dispersion and controlling variables were defined.

2. The general application range of "48 Process" was defined with respect to pigment types and vehicle requirements.

3. Four distinct basic types of dispersion mixtures were numerically defined and relative dispersion behavior determined. From this work, direct calculation procedures for "48 Process" formulas were developed.

4. A high-efficiency vertical tank mixer was designed, and eight 1000-gallon units are in operation with one or more at each of the following Plants: Chicago, Fort Madison, Everett, So. San Francisco, and Philadelphia.

Accomplishments under the fourth general objective can be summarized as follows:

1. Between 15% and 20% of divisional production of Orthodox (including emulsions) and "Dulux" Pigmented Products is currently made by "48 Process".

2. A Release Letter on "48 Process" method of manufacture was approved (Philadelphia Plant Laboratory Release Letter No. 44, July 1, 1953).

3. A Formulating Practice, FP-01-B, was issued February, 1955, describing procedures for developing "48 Process" formulas.

Operating advantages realizeable from "48 Process" are summarized as follows:

1. Moderate savings in manufacturing cost (estimated at 1 to 4 cents per gallon of finished product versus 3-Roll Milling).

2. Minimum equipment and building investment per unit of production capacity of any currently used dispersion process.

3. Simplification of manufacturing procedures and increased operating flexibility.

4. Improved batch-to-batch product uniformity.

Important collateral benefits resulted from Study P-10, "48 Process" Development." These are:

1. Basic information on behavior of pigment dispersion mixtures has been obtained which permitted development of generalized equipment performance analysis and formula calculation procedures that: (a) have already been applied to "47 Process" (Formulating Practice FP-01-A, 11-9-54) and the solution of a variety of production problems; and, (b) are applicable to other dispersion processes and finished production formulation.

C. CONCLUSIONS AND RECOMMENDATIONS

1. "48 Process," "47 Process", and Ball Milling by "45" or "46 Processes" comprise a high-efficiency dispersion process combination for Orthodox and "Dulux" type products, providing milling action levels ranging from simple dispersion to crystalline particle fracture respectively.

2. Substantial extension of "47 Process" application, and also "47 Process", will require product formulations with better ground and/or classified pigments, and a program for procurement and use of such pigments appears desirable for increased utilization of these more economical processes.

3. Considerable increase in "48 Process" production should be possible without additional 1000-gallon units.

4. Development of adaptable new and revised formulas directly on a "48 Process" basis by product formulators is necessary for most effective production application.

D. FUTURE WORK

Further "48 Process" development work does not appear to be necessary and this study has been terminated. Expansion of basic data for formulation work on all major processes is continuing under Study P-15, Dispersion Fundamentals.

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II - DISCUSSION

A. ORIGIN OF INVESTIGATION

The first Finishes Division large-scale mixer-dispersion study under the title of "CA Mixer Dispersion," was initiated December, 1946 as a result of an C.I.L. memorandum*(9) on preliminary laboratory tests, and was directed toward immediate application to easily dispersed products. Formulas and loading procedures were developed empirically to obtain maximum allowable power input and satisfactory flow.

A 40 H.P. 1,000 gallon "CA" mixer (10) was designed and installed at the Philadelphia Finishes Plant in March of 1948. Except for short vertical bars on the bottom blade tips, the agitator was a two-blade pitched-paddle design. Two products, 301-864 and 301-875, Outside White House Paints, were aligned. Other Orthodox type products were manufactured on an experimental basis but results were unsatisfactory. A number of casein base interior finishes ("Speed-Easy") were subsequently aligned and manufactured in this unit.

Conclusions reached in this study (11) were:

(1) Improved agitator performance was essential for general application.

(2) Power input appeared to be the major variable, limited by flow and circulation failure in the mixer.

Maximum range of application, formulation principles, and controlling variables remained to be established.

The present study was instituted December, 1950 under the revised designation of "48 Process" Development to obtain this information, design a high efficiency mixer, and align all adaptable major products on "48 Process."

B. COURSE PURSUED IN THE INVESTIGATION

1. PROBLEM SURVEY: The overall problem consisted of determining the best mixer design for the best type dispersion mixture formulation. The major considerations included in the term, "best" were investment cost, manufacturing cost, and range of application with respect to types of finished products.

*(Numbers in parenthesis () are bibliography numbers)

A review of literature and the original "CA" mixer-dispersion program results did not yield data suitable as a basis for development. All formulation variables and mixer design parameters remained to be identified.

Microscopic study of simple laboratory pigment dispersions indicated that an agglomerate fraction of appreciable mechanical strength (when either dry or wet) and resistant to dispersion by ordinary mixing procedures was present in practically all pigments except a few coarse extenders. Effective mechanical action was, therefore, necessary for dispersion or "wetting out" with vehicle.

Analysis of large-scale mixer designs indicated that with reasonable input power, the maximum available shear stress on the mixture would be restricted to only a few pounds per square inch. Development of maximum shear stress at a given power input required operation at the lowest practical shear rate on the dispersion mixture. Power consumed in circulation and turbulence would be in addition to that consumed in development of the shear stress.

Laboratory tests to evaluate variables gave the following results:

a.) Pigment concentration and applied shear stress, regardless of input power or mixture flow resistance, were the primary variables.

b.) High pigment concentrations resulting in stiff paste-consistency mixtures were required for effective dispersion action.

c.) Vehicle composition limited maximum pigment concentration for a given power input to a specific mixer.

<u>2. ANALYSIS OF FLOW MECHANICS:</u> Schematic analysis of motion and force distribution in solid particle and liquid systems indicated that two major changes should be encountered as the particle concentration was increased. From the independent particle movement in dilute systems; (1) there should first develop substantial particle interaction through intervening liquid layers, and (2) finally the particles should "lock up" by direct mechanical interference. Close particle packing was essential for effective development of shear force on the particles.

The theoretical degree of particle packing necessary was calculated and confirmed in subsequent laboratory tests. The previously anamolous results of the "CA" mixer-dispersion work were found to correlate on this basis.

Studies of pigment and liquid mixtures under flow conditions revealed a wide variation in dynamic packing characteristics. Complex particle systems were then analyzed, applying corrections for packing of smaller particles in the voids of the larger particles and for irregular particle shape.

All further development of "48 Process" was based on flow mechanics principles and particle packing considerations evolved during the above studies.

3. FORMULATING PROCEDURE: The development program on formulation was organized to obtain basic data in terms of dispersion mixture Pigment Volume to Liquid Volume Ratios (P/L), and vehicle viscosity and wetting requirements.

Parallel development of a mixer design was necessary to establish formulation requirements. Only minimum restrictions on applied shear force were imposed until formulation variables could be explored under a wide range of mixing conditions.

A combination of experimental and mathematical procedures for evaluating the dynamic packing behavior of single and combination pigment systems, respectively, was developed during the study of formulation to permit correction for the more than 10:1 variation in packing characteristics. (Liquid requirements per gallon of pigment for mechanically comparable systems can vary from 5 gallons down to less than 0.5 gallon depending on these packing characteristics). This was necessary to permit evaluation of formulation variables and development of direct formula calculation procedures.

A new Philadelphia Process and Methods Group study, P-15, Dispersion Fundamentals, was subsequently started for purposes of obtaining basic data on particle size and packing behavior of pigments, and related basic information on vehicle components. Data from this study were incorporated in the formulation program.

Letdown behavior of the heavy, concentrated dispersion mixtures, and ordinary finished product mixer performance, were studied to determine the effects of vehicle addition procedure, mixer operation, and degree of reduction before transfer to regular mixers, on completeness and uniformity of dispersion. Two distinct types of letdown failure not previously defined were encountered. These were non-uniform dilution and osmotic shrinkage. The mechanism, cause, and requirements for avoiding each were determined.

The conditions producing both types of letdown failure were such as to be common to any finishes manufacturing process and a survey of production difficulties with other processes indicated that this was true.

Formula calculation procedures were developed and refined as data on pigment systems and mixer performance was obtained. During 1953, all available data was collected and consolidated into a formulating procedure covering dispersion mixture formulation, letdown requirements, and evaluation methods. These procedures were evaluated during 1954, and released in Formulating Practice FP-01-B dated 2-18-55, which is included as Appendix A.

Meanwhile, the application range of this formulation procedure was explored and found to be applicable to all major dispersion processes. Adaptation to "47 Process" was made under study P-15, Dispersion Fundamentals, and released in Formulating Practice FP-01-A dated 11-9-54.

4. MIXER DESIGN REQUIREMENTS: The problem was to design a large, high-efficiency mixing unit for use on "48 Process" formulas. A simple low-cost unit, preferably vertical-tank type, was desired.

Low operating horsepower was necessary for low cost operation and unit design, and an arbitrary goal of a 25 H.P. 1000-gallon unit was initially imposed.

Considerably better performance than could be obtained with the original 1000-gallon 40 H.P. "CA" unit was required for practical product application. Satisfactory action on dispersion mixtures in the 500 to 3000 Poise apparent viscosity range plus rapid uniform mixing during letdown to the 5 to 50 Poise range of intermediate bases and finished product were the overall performance requirements.

Various types of mixer designs were analyzed for power dissipation, circulation development, and shear stress development, but no existing large-scale mixer design met the general operating specifications developed from fluid-mechanics calculations. These were as follows:

a.) Concentration of input power in the smallest possible mixture volume plus positive shear at minimum practical shear rates, for development of appreciable shear stress on the dispersion mixtures with reasonable operating horsepower (below 100 HP per 1000-gallons).

b.) Self-cleaning agitator design to operate without wall-baffles, for prevention of dispersion mixture or semi-wet pigment build-up.

c.) Positive pumping action and displacement of material at the tank wall surface, for uniform mixing of the high flow-resistant dispersion mixtures.

d.) Overall circulation rate sufficient to mix-in dry pigment additions and pass all the material through the shear zone in the shortest practical time without high power consumption in development of such circulation, for practical and economical manufacturing operations.

Mulling type mixer designs were eliminated by requirement (a). High-speed agitator type mixers were eliminated by requirements (a), (c), and (d). Horizontal mixer design offered no basic advantages over vertical mixer design and most horizontal arrangements were eliminated by requirement (c).

The combination of the above requirements restricted mixer design to a vertical-tank type unit with a thin-section "anchor" agitator, streamlined and contured to maintain flow over all surfaces and minimize drag on the main mixture mass. The least possible drag was necessary for both power conservation, and the development of sufficient differential rpm between the agitator and fluid mass to produce positive pumping action. Pumping action required addition to the basic agitator of an impellor section which conformed to overall design requirements.

5. EXPERIMENTAL AGITATOR DESIGN: In March, 1951, a 150-gallon 5 H.P. variable-speed experimental mixer was installed in Philadelphia Plant Building 51. The original test agitator was a semi-streamlined anchor-type assembly constructed from thin flat rectangular-bar and round rod sections, with a short pumping impeller section integral with the thin flat bottom sweep-blade section. The overall design concentrated the input power in a small moving shear zone developed between the agitator and tank wall. General performance confirmed the design principles employed.

Prevention of hard-packed material build-up on the agitator and tank wall, and development of adequate circulation for dry pigment mix-in proved to be the principle problems.

Progressive improvements in design of all agitator components and total streamlining finally corrected these deficiencies and satisfactory performance was obtained on a wide range of both emulsion and orthodox type products.

Agitator design parameters were established and these plus the final "48 Process" mixer design specifications are given in the Appendix. The critical agitator design features are: (a) vertical blade section shape and orientation, (b) bottom sweep-blade, hub and pump-blade section dimensions and conture; (c) sloping arrangement of the upper cross arms; (d) bottom valve scraper blade design and clearance; and (e) balance between operating speed and agitator-to-wall clearance.

6. PRODUCTION UNIT CONSTRUCTION AND INSTALLATION: A 1000-gallon "48 Process" unit was designed during 1952, prior to completion of the experimental design work in the 150-gallon pilot plant unit. Construction was begun at five different plants shortly thereafter. Several minor but important design changes were made as the result of the final experimental design work prior to completion of these units.

Initial performance results on the first 1000-gallon unit installed during 1952 at Fort Madison matched pilot plant results, establishing the validity of scale-up procedures based on equal applied shear stress and shear rate.

Correct operating speed for the 1000-gallon units was established at 81 rpm. (10% below original estimates) and the operating practicability of the power increase from the minimum requirement of 30 HP, to 40 HP was confirmed.

A standard 1000-gallon 40 HP. "48 Process" mixer design was prepared and used for construction of all other 1000-gallon units. Checklists were employed to insure standardization of the units installed at Chicago, Philadelphia, Everett, South San Francisco, and Fort Madison Finishes Plants.

7. PRODUCTION OPERATION AND CONTROL: A brief memorandum report, "48 Process" Operating Procedures was issued November, 1952, outlining basic characteristics and operating requirements.

Control of the entire dispersion and letdown operation was based on input power which accurately indicated even slight changes in the condition of the mixture.

A second memorandum report, "Instrumentation and Control of Operation Conditions" was issued June, 1953, which also included a list of standard operating instructions. No changes have been necessary.

8. ADDITIONAL DESIGN WORK: Intermediate size units, designed on the equal applied shear stress and shear rate basis, were a 25 HP, 500-gallon mixer (for the Mexico plant), a 10 HP, 150-gallon experimental unit for the Philadelphia Process and Methods Group Pilot Plant, and 1 gallon and 5 gallon laboratory units.

Auxiliary equipment, such as an automatic pigment loader, was considered but not included in this study because the amount and type of equipment justifiable depended upon actual operating economics, and in this respect was largely an individual plant problem. A special pigment loading funnel to control distribution and improve operating performance was the only auxiliary equipment item developed.

9. FORMULA ALIGNMENT: The first group of products investigated following the installation of the original 5 HP 150-gallon experimental unit, was a newly developed line of alkyd-emulsion

Cement and Stucco Finish. This was successfully completed and a report (35) was issued August 15, 1951. This line of products subsequently proved unsatisfactory in field-test performance and was not produced commercially.

a.) Outside White House Paints: This most important and definitely adaptable group was selected as a starting point. The 301-885, #40 Outside White, was manufactured without difficulty in the original 5 HP, 150-gallon unit.

Prior to installation of production units, the formula was revised to the 301-892 high-gloss composition which could not be made in the 1000-gallon "CA" Mixer, reduced 3-Roll Mill rates from 5,000 to 3,000 pounds per hour, and gave production difficulties with respect to gloss control.

Development of a satisfactory "48 Process" formula for 301-892 was successfully completed after a detailed study of gloss control problems. Production was placed on a "48 Process" basis but the product subsequently exhibited unsatisfactory long-term stability and application properties.

Alignment of a series of revised #40 Outside White House Paint formulas has since been necessary.

b.) "Flow Kote": Development of "48 Process" formulas for the 391 Line, "Flow Kote" emulsion finishes, was undertaken because streaking difficulties with these products as made in the 1000-gallon "CA Mixer", resulted in a change to 3-Roll Mill manufacture by the formulators.

Formula composition changes to eliminate sodium and lower the gloss level were made as the initial development work neared completion. "48 Process" and shading base formulation requirements to eliminate streaking were reviewed with formulators who then did the final development work.

A subsequent investigation was necessary when product settling difficulties were encountered which proved to be basically a dispersion mixture letdown problem.

c.) Sealer-Coater: 3-Roll Mill production difficulties with 391-001, Sealer-coater, resulting from coagulation of PVA emulsion led to development of a "48 Process" formula. Alignment was accomplished in cooperation with the Fort Madison plant.

Subsequent production difficulties with solution of the "Methocel" bodying agent were also resolved using a more soluble grade of "Methocel" and a pre-dispersion dry-blend with part of the pigment. Several other minor composition revisions were also successfully treated during this program.

d.) "Dulux" White Tinting Enamel: Manufacture of 33-5043 was undertaken in an effort to span the entire potential application range of "48 Process." Although early laboratory work was successful, difficulties with scattered small agglomerates in the pilot plant and production units (Chicago) indicated that major equipment design changes would be required which could not be justified in view of the performance of the new large "47 Process" units on this type product.

e.) Orthodox Flat Wall Finishes: Flat Wall White (621-900) was investigated and reformulation was found to be necessary due to coarse extender particles ("Celite #110"). During this study, the composition was completely revised in the conversion to the low odor type product. The coarse extender problem was eliminated but the new vehicle was a poorer dispersion vehicle, and the dispersible grade of TiCal (W-92) was replaced by a higher hiding grade of TiCal (W-49) containing dispersion-resistant agglomerates. Samples of W-49 ground at lower through-put rates by the Pigments Department did not correct the difficulty and further work was restricted to "47 Process."

f.) Tinted Outside House Paints: All the major products of the 301 Line Tinted Outside House Paints were aligned. The composition revision to the calcium carbonate extender basis during the development work resulted in an overall pigment system highly suited to "48 Process" manufacture which simplified final development.

g.) Cement and Stucco Finish: Manufacture of the 601-Line Cement and Stucco Finishes was investigated and the major product, 601-911 White, was successfully manufactured after revising the formula to replace the coarse Johns-Manville "Celite #110". Approval for this change was obtained on Philadelphia Plant Laboratory Release Letter #56, 12-29-54. Prime bases for the light and dark tints were developed but development work was stopped because of severe bodying after manufacture. This was caused by the tinting pigments, and the problem was referred to the formulators.

h.) Miscellaneous: A number of production problems with previously aligned products and others which were potentially adaptable to "48 Process" manufacture were studied. Several special products, such as a series of pigment-diethylene glycol mixes for Armstrong Cork Company, were also investigated.

* * *

The formula alignment program was closed at the end of 1954. Responsibility for formulation is being transferred to regular product formulating groups.

10. PATENT STATUS AND CLASSIFICATION OF INFORMATION: Patent aspects were discussed with the Patent Section of the Legal Department following the development of the basic mixer design and general formulation principles. Patent Proposal FFD-1541 (36) explored the possibilities and concluded that an enforcible patent could not be obtained either on the process or the equipment.

"48 Process" information is classified "Confidential" and restricted to Dupont Company use.

C. RESULTS

1. FACTORS CONTROLLING DISPERSION: The mechanics of dispersion and the controlling variables have been determined. Pigment Volume to Liquid Volume Ratio (P/L) and applied shear stress, not mixture flow resistance and input power, are the primary variables. Vehicle composition and shear rate are important to the extent that they control power requirements for a given mixture and restrict maximum practical P/L.

2. "48 PROCESS" APPLICATION RANGE: Application is generally restricted to (a) pigments with an average basic particle diameter of approximately 0.2 micron (i.e., TiO_2, ZnO, etc.) or larger which do not contain crystals or hard agglomerates larger than permissible in the particular product; and (b) product compositions permitting use of dispersion vehicles of low to moderate viscosity which wet the pigments to an appreciable degree.

3. TYPES OF DISPERSION MIXTURES: One simple and three distinct types of complex pigment and liquid dispersion mixtures have been numerically defined. The cause and extent of differences in their dispersion characteristics have been determined.

4. DIRECT CALCULATION OF FORMULAS: "48 Process" formula calculation procedures have been developed which restrict the experimental work to narrow composition ranges, making the precise formulation work required practical. These procedures are based on individual pigment particle size and Packing Index (β) values and make it possible to account for the more than 10:1 variation in liquid volume required per gallon of pigment for mechanically equivalent mixtures.

5. MIXER DESIGN: A mixer design for units up to 1000 gallons working capacity was developed which efficiently handles pigment and liquid mixtures at the stiff paste-consistency level required for "48 Process" dispersion, as well as the reduction to finished product viscosity. Eight 1000-gallon units, 2 producing emulsion finishes and six producing orthodox finishes are currently in operation at five Finishes Division Plants.

The efficiency of power utilization is indicated by the 40 HP required for these 1000 units (versus more than 80 HP required to handle regular "48 Process" dispersion mixtures in the original "CA" unit).

Dispersion cycles (time from last pigment addition to completed dispersion) range from 0.5 to 1 hour (versus 2 to 4 hours for the "CA" mixer). Overall manufacturing cycle of the "48 Process" units is 4 to 8 hours depending upon the product.

Production capacity of 1000-gallon units in terms of finished product is rated at 2000 gallons of Orthodox and "Dulux" type product, and 3000 gallons of Emulsion-type product per day for three-shift operation under average conditions. Present divisional production capacity on this basis is 4,000,000 gallons per year.

The mixer design causes it to function as a viscosimeter on the heavier consistency mixtures, permitting control of both pigment loading and letdown procedure by indicated input power. The method of control automatically adjusts for product differences and eliminates the need for special operating procedures for each product.

6. PRODUCTS BEING MANUFACTURED: Between 15% and 20% of total Divisional production of pigmented products is currently being manufactured by "48 Process." Indluded in this group are White and Tinted House Paints, White Wood Primer, Cement and Stucco Finish (601 Line)(38), and practically all major emulsion-type products.

7. PROCESS APPROVAL: Philadelphia Plant Laboratory Release Letter #44, (37), 7-1-53, covering the use of "48 Process" for any product where finished product quality requirements can be met, has been approved. Separate or supplementary release letters are required where composition changes are necessary.

8. COLLATERAL RESULTS: Basic information on pigmented systems was obtained as a result of this study which may prove to be of greater importance than "48 Process" per se. This information is generally applicable to pigmented systems with average basic particle diameters above 0.1 micron.

a.) Basic data on pigment packing behavior and flow mechanics of dispersion mixtures have permitted development of generalized equipment performance analysis and formula calculation procedures that: (a) have already been applied to "47 Process" premixing and grinding formulation (Formulating Practice FP-01-A, 11-9-54), several plant production problems, and evaluation of proposed new equipment, and (b) are generally applicable to all major dispersion processes.

b.) General letdown requirements for pigmented systems have been established for preventing two basic types of letdown failure; (a) "non-uniform dilution" of high yield-value materials, and (b) "osmotic shrinkage" (the most serious) of pigmented mixtures containing low-solids vehicles when a high-solids letdown vehicle is added.

c.) The same data employed for dispersion mixture formula calculation have been found to be applicable to calculation of pigment substitutions for existing formulas, and estimating pigmentation changes required to produce a specific desired change in the product properties controlled by pigmentation.

D. CONCLUSIONS

"48 Process" in combination with "47 Process" and "45" and "46" Ball Mill Processes provide a high-efficiency process combination ranging in milling action from simple dispersion to crystalline particle fracture, respectively.

1. APPLICATION: "48 Process" cannot substantially reduce oversize crystalline or hard agglomerate particles, and the presence of such particles in many currently used pigments is the primary factor restricting "48 Process" application.

2. MANUFACTURING COSTS: Moderate savings in manufacturing costs are obtained from reductions in yield loss, equipment maintenance, and operating labor; the amount under each item depends upon the type of product and alternate method of manufacture.

Yield loss is reduced by the single closed unit operation. The increase in yield versus "47 Process" and 3-Roll Milling in terms of finished product gallonage ranges from 0.1% to 0.5%, equivalent to approximately 0.5 cents per gallon savings on the overall production average.

Maintenance has amounted to approximately 0.1 cents per gallon of finished product versus "47 Process" at 0.6 cents per gallon, and 3-Roll Mill at 0.9 cents per gallon.

Operating labor has amounted to approximately 1.0 cents per gallon of finished product versus "47 Process" at 1.5cents per gallon on high rate items, and 3-Roll Mill at 3.0 cents per gallon for identical product.

The above figures are based on 1954 Philadelphia Plant cost records. Average overall savings versus 3-Roll Mill, which is the most nearly equivalent alternate process, range from 1 to 4 cents per gallon of finished product on this basis.

3. INVESTMENT: Building and equipment investment per unit production capacity are minimized by the single mixer-dispersion unit. Neither premixing equipment nor auxiliary pumping equipment are required. Building floor load requirements are only about 1.5 times that of conventional finished product mixers.

Approximate costs of processing equipment with comparable production capacity, installed and complete with necessary controls, are as follows:

Item	"48 Process" (1000-gallon)	"47 Process" (30-gallon)	3-Roll Mill (L-Shape HS)
Premix Facilities	none	$ 6,000	$11,000
Processing Unit	$10,000	$ 6,000	$16,000
Transfer Pumps	none	$ 2,000	$ 1,000
TOTALS:	$10,000	$14,000	$28,000

4. SIMPLIFICATION: Premixing and dispersion are combined into one operation in a single processing unit. One operator controls and completes the entire operation from one point. Formulation controls process performance and there are no through-put rate controls to be set.

Solution of dry vehicle-solids components frequently can be combined with the dispersion operation to eliminate manufacture of an intermediate. In some cases, dry-blending of soluble materials with pigment, prior to solvent addition, can be employed to increase solution rates by preventing lump formation.

5. FLEXIBILITY: The independent operation of the "48 Process" units eliminates the necessity for simultaneous scheduling of auxiliary equipment, and production delays caused thereby. Although transfer of bases to letdown mixers for completion is required for maximum "48 Process" production capacity, schedule fluctuations up to one-half the base manufacturing cycle can be absorbed. Where a long hold-up of material in the finished product mixers is encountered, "48 Process" unit operation can be continued by completing the product in this unit, except for some types of emulsion finishes which tend to incorporate excessive amounts of air.

The closed unit generally permits satisfactory operation with emulsion type vehicles which tend to coagulate on open milling equipment,

6. PROCESSING UNIFORMITY: The fewer operating variables should result in improved batch-to-batch uniformity. The limited data, obtained to date, indicate that this advantage is being realized.

E. RECOMMENDATIONS

1. EXTENSION OF APPLICATION: A definite program for procurement of better ground and/or classified pigments to permit extension of "48 Process" appears desirable. A successful program of this type would also permit extension of "47 Process" application plus improved balancing and control of finished product properties.

Improvement of extender selection offers the most potential for immediate increase in "48 Process" and "47 Process" application because a large portion of current pigment grinding capacity is consumed in grinding the coarse particle fraction in present extenders although this fraction usually comprises less than 20% of their overall volume.

2. FORMULATION: Adaptable new product formulas should be developed directly for "48 Process" manufacture on the basis of Formulating Practice FP-01-B.

Existing product compositions are frequently revised for reasons other than change of process. Where possible, conversion of potentially adaptable products to "48 Process" should be combined with these regular formula development activities to avoid duplication of effort, particularly with regard to long term performance testing.

3. PRODUCTION CAPACITY: Present production requirements for the 1000-gallon units is below capacity but when maximum utilization becomes necessary, greater use should be made of auxiliary let-down mixers to increase turnover of the more expensive "48 Process" units.

4. SMALL UNIT INSTALLATION: Installation of a few smaller "48 Process" units for manufacture of experimental products, slower moving finished products, and colored intermediates may prove justified. Any such units should be of the largest practical size, as operating labor and cycle time are about the same for any batch size.

5. OTHER "48 PROCESS" MIXER APPLICATIONS: Evaluation of "48 Process" mixer performance should be considered whenever high-consistency mixtures must be handled, particularly if appreciable shear action must be developed.

F. FUTURE WORK

No further development work directly on "48 Process" is and this study has been closed. Development of additional basic data on pigments and vehicle components for application to all major dispersion processes will be continued under Philadelphia Process and Methods Study P-15, Dispersion Fundamentals.

APPENDIX

SECTION: A

"48 PROCESS" FORMULATING PRACTICE

The following formulating practice was prepared by D. G. Bosse, Philadelphia Process and Methods Group, as a basis for conversion of "48 Process" from experimental to standard production process status.

MARSHALL LABORATORY
STANDARD FORMULATING PRACTICE FP-01-B
"48 PROCESS"

DATE OF ISSUE: 2/18/55 SUPERSEDING: NEW